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The Influence of Augmented Reality-Based Learning Media on Understanding Mathematics Concepts of Fifth-Grade Students

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Abstract

The technology known as augmented reality allows the real and virtual (digital) worlds to merge. Specifically, it projects three-dimensional (3D) objects onto the surface of the real world using the medium of a camera, giving the impression that the objects are actually there. This research, thus, aims to find out how fifth-grade students at the State Elementary School of 064005 Medan understand mathematical ideas in relation to augmented reality-based learning materials. The research population was fifty fifth-grade students at the State Elementary School of 064005 Medan. The whole sampling technique was employed to collect research samples. Two classes of the elementary school, namely class V A as the experimental class and class V B as the control class, were the samples used in this research. Based on post-test data, the average learning outcome score for the experimental class was 89.00, while the control class was 79.80. According to research findings, augmented reality-based educational materials exerted a significant impact (sig. < 0.05) on the understanding of mathematical concepts for fifth-grade students, with a percentage of 80.88%, so the students' answers to the augmented reality-based learning media for mathematics concepts for fifth-grade students at the State Elementary School of 064005 Medan can be classified as good. Hence, the use of media is practical and scientifically effective. These results demonstrate that students' responses to augmented reality-based learning media in understanding mathematical concepts in flat-sided geometry material are in a good category. The implication is that teachers can put more emphasis on the use of advanced technological media in understanding concepts and other mathematical skills.

Keywords: Augmented Reality, Learning Media, Mathematics Concept

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Abstrak

Teknologi yang dikenal sebagai augmented reality memungkinkan dunia nyata dan dunia maya (digital) menyatu. Secara khusus, ia memproyeksikan objek tiga dimensi (3D) ke permukaan dunia nyata dengan menggunakan media kamera, sehingga memberikan kesan bahwa objek tersebut benar-benar ada. Penelitian ini bertujuan untuk mengetahui bagaimana siswa kelas V SDN 064005 Medan memahami ide matematika dalam kaitannya dengan materi pembelajaran berbasis augmented reality. Populasi penelitian adalah lima puluh siswa kelas V SDN 064005 Medan. Teknik Whole Sampling digunakan untuk mengumpulkan sampel penelitian. Dua kelas yaitu kelas V A sebagai kelas eksperimen dan kelas V B sebagai kelas kontrol menjadi sampel yang digunakan dalam penelitian ini. Berdasarkan data postes rata-rata skor hasil belajar kelas eksperimen sebesar 89,00 sedangkan kelas kontrol sebesar 79,80. Berdasarkan hasil penelitian, materi pendidikan berbasis augmented reality memberikan dampak signifikan (sig. <0,05) terhadap pemahaman konsep matematika siswa kelas V dengan persentase sebesar 80,88% sehingga jawaban siswa terhadap media pembelajaran konsep matematika berbasis augmented reality untuk siswa kelas V sebesar 80,88%. siswa kelas V SDN 064005 Medan dapat tergolong baik. Oleh karena itu, penggunaan media bersifat praktis dan efektif secara ilmiah. Hasil tersebut menunjukkan bahwa respon siswa terhadap media pembelajaran berbasis augmented reality dalam pemahaman konsep matematika pada materi geometri sisi datar berada pada kategori baik. Implikasinya adalah guru dapat lebih menekankan penggunaan media teknologi canggih dalam pemahaman konsep dan keterampilan matematika lainnya.

Kata Kunci: Augmented Reality, Media Pembelajaran, Konsep Matematika

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INTRODUCTION

Learning is a process that students do that is adjusted to the objectives to be achieved. Conducive learning conditions will make the learning process more effective and efficient. In this case, mathematics learning is learning that requires high-level thinking in problem-solving and concept understanding. Mathematics learning also emphasizes conceptual understanding rather than procedural mastery, which will build student activity and creativity (Ermawati & Zuliana, 2020; Setyaningrum et al., 2023).

Further, a person's ability to understand a problem is considered to be the basis from which he can obtain a solution to the problems he faces. The fundamental idea behind improving comprehension skills is something that many educational disciplines, especially mathematics, strive to achieve. Widyasari and Soptianingrum (2019) underscore that one of the main skills needed to support other mathematical abilities during the learning process is the ability to understand mathematics.

