

## Development of Android-Based Augmented Reality 3D Card Media for Elementary School Students

Listyana Kumala Sita Nanda\*, Trisniawati, Mahmudah Titi Muanifah

Universitas Sarjanawiyata Tamansiswa, Indonesia

\*listyanakumalasilananda@gmail.com

### ABSTRACT

This study aims to develop an Android based Augmented Reality 3D Card Media on solid figures materials for the grade VI elementary school student, to describe the feasibility and the student responses on Android based Augmented Reality 3D Card Media on solid figures materials for the grade VI elementary school student. This study were Research and Development (R&D) with reference to the Borg & Gall model and which is modified into 7 steps, there are (1) research and initial information collection, (2) planning, (3) initial product development, (4) initial trial, (5) revision I, (6) field trials, (7) revision II. The initial trials is a validation of media experts and material experts. The field trials consisted of teacher trials and small group trials on 6 students in grade VI of SD Negeri 1 Gondangsari. The instrument data that were used to collect data were interview guides and questionnaires. The study results showed that the Android based Augmented Reality 3D Card Media consisted of ARB (Augmented Reality Bangun Ruang) application and the card as a marker and completed with a guidebook to facilitate the user. This Android based Augmented Reality 3D Card Media on solid figures materials meet the feasibility criteria as evidenced by the percentage score of the validation results form media experts 78,66%, material expert validation 85,33%, the teacher trials 90,66%, and the small group trials 94,22% accompanied by positive responses from the students. Therefore, the Android based Augmented Reality 3D Card Media on solid figures materials feasible used as alternative media on mathematics learning at pandemic COVID-19 era for the grade VI elementary school students to help learning everywhere and anytime by maximizing the technological developments.

**Keywords:** Augmented Reality, Android, Learning Media, Solid Figures.

### ABSTRAK

Penelitian ini bertujuan mengembangkan Media Kartu 3D *Augmented Reality* berbasis *Android* pada materi bangun ruang untuk siswa kelas VI Sekolah Dasar, mendeskripsikan kelayakan dan respon siswa terhadap media Kartu 3D *Augmented Reality* berbasis *Android* pada materi bangun ruang untuk siswa kelas VI Sekolah Dasar. Penelitian ini merupakan penelitian *Research and Development* (R&D) dengan mengacu pada model Borg & Gall yang dimodifikasi menjadi 7 langkah yaitu (1) penelitian dan pengumpulan informasi awal, (2) perencanaan, (3) pengembangan produk awal, (4) uji coba awal, (5) revisi I, (6) uji coba lapangan, (7) revisi II. Uji coba awal merupakan validasi ahli media dan ahli materi. Uji coba lapangan terdiri dari uji coba guru dan uji coba kelompok kecil terhadap 6 siswa kelas VI SD Negeri 1 Gondangsari. Instrumen yang digunakan untuk mengumpulkan data adalah pedoman wawancara dan kuesioner. Hasil penelitian menunjukkan bahwa Media Kartu 3D *Augmented Reality* berbasis *Android* terdiri dari aplikasi ARB (*Augmented Reality* Bangun Ruang) dan kartu sebagai *marker* serta dilengkapi dengan buku panduan untuk memudahkan pengguna. Media Kartu 3D *Augmented Reality* berbasis *Android* pada materi bangun ruang memenuhi kriteria kelayakan yang dibuktikan dengan persentase skor hasil validasi ahli media 78,66%, validasi ahli materi 85,33%, uji coba guru 90,66% dan uji coba kelompok kecil 94,22% disertai respon positif dari siswa. Dengan demikian, Media Kartu 3D *Augmented Reality* berbasis *Android* pada materi bangun ruang layak digunakan sebagai alternatif media pembelajaran matematika pada masa pandemi *COVID-19* untuk siswa kelas VI Sekolah Dasar yang dapat membantu belajar dimanapun dan kapanpun dengan memaksimalkan perkembangan teknologi.

**Kata kunci:** *Augmented Reality*, *Android*, Media Pembelajaran, Bangun Ruang.

Received : January 20, 2022

/Revised : January 25, 2022

/Accepted : May 30, 2022

/Published : May 30, 2022

### Introduction

Mathematics is one of the subjects at the elementary school level. Learning mathematics at the elementary school level is the beginning to instill basic concepts for students, where the planting of these concepts must be emphasized so that they are accepted and can open students' thinking

power to understand mathematical concepts to the next level. However, mathematics is often considered a difficult subject for students, due to the nature of mathematics learning which is abstract, deductive, consistent, hierarchical, and logical. So that mathematics learning needs to be presented based on the stage of students' cognitive development, so that it can be internalized in students' minds or cognitive structures (Ismayani, 2020). Based on the theory revealed by Piaget (Susanto, 2013) the cognitive development of elementary school age children in the age range of 7-11 years is still in the concrete operational stage. So it is necessary to use the right learning media so that students easily understand the material being taught.

Learning media is one of the most important factors in a learning process in elementary schools, where elementary school student's cognitive development is still in the concrete operational stage. With the learning media, it is hoped that it can help students understand abstract material and material that cannot be explained in verbal language. Currently, many learning media are developed using the latest technology to support the learning process. Moreover, the implementation of the physical distancing in the era of COVID-19 pandemic has made the basis for implementing learning from home or online learning, where teachers are required to take advantage of technological developments that are integrated into learning media so that they can support the online learning process.

However, the reality on the ground there are many lessons that have not used the media according to technological developments because the ability of teachers to use technology for learning activities is still limited. Based on the results of interviews with the grade VI teacher of SD Negeri 1 Gondangsari on October 15, 2020, grade VI students of SD Negeri 1 Gondangsari did not understand the lessons that were delivered online, one of which was learning mathematics in solid figures materials. The lessons delivered by the teacher using Zoom Cloud Meeting did not run optimally due to network constraints. So that the teacher only conveys the material and the assignment to take from the package book or LKS is sent to the WhatsApp Group. The ability of teachers to use technology for learning is also limited, so the media used by teachers during online learning is still lacking, only in the form of images and videos sourced from YouTube. In addition, the media for solid figures available in schools is limited, some of which have been damaged and cannot be used during online learning during the COVID-19 pandemic. In addition, most students have not used smartphones optimally in online learning, students use smartphones more for games.

From the problems above, it is deemed necessary to develop technology-assisted learning media in the form of media that are operated on Android-based smartphones by utilizing Augmented Reality (AR) technology. Augmented Reality is a technology that combines the dimensions of the real world with the dimensions of the virtual world that is displayed in real time (Mahendra, 2016). Augmented Reality has the potential to be used in learning. Learning can be made more interesting and clearer by using Augmented Reality (Ismayani, 2020). Augmented reality is packaged in an application that is installed on a smartphone so that it can reach all students and teachers, the majority of whom already have an Android-based smartphone. With Augmented Reality, material in mathematics learning that is abstract such as solid figure can be displayed into a 3D object that is integrated into the real environment, thus helping students visualize and making it easier for students to understand the material. The tools that help in this stage of making augmented reality are the Vuforia SDK which is used as a marker storage area (Ramadhan et al., 2022).

The advantage of using Augmented Reality technology in learning is that Augmented Reality is easy to develop, reaching teachers and students because the majority currently have an Android-based smartphone. In addition, it can reduce the burden of teaching materials, such as books, mathematical models in the form of wooden blocks, globe models for geography lessons, etc. So, the learning process becomes more interesting, can be done anywhere and anytime, and follows technological developments (Mareta, 2015). The use of Android-based Augmented Reality packaged into learning media is expected to make it easier for students to obtain learning materials anywhere and anytime, especially in the era of COVID-19 pandemic, it will greatly assist the learning process by maximizing technological developments. In this online learning media, students use internet facilities so that they can communicate and distribute material online over long distances (Trisniawati et al., 2021). Now the world of education can be combined using technological advances so that learning can keep up with the times (Ayu et al., 2021).