Mathematics, on the other hand, is seen as a difficult subject by students (Mulyati & Evendi, 2020). This is because mathematics material tends to be abstract, and learning is not fun. Therefore, teachers must be able to create fun mathematics learning and make students active, creative, and innovative in learning activities (Fatimatuzzahro et al., 2021). Learning media, in this instance, can make abstract material real, and it can be utilized as a link between material and natural findings by including content/images in accordance with the material so that students can more easily understand and remember the material (Febriyandani & Kowiyah, 2021). The use of media can also make it easier for students to understand the lesson material, as they can be designed to be interesting and fun to learn. In addition, students do not get bored quickly, and this can motivate and stimulate them to be enthusiastic about learning, supporting the achievement of effective and efficient learning goals (Wangge, 2020).

One of the learning media that can be used to make students active by starting direct experience and can also attract student interest in learning is augmented reality. According to Azuma (in Mustaqim & Kurniawan, 2017), augmented reality is a technology that allows the combining of the real and virtual (digital) world by displaying three-dimensional (3D) objects in the real world through camera media so that the camera looks as if the 3D exists in the real world. AR also allows the display of illustrations that are difficult to realize concretely.

This can be compared to the foundation of a building. If it is fragile and easy to build, it will easily collapse. However, if the foundation is solid, the structure will withstand shocks and remain standing. For this reason, the capacity for an in-depth understanding of mathematics learning is the basic foundation of education (Larasati & Widyasari, 2021), especially so that students can use problem-solving techniques and understand the material, concepts, principles, and procedures for a problem presented and so that they understand every concept to be delivered. This helps students not only memorize concepts but also better understand and comprehend concept lessons (Alan & Afriansyah, 2017). Students must also actively participate in the learning process carried out in front of them with the teacher so that they can understand mathematics (Radiusman, 2020).

Moreover, the ability to understand mathematical concepts is crucial in learning mathematics because learning mathematical concepts must emphasize the development of students' ways of thinking. Concept understanding is a vital thing that students must have. Concept understanding is carried out through a process of review and then presented in student skills (Khoirina et al., 2023). Without understanding, of course, students will find it more difficult to remember the information conveyed by the teacher. Since understanding is the process of becoming aware, it is a process that someone does to comprehend (Kholidah & Sujadi, 2018).

From the results of observations made at the State Elementary School of 064005 Medan on December 18 to 19, 2023, many students still did not understand mathematical concepts optimally. The researchers suggest that many students did not like mathematics and had low scores. The cause was the lack of understanding of mathematical concepts by students and the failure to solve problems

given by the teacher. In addition, the results of interviews conducted by researchers with the fifth-grade homeroom teacher on December 19, 2023, stated that many students still scored below the Minimum Completion Criteria (KKM). Teachers repeatedly explained in the learning process that the utilization of the media was not optimal. Many teachers still used monotonous media, so students were not interested in learning mathematics.

This fact proves that mathematics is an abstract lesson in the form of concepts, principles, and operations (Wahid, 2018). Mathematical concepts must be understood first to know the principles and operations in their application (Apriliyana et al., 2023). Not a few students disliked mathematics lessons due to a lack of understanding at the beginning. Another thing is also based on students who mentioned that problems in mathematics were difficult with practical steps, and they tended only to write answers; some students still had difficulty understanding mathematical concepts (Ermawati & Amalia, 2023).

However, the previous explanation regarding the importance of understanding capacity is not in accordance with students' understanding abilities at elementary school. Many elementary school children experienced confusion when trying to answer the instructor's questions, which had been changed from the first example. Thus, improving mathematical understanding has been the focus of several initiatives undertaken by academics, governments, and educators, among others.

Additionally, thanks to advances in technology, learning activities must now be able to support world conditions through the use of media, teaching materials, and learning strategies that align with the current state of science. As is known, most learning activities involve learning media. This happens because educational media can increase students' interest in the topic, facilitate the teacher's delivery of content to students, reduce or even prevent learning boredom, and improve student learning outcomes.

According to Atmajaya (2017), augmented reality is a technology that simultaneously combines virtual and real three-dimensional (3D) objects in the same space and time. This is done by combining the distance between real objects and virtual objects so that they can be linked together to create a three-dimensional display in real time—utilization of augmented reality in research to increase the conceptual understanding of fifth-grade students.