Several previous research have also shown success in utilizing Augmented Reality technology as a learning medium. Among them are the results of research conducted by (Mukti, 2019) showing that Augmented Reality learning media is feasible to be used as a learning resource for grade VI elementary students. The results research also show that Mobile Augmented Reality as an interactive learning medium for nets of cubes and blocks is feasible to be used to replace conventional teaching aids, where nets of cubes and blocks can be simulated in an android smartphone without requiring long preparation and great space (Farisi & Pratamasunu, 2018). In addition, the results of research show that Augmented Reality-based Learning Media is classified as very high qualification as a learning medium in elementary schools in terms of the level of effectiveness, efficiency, and attractiveness (A. K. Sari et al., 2018).

Which underlies the researchers to develop the Augmented Reality 3D Card Media is the limited number of mathematics learning media that utilizes technological developments according to the stage of students' cognitive development. In this study, researchers developed card media as marker and applications by utilizing Augmented Reality technology based on Android which was designed using the game engine Unity 3D as the main software and Blender to create 3D objects. The material discussed in the media relates to the definition, characteristics, examples of solid figures in everyday life, the discovery of the concept of the formula for surface area and volume of 7 solid figures which include cube, rectangular prism, triangular prism, rectangular pyramid, cylinder, cone and sphere. The purpose of this study is to develop an Android-based Augmented Reality 3D Card Media on solid figures materials for the grade VI Elementary School students, to describe the feasibility and the student responses on Android-based Augmented Reality 3D Card media on solid figures materials for the grade VI Elementary School students.

### **Research Methods**

This study were Research and Development (R&D), namely research used to produce certain products and test the effectiveness of these products (Sugiyono, 2010). The development procedure reference to the Borg & Gall model which is modified into 7 steps, there are research and initial information collection, planning, initial product development, initial trial, revision I, field trial, revision II.

Data collection techniques were carried out by interviews and questionnaires. Interviews were conducted with the grade VI teacher of SD Negeri 1 Gondangsari which aims to analyze needs related to the potential and problems that occur in the field. The interview guide is used as a

reference that contains aspects of teacher knowledge related to the problem of implementing learning, materials and media needed in learning. To validate and assist researchers in making revisions to the developed media, validation of material experts and media experts was carried out through a questionnaire sheet. Furthermore, to determine the feasibility and response to the media, teacher trials and small group trials involving 6 students in grade VI were carried out using a questionnaire sheet.

The data analysis technique used in this study is a descriptive percentage analysis technique. Where the percentage descriptive analysis technique is used to convert quantitative data into percentage form then the data is interpreted in the form of qualitative sentences (Sari, 2019). The data obtained in the form of qualitative and quantitative data. Qualitative data analysis techniques were used to analyze data in the form of comments and suggestions as outlined in the questionnaire of material experts, media experts, teachers and students. The qualitative data is used as a reference for revising the product. Meanwhile, quantitative data analysis techniques were used to analyze the data in the form of numbers obtained from the results of the questionnaire measured by a Likert scale.

The score obtained from the results of the questionnaire; the percentage is calculated. After obtaining the percentage of the calculation results, the data is converted into a predicate statement or criteria so that conclusions can be drawn regarding the quality of the product developed. The assessment criteria are presented in the following table.

**Table 1.** Criteria for Assessment Results of Experts, Teachers and Small Groups

Interval	Criteria
$80\% < P \leq 100\%$	Very Feasible
$60\% < P \leq 80\%$	Feasible
$40\% < P \leq 60\%$	Fairly Feasible
$20\% < P \leq 40\%$	Less Feasible
$0\% < P \leq 20\%$	Not Feasible

Android based Augmented Reality 3D Card media is declared feasible based on the percentage score, the higher the score percentage in data analysis, the higher the feasibility level of Android based Augmented Reality 3D Card media. In this study, the minimum feasibility criteria was determined as "Fairly Feasible" with an interval of  $40\% < P \leq 60\%$ . Based on table 1, if the percentage of scores from the validation of material experts, media experts, teacher trials and small group trials enter the minimum criteria of "Fairly Feasible" then the product developed is considered feasible.

### Result and Discussions

In this development research, the initial steps taken are research and initial information gathering by conducting a needs analysis. The needs analysis was carried out by interviewing the grade VI teacher of SD Negeri 1 Gondangsari on October 15, 2020. The needs analysis aimed to identify potentials and problems that occur in the field, so that this research can produce products that suit the needs of students. The results of the interviews showed that the grade VI students of SD Negeri 1 Gondangsari did not understand the learning delivered online, one of which was learning mathematics in solid figures materials. The learning delivered by the teacher through the Zoom Cloud Meeting did not run optimally due to network constraints. So that the teacher conveys the material and the assignment to take from the package book or LKS

is sent to the WhatsApp Group. The ability of teachers to use technology for learning is also limited, so the media used by teachers during online learning is still lacking, only in the form of images and videos sourced from YouTube. In addition, the media for solid figures available in schools is limited, some of which have been damaged and cannot be used during online learning during the COVID-19 pandemic. Most students have not used smartphones optimally in online learning, students use smartphones more for games. In addition, teachers need technology-based media to help students learn anywhere and anytime that is packaged attractively according to the stage of students' cognitive development.

The next stage in this research is planning. At the planning stage, the researcher conducted a literature study to obtain further information about media creation such as analyzing the material, student needs, learning conditions in schools, and the needs to design products. The researchers conducted a review of the learning materials based on the syllabus of grade VI SD Negeri 1 Gondangsari. One of the materials that is not understood by grade VI students is the material of solid figures, Basic Competence (KD) 3.6, 4.7, 3.7, and 4.7. For this reason, the researchers developed an Android-based Augmented Reality 3D Card Media where solid figures can be displayed into a 3D object that is integrated into the real environment, so helping students visualize and making it easier for students to understand material concepts and can be used anywhere and anytime. In addition to analyzing the material, the researcher also examines the techniques and needs for making 3D Augmented Reality Media Cards based on Android as the basis for making media designs. At this stage, the researcher also developed an assessment instrument in the form of a questionnaire for the implementation of the initial trial (expert validation), teacher trials, and small group trials. The advantage of the developed media is that it has an attractive appearance, can be used anywhere and anytime without being connected to the internet (Risma et al., 2021).

This research stage is continued with the initial product development by designing an Android-based Augmented Reality 3D Card media using the game engine Unity 3D 2018.4.6f1. The Augmented Reality 3D Card media design developed in the form of an Android-based Augmented Reality Solid Figures application and cards media used as marker. The Augmented Reality application consists of Augmented Reality Menu, Material Menu, Quiz Menu, Guide Menu, Basic Competence Menu and Indicators. The Augmented Reality menu is the main menu, its use is by pointing the camera at the card then on the card will display 3D objects (Augmented Reality), the name of the shape, and a summary of the material. In the material menu there are 7 choices of solid figures materials. The material is in the form of solid figures framework, definitions, characteristics, discovery of the concept of volume and surface area formulas, as well as examples of solid figures in everyday life. The quiz menu contains practice questions along with their discussions and activities that invite students to be creative in making a model of solid figures. The guide menu contains a guide that provides features for downloading cards that will be used as marker on the Augmented Reality menu. The menu of basic competencies and indicators displays basic competencies and learning indicators. In addition, it is also equipped with sound, close, and profile buttons.

The initial trial stage is the validation of media experts and material experts as formative evaluations. This product validation aims to obtain criticism, suggestions, and assessments of the products developed by researchers as a reference for improvement (revision). Media expert validation is carried out on January 30, 2021 - February 16, 2021 by lecturer of primary school teacher education at Universitas Sarjanawiyata Tamansiswa who is competent in his field. Media validation is carried out on four aspects, there are navigation, language, display design,

and the purpose of media presentation. The results of media expert validation can be seen in the following table.

**Table 2.** Media Expert Validation Results

No.	Aspects	Earning Score	Maximum Score	Percentage	Category
1.	Navigation	8	10	80%	Feasible
2.	Language	12	15	80%	Feasible
3.	Display Design	15	20	75%	Feasible
4.	Media Presentation Purpose	24	30	80%	Feasible
	Total	59	75	78,66%	Feasible

Based on table 2, the results of the validation of the Android-based Augmented Reality 3D Card Media with 15 indicator items obtained a percentage score of 78,66% in the "Feasible" category to be tested with revisions according to suggestions. Material expert validation is carried out on January 30, 2021 - February 17, 2021 by lecturer of primary school teacher education at Universitas Sarjanawiyata Tamansiswa who is competent in her field. Material validation is carried out on three aspects, there are learning, material, and appearance. The results of the material expert validation of the Android-based Augmented Reality 3D Card Media with 15 indicator items obtained an overall score percentage of 85,33% with the "Very Feasible" category to be tested with revisions according to suggestions. The results of material expert validation can be seen in the following table.