This is reinforced by the research findings of Larasati & Widyasari (2021), showing that students' mathematical understanding abilities increase when they are faced with augmented reality learning material. According to Nugraha et al. (2021), students can enjoy a more interesting and interactive learning environment and increase their understanding of augmented reality media. Ermawati et al.'s (2022) research findings further support this, indicating that the use of the Mat Joyo application has an impact on fifth-grade students' understanding of mathematical ideas, which has a positive impact on their activities and interactions with each other to master the material and reach their highest potential. As Widayanti & Nuraini (2020) stated, an android-based learning media product developed using augmented reality has gone through an expert validation process and had very good practicality criteria. The learning outcomes of students who learned with it were better than those of students who used conventional learning. In addition, a quasi-experimental study (Hidayat & Asmalah, 2020) concluded that students who used augmented reality exhibited higher motivation and lower mathematics anxiety. Pseudo-experimental research has also been conducted (Nasrulloh et al., 2022), with the results revealing that the use of augmented reality in blended learning is more effective than online learning in improving student learning outcomes. Besides, another research's results (Putra & Sofiana, 2022) showed that the application of 3D geometric shapes learning media using augmented reality technology could attract students' interest in studying mathematics subjects, especially materials of three-dimensional shapes.

The difference between the research that the authors conducted and the previous study lies in that the topic specifically focuses on understanding augmented reality-based learning and understanding mathematical concepts. The researchers compared

conventional models in understanding mathematical concepts with the use of self-developed augmented reality-based learning media in the experimental class.

Based on explanations found by researchers and support from relevant ideas, the researchers conducted the study. They sought to find out how the use of augmented reality-based learning media influenced the understanding of mathematics concepts for fifth-grade students at SD Negeri 064005 Medan.

METHODS

This research used quantitative methods and belonged to experimental research. The research design of this study was quasi-experimental, implying that random clusters are typically used to determine treatment and control groups and limit the researchers' ability to change subjects. This research specifically employed a quasi-experimental research design. Time series design and nonequivalent control group design are two types of quasi-experimental designs. Before receiving treatment, a pre-test was given to the experimental and control groups to determine the pre-treatment state of each group.

Table 1. Research Design

Class	Pre-test	Treatment	Post-test
Experiment	T1	P1	T2
Control	T1	P2	T2

Information:

P1 : Treatment takes the form of a scientific approach using augmented reality-based learning.
P2 : Treatment with conventional models
T1 : Pre-test
T2 : Post-test

The use of augmented reality-based learning media in understanding mathematical concepts in the form of a test room was carried out using multiple-choice questions. After that, students' responses were given learning treatment using augmented reality-based learning media to determine the level of practicality of the model. Then, the test results were tested for the validity of each question item used and for its reliability.

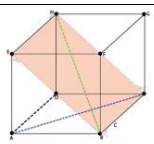
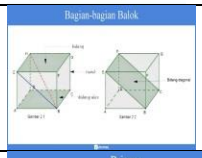
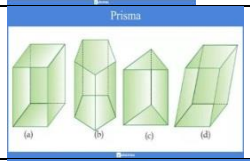
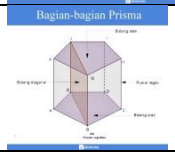
Following that, cognitive tests were given at the beginning and end of the learning, which functioned as the main data collection instruments in this research. After completing the learning/treatment process in each experimental class, data analysis procedures were carried out. This procedure included calculating changes in student learning outcomes (the difference in learning outcomes between post-test and before treatment) obtained in each class, as well as carrying out the necessary statistical analysis tests, especially normality tests. Moreover, apart from the data homogeneity test, the t-test was also used to measure the average difference in student learning outcomes between experimental classes I and II.

RESULTS AND DISCUSSION

The Augmented Reality Media

The authors applied augmented reality-based learning media to understanding mathematical concepts in flat-sided geometric material. Some of the flat-sided geometric material included in augmented reality-based learning media can be seen in the following table.

Table 2. Three-Dimensional Shape with Flat Sides

No	Material	Object
1.	Elements of three-dimensional shape	
2.	Cuboid parts	
3.	Prism	
4.	Pyramid	
5.	Prism parts	

The results of research conducted in class V at SD Negeri 064005 Medan on December 18-19, 2023, by doing some tests are as follows.

Normality Test

In the normality test, there is an indicator called the significance level. If the data has a significance level of less than 0.05, it can be said that the data is normal. This is true for Kolmogorov-Smirnov but not for Shapiro-Wilk. The difference in the experiences of the two users is caused by the number of test samples used. If the sample size is less than or equal to fifty, Shapiro-Wilk is more suitable for use in the normality test. Conversely, to get a larger sample size, at least 50, Kolmogorov-Smirnov is used to ensure more accurate results. The results of the normality test data on the pre-test and post-test on student learning outcomes are listed in Table 3 below.