**Table 3.** Material Expert Validation Results

No.	Aspects	Earning Score	Maximum Score	Percentage	Category
1.	Learning	34	40	85%	Very Feasible
2.	Material	17	20	85%	Very Feasible
3.	Display	13	15	86,66%	Very Feasible
	Total	64	75	85,33%	Very Feasible

Based on table 3, the results of the validation of media experts and material experts, several comments and suggestions were obtained which were used as a reference for product revision and improvement. Suggestions from media experts include the coloring and location of the navigation buttons to be improved by focusing on currently trending applications such as AR choki-choki but the content is adapted to education, some visual objects/images using minimal pixels need to be fixed with larger pixels, naming the application too long should be easy to hear, interesting and easy to remember, besides that the developer profile icon should be placed at a certain angle using the help button so that it does not become the main focus for users. Meanwhile, suggestions from material experts, there are the Android-based Augmented Reality 3D Card Media, need to be equipped with a guidebook, some materials need to be improved a little according to the suggestions and add sample material around objects along with their pictures for each solid figures. In addition, in the quiz, add questions according to the indicators and creative activities to create a solid figure should be made a separate icon, not integrated with the quiz menu. The researcher revised I and refined the Augmented Reality 3D Card Media product based on Android according to the advice of these experts. From the results of the

validation of media and material experts, it was concluded that the product was feasible for use with revisions according to suggestions and continued with field trials.

The field trial phase was carried out after revisions according to suggestions from media experts and material experts. Field trials in the form of teacher trials and small group trials involving 6 students in grade VI of SD Negeri 1 Gondangsari. The teacher trial was held on March 9, 2021 by grade VI teachers. The teacher's trial was used to determine the feasibility of the Android-based Augmented Reality 3D Card Media on the solid figures material. After the teacher conducted a product trial, the teacher was given an assessment questionnaire that included three aspects, there are learning, benefits, and appearance with 15 indicators. The results of the calculation of the teacher's trial are presented in the following table.

**Table 4.** Teacher Trial Results

No.	Aspects	Earning Score	Maximum Score	Percentage	Category
1.	Learning	26	30	86,66%	Very Feasible
2.	Benefit	19	20	95%	Very Feasible
3.	Display	23	25	92%	Very Feasible
	Total	68	75	90,66%	Very Feasible

Based on table 4, the teacher's trial of Android-based Augmented Reality 3D Card Media obtained an overall score percentage of 90,66% with the "Very Feasible" category for use without revision. After the teacher trial, it was followed by a small group trial which was held on March 10, 2021 in the grade VI of SD Negeri 1 Gondangsari. The small group trial involved 6 students in grade VI of SD Negeri 1 Gondangsari. Due to the COVID-19 pandemic conditions, the headmaster only allowed 6 students and followed the directions from the headmaster during the test, the students did not need to be in uniform. After the students did the experiment, which was accompanied by the teacher, the students were then given a questionnaire and the researcher conducted a few interviews to find out the students' responses to the media. The results of a small group trial of Android-based Augmented Reality 3D Card Media with 15 indicator items obtained an overall score percentage of 94,22% with the "Very Feasible" category for use without revision. The results of the calculation of the small group trial are presented in the following table.