Table 3. Normality Test of Pre-Test and Post-Test Data

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experiment class	.163	25	.087	.924	25	.065
Control class	.233	25	.001	.923	25	.061

Because the significance value in the table above was more than 0.05, it can be concluded that all samples from the pre-test and post-test data sources were normally distributed.

Homogeneity Test

If the significant value is > 0.05, the data distribution is homogeneous. Conversely, if the significant value is <0.05, then the data distribution is not homogeneous.

Table 4. Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.
Learning outcomes	Based on Mean	.562	1	48	.457
	Based on Median	.390	1	48	.535
	Based on the Median and with adjusted of	.390	1	47.342	.535
	Based trimmed mean	.563	1	48	.457

Thus, it can be concluded that the pre-test and post-test data are homogeneous.

Hypothesis Testing

Statistical tests, such as the t-test, can be used for hypothesis testing after ensuring that the data is homogeneous and normally distributed. The hypothesis in this research will be accepted or rejected using the t-test, especially one sample t-test. Data from hypothesis testing on student learning outcomes can be seen in Table 5 and Table 6 below.

Table 5. Hypothesis Test Results

Group	N	Mean	Std. Deviation	Std. Error Mean
Experiment class	25	89.000	6.9222	1.3844
Control class	25	79.800	6.0346	1.2069

This can be seen that the experimental class mean is higher than the control class with 89.00 compared to 78.80. The difference in mean values indicates that the medium is better. It is then clarified using hypothesis testing.

Table 6. Independent Samples Test

		F	Sig.	t	df	Sig.(2-tailed)
Learning outcomes	Equal variances assumed	.562	.457	5.009	48	.000
	Equal variances are not assumed.			5.009	47.12	.000

This can be seen in Equal Variances Assumed Sig. (2-tailed) 0.00 < 0.05 that H_a was accepted and H_0 was rejected because the significant value was < 0.05.

N-Gain Test

A post-test was given to students at the end of the meeting to assess their learning outcomes. Table 5 displays the mean, standard deviation, and variance of the data before and after the test for each class after the data was tabulated. N-Gain data on student learning outcomes revealed that students' final knowledge was treated, with the experimental class group experiencing a percentage increase in learning outcomes of 85.45% in the high category and the control class group experiencing a percentage increase of 74.36% in the high category. They were in the same category. Thus, students in the experimental class saw greater learning outcomes than students in the control class.

Discussion

Two classes, namely the experimental and the control classes, were used in this research. In the experimental class, the researchers used augmented reality-based learning media as a teaching tool. The researchers gave students worksheets to complete during the learning session, and after that, students had conversations with their group members. The researchers supervised, guided, and assisted students during discussions. Apart from that, students had to be able to complete the subjects they had studied and propose solutions to the problems given at the final stage. In the control group, PowerPoint presentations and traditional models were used for teaching. The learning objectives presented in PowerPoint slides were explained to students by the teacher during introductory activities. After explaining the lesson content, the instructor provided the class the opportunity to ask questions about unclear things. The lesson ended with a closing exercise in which the instructor summarized the material that had been covered and asked the class to take notes in their notebooks. After treatment for both classes, the researchers gave a post-test, or final exam, which consisted of 20 multiple-choice questions, the same number as the initial test. The average learning outcome score for the experimental class was 89.00, while the control class was 79.80 based on post-test data. The percentage increase in experimental class learning outcomes was 85.45%, while the percentage increase in control class learning outcomes was based on N-gain results of 74.36%. The increase in student learning outcomes taught using augmented reality-based learning media was greater than the increase in student learning outcomes taught using conventional models, as shown by the results of N-gain's calculations.

This is possible because students were more enthusiastic about learning and more involved in using augmented reality-based learning resources, thus having an impact on improving student learning outcomes. This aligns with the view of Sadirman (in Syam et al., 2021), who states that motivation for learning activities can be seen as a general driving force for students, inspiring learning activities, ensuring their continuity, and providing direction so that they achieve their goals. Learning outcomes will be ideal if there are the right incentives. This new educational tool for students is augmented reality learning. It combines virtual objects into realistic three-dimensional settings and displays them in real time, giving the impression that the visuals are alive and right in front of us. This educational resource used five Photoshop-created bookmarks and six AR Toolkit applications, each of which has unique animations. In the process of using media, students explored the spatial structures contained in the markers through augmented reality-based learning media. In addition, augmented reality-based learning media can also train students' imagination and creativity. This can be seen during the learning process through the use of augmented reality-based learning media. Students can understand a spatial concept and interpret it or describe the spatial structure without listening to the teacher's further explanation. Therefore, augmented reality-based learning media can help students imagine objects or spatial structures.