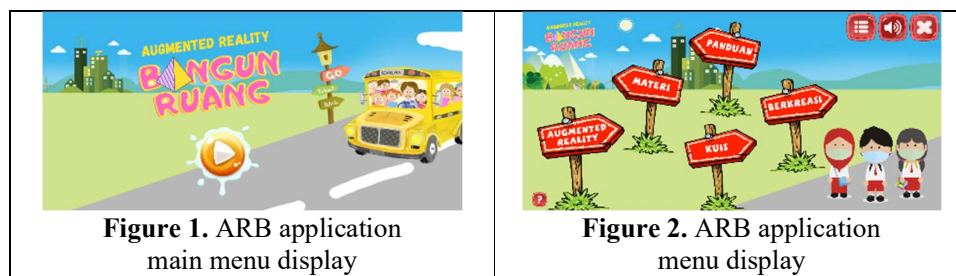
**Table 5.** Small Group Trial Results

No.	Name	Earning Score	Maximum Score	Percentage	Category
1.	JA	70	75	93,33%	Very Feasible
2.	D	74	75	98,66%	Very Feasible
3.	AO	70	75	93,33%	Very Feasible
4.	LN	68	75	90,66%	Very Feasible
5.	RP	71	75	94,66%	Very Feasible
6.	DBS	71	75	94,66%	Very Feasible
	Total	424	450	94,22%	Very Feasible

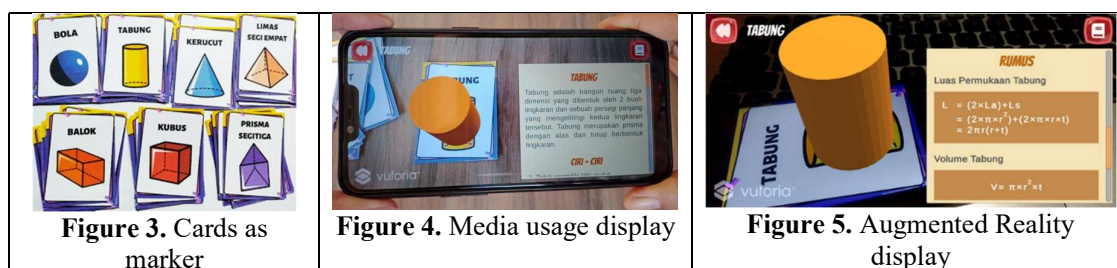
Based on the results of teacher trials and small group trials in table 5, it can be concluded that the Android-based Augmented Reality 3D Card Media meets the feasibility criteria and no further revision is needed. Students also gave a positive response to the Android-based Augmented Reality 3D Card Media on the material of solid figures. When interviewed by

researchers, students commented that the media was good, such as the AR choki-choki game, when the card was scanned a 3D object appeared, it was fun and interesting to learn solid figures while playing cards so that they were enthusiastic in learning mathematics. In addition, during the trial the students were very enthusiastic, actively participated, and interested in the Android-based Augmented Reality 3D Card Media in solid figures materials and gave positive comments written on the questionnaire.

After going through several stages of development, the final product development form of Augmented Reality 3D Card Media is ARB (Augmented Reality Bangun Ruang) application based on Android and cards media used as marker. The ARB (Augmented Reality Bangun Ruang) application consists of an Augmented Reality menu, a material menu, a quiz menu, a creative menu, and a guide menu. The utilization of learning media using Augmented Reality is useful in increasing student interest in the learning process because Augmented Reality technology displays animation can be a stimulus to students to be more active in learning activities (Pujiastuti, Haryadi, & Arifin, 2020). This card requires several points as a marker reference to be recognized properly by the AR application (Budhi, 2019). In addition, it is also equipped with a basic competency menu and indicators, a sound button, a help button containing the developer profile (creator), and a close button.



Based on figure.1 and figure.2, the Augmented Reality menu is the main menu, its use is by pointing the camera at the card then on the card will display 3D objects (Augmented Reality), the name of the shape, and a summary of the material. In the material menu there are 7 choices of solid figures materials. The material is in the form of solid figures framework, definitions, characteristics, discovery of the concept of volume and surface area formulas, as well as examples of solid figures in everyday life. The quiz menu is used as an exercise containing questions and their discussion. The creative menu contains activities that invite students to be creative in making a model of solid figures by utilizing the objects around them. The guide menu contains a guide that provides features for downloading cards that will be used as marker on the Augmented Reality menu. The menu of basic competencies and indicators displays basic competencies and learning indicators.



As we can see in figure 3 android-based Augmented Reality 3D Card Media is equipped with a card that is used as a marker. Later when the camera is pointed at the card (scan card), it will display 3D objects (Augmented Reality). In addition, it is also equipped with a guidebook to make it easier for users to learn the contents and instructions for using the media. Based on figure 4 and figure 5 android-based Augmented Reality 3D Card Media was developed based on the stage of students' cognitive development to help visualize students and make it easier to understand the concept of solid figures. In line with that with media that utilize Augmented Reality technology, learning can look more real and make students more interested in learning mathematics (Huda and Purwaningtias, 2017).

Android-based Augmented Reality 3D Card Media can be used anytime and everywhere, with or without a teacher so that it supports online learning processes that take advantage of technological developments. In line with the research results is smartphone technology with Augmented Reality applications can maximize distance learning and make it easier for students to understand the concept of solid figures that requires a high visual level (Ummah & Ariwibowo, 2021). Android-based Augmented Reality 3D Card Media is attractively packaged like a game, thus creating interactive learning according to technological developments. This is in line with the combination of Augmented Reality technology with education creates applications that aim to increase effectiveness and attractiveness by seeing real objects become more interactive (Kesim and Ozarslan, 2012). The application can run according to the minimum specifications of the device or above and all the feature was executed well (Wisnawa & Wibawa, 2021). Therefore, the Android-based Augmented Reality 3D Card Media on solid figures materials is appropriate to be used as an alternative medium for mathematics learning during the COVID-19 pandemic by maximizing technological developments.

### **Conclusion**

Based on the development research that has been carried out, it can be concluded that the Android-based Augmented Reality 3D Card Media on solid figures materials consists of the ARB (Augmented Reality Bangun Ruang) application and the card as a marker equipped with a guidebook to facilitate users. Android-based Augmented Reality 3D Card Media on solid figures materials meets the feasibility criteria as evidenced by the percentage score of media expert validation results 78,66%, material expert validation 85,33%, teacher trial 90,66% and small group trial 94,22%. As well as getting a positive response, it was shown that students were very enthusiastic, participated actively, were interested and gave positive comments written on the questionnaire. Therefore, the Android-based Augmented Reality 3D Card Media on solid figures materials is feasible to be used as an alternative medium for mathematics learning during the COVID-19 pandemic for grade VI Elementary School students to help learn everywhere and anytime by maximizing technological developments. Furthermore, the product of augmented reality media the product still needs to be tested on a wider scale

### **Acknowledgement**

The researcher would like deliver thanks to Sarjanawiyata Tamansiswa University and primary school teacher education lecturers for all their support in finishing this research. Also, thanks to the headmaster, teachers, and grade VI students of SD Negeri 1 Gondangsari who have helped in carrying out this research

### **Bibliography**

Ayu, R. F. K., Jannah, Z., Fauziah, N., Ningsih, T. N., Manilaturohmah, M., Suryadi, D. A., Budiarti, R. P. N., & Fitriyah, F. K. (2021). Planetarium Glass Based on Augmented