Furthermore, a software library called AR Toolkit is used to create augmented reality (Andriyadi in Ardhianto et al., 2012). The use of this media has succeeded in improving lower and upper-level cognitive functions. This means that students with different levels of intelligence can understand the content of this augmented reality-based learning tool. The claim that “only by using augmented

reality media can one understand the concept of particle dynamics at a high level of intelligence" was rejected by students in a survey who believed this. Based on this knowledge, students can accept the use of augmented reality media.

The results of this research corroborate the results of research by Rusnandi et al. (2015) that the development of AR media is very appropriate to the needs of elementary school children who need help with visualization and concepts to become more realistic. The research conducted by Pambudi et al. (2018) also supported the conclusion that the average learning outcomes in the experimental class using this augmented reality-based Android media were better than the average learning outcomes in control classes that used conventional learning media.

This is reinforced by the research findings of Larasati & Widyasari (2021), which showed that students' mathematical understanding abilities increase when they are faced with augmented reality learning material. The media help teaching to be more interesting and interactive (Nugraha et al., 2021) and impactful in elementary school, especially in mathematics teaching (Ermawati et al., 2022).

The self-developed AR media has been proven suitable for elementary-level teaching. It is supported by Widayanti & Nuraini (2020) that the practicality should be addressed to lead a successful AR media. It increases mathematics learning outcomes and motivation and decreases students' mathematics anxiety (Hidayat & Asmalah 2020). The specific material will be adequately effective because it not only addresses the students' learning needs in mathematics (Nasrulloh et al., 2022) but also attracts students' interest in studying mathematics subjects (Putra & Sofiana, 2022).

The results of this research support previous research with several differences, such as the focus on material and forms of media that are developed more personally for learning. This research contributes to providing a deeper understanding of the forms of learning using AR in various grade levels. Future research should investigate different variables and a broader and deeper scope, such as their influence on critical thinking abilities and mathematical literacy, or use testing at a higher cognitive level (such as reasoning and critical thinking).

CONCLUSION

The use of augmented reality in research could increase the conceptual knowledge of fifth-grade elementary school students. This is reinforced by the demonstration of students' ability to understand mathematics when exposed to augmented reality learning materials. Based on research that has been done, students understood using augmented reality learning materials more than conventional learning materials, with the results seen increasing. Augmented reality-based learning media based on the understanding of mathematical concepts of fifth-grade students of the Elementary State of 064005 Medan obtained a very good assessment with a percentage of 80.88%. These results indicate that students' responses to augmented reality-based learning media in understanding mathematical concepts in flat-sided geometry material were in a good category. In other words, the use of media is practical and scientifically effective. The implication is that teachers can put more emphasis on the use of advanced technological media in understanding concepts and other mathematical skills

REFERENCES

Alan, U. F., & Afriansyah, E. A. (2017). Kemampuan pemahaman matematis siswa melalui model pembelajaran Auditory Intellectualy Repetition dan problem based learning. *Jurnal Pendidikan Matematika, 11*(1), 67–78.

Apriliyana, D. A., Masfu'ah, S., & Riswari, L. A. (2023). Analisis pemahaman konsep matematika siswa kelas V pada materi bangun ruang. *JIIP–Jurnal Ilmiah Ilmu Pendidikan, 6*(6), 4166–4173.

Ardhianto, E., Hadikurniawati, W., & Winarno, E. (2012). Augmented reality objek 3 dimensi dengan Perangkat Artoolkit dan Blender. *Jurnal Teknologi Informasi DINAMIK, 17*(2), 107–117.

Atmajaya, D. (2017). Implementasi augmented reality untuk pembelajaran interaktif. *ILKOM: Jurnal Ilmiah, 9*(2), 227–232.

Ermawati, D., & Amalia, N. (2023). The effect of Mat Joyo application on students' understanding of mathematical concepts fifth grade elementary school. *JPSD: Jurnal Pendidikan Sekolah Dasar, 9*(1), 12–22.

Ermawati, D., Riswari, A. L., & Wijayanti, E. (2022). Pendampingan pembuatan aplikasi Mat Joyo (Mathematics Joyful Education) bagi guru SDN 1 Gemiring Kidul. *