- Reality to Improve Science Literacy Knowledge in Madura Primary Schools. *Child Education Journal*, 3(1), 19–29. <https://doi.org/10.33086/cej.v3i1.1768>
- Budhi, R. K. (2019). Making Of Flash Card And Augmented Reality-Based Application As A Learning Media For Children With Special Needs. *Jurnal Transformatika*, 16(2), 135. <https://doi.org/10.26623/transformatika.v16i2.923>
- Farisi, O. I. R., & Pratamasunu, G. Q. O. (2018). Mobile Augmented Reality sebagai Media Pembelajaran Interaktif Jaring-jaring Kubus dan Balok. *NJCA (Nusantara Journal of Computers and Its Applications)*, 3(2), 96–104. <https://doi.org/10.36564/njca.v3i2.58>
- Huda, N., & Purwaningtias, F. (2017). Pemanfaatan Teknologi Augmented Reality (Ar) Pembelajaran Matematika Menggunakan 3 (Tiga) Bahasa Pada Tingkat Sekolah Dasar Berbasis Android. *Prosiding Seminar Nasional Darmajaya*, 1(1), 1–9. <https://jurnal.darmajaya.ac.id/index.php/PSND/article/view/744>
- Ismayani, A. (2020). *Membuat Sendiri Aplikasi Augmented Reality*. PT. Elex Media Komputindo.
- Kesim, M., & Ozarlan, Y. (2012). Augmented Reality in Education: Current Technologies and the Potential for Education. *Procedia - Social and Behavioral Sciences*, 47(January 2015), 297–302. <https://doi.org/10.1016/j.sbspro.2012.06.654>
- Mahendra, I. B. M. (2016). Implementasi Augmented Reality ( Ar ) Menggunakan Unity 3D Dan Vuforia Sdk. *Jurnal Ilmiah ILMU KOMPUTER Universitas Udayana*, 9(1), 1–5.
- Mareta, A. (2015). *Implementasi Media Ajar Bangun Ruang Berbasis Augmented Reality Pada SMPN 2 Selomerto Kabupaten Wonosobo*. UNNES.
- Mukti, F. D. (2019). Pengembangan Media Pembelajaran Augmented Reality (AR) di Kelas V MI Wahid Hasyim. *ELEMENTARY: Islamic Teacher Journal*, 7(2), 299. <https://doi.org/10.21043/elementary.v7i2.6351>
- Pujiastuti, H., Haryadi, R., & Arifin, A. M. (2020). The development of Augmented Reality-based learning media to improve students' ability to understand mathematics concept. *Unnes Journal of Mathematics Education*, 9(2), 92–101.
- Ramadhan, Z. S., Andrea, R., & Suswanto. (2022). Development of Augmented Reality Traditional Musical Education Applications. *Tepian*, 3(1), 49–54. <https://doi.org/10.51967/tepian.v3i1.690>
- Risma, R., Farida, F., & Andriani, S. (2021). Android Mobile Learning: MIT App Inventor dan Pengembangannya pada Pembelajaran Matematika. *AlphaMath : Journal of Mathematics Education*, 7(1), 64. <https://doi.org/10.30595/alphamath.v7i1.8800>
- Sari, A. K., Dellia, P., Dicky, M., & Cholillah, C. (2018). Pengembangan Media Pembelajaran Bangun Ruang Berbasis Augmented Reality pada Tingkat Sekolah Dasar. *Prosiding Seminar Nasional Pendidikan KALUNI*, 1(April), 56–57. <https://doi.org/10.30998/prossnp.v1i0.15>
- Sari, T. K. A. (2019). Pengembangan Media Pembelajaran Matematika Berbasis Adobe Flash di SD Negeri 4 Metro Barat. *Metodologi Penelitian Terapan*, 161. [https://repository.metrouniv.ac.id/id/eprint/608/1/Temu Kurnia Ambar Sari\\_1501050137\\_PGMI - Perpustakaan IAIN Metro.pdf](https://repository.metrouniv.ac.id/id/eprint/608/1/Temu%20Kurnia%20Ambar%20Sari_1501050137_PGMI%20-%20Perpustakaan%20IAIN%20Metro.pdf)
- Sugiyono. (2010). *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, dan R&D*. Alfabeta.
- Susanto, A. (2013). *Teori Belajar & Pembelajaran di Sekolah Dasar*. Kencana. <https://journal.unnes.ac.id/sju/index.php/prisma/article/view/20762/9884>
- Trisniawati, T., Muanifah, M. T., Rhosyida, N., & Hidayat, R. A. (2021). Eksplorasi Hasil Belajar Matematika melalui Penerapan Sistem Pembelajaran Daring (SI PEDAR) di Masa Pandemi Covid-19. *AlphaMath : Journal of Mathematics Education*, 7(1), 57. <https://doi.org/10.30595/alphamath.v7i1.10195>

- Ummah, I., & Ariwibowo, M. R. (2021). Augmented Reality Sebagai Media Pendukung Pembelajaran Masa Pandemi Covid-19. *Science Tech: Jurnal Ilmu Pengetahuan Dan Teknologi*, 7(1), 15–25.
- Wisnawa, A., & Wibawa, I. G. A. (2021). Augmented Reality Application Development for Elementary School Purpose. *JELIKU (Jurnal Elektronik Ilmu Komputer Udayana)*, 9(4), 475. <https://doi.org/10.24843/jlk.2021.v09.i04.p04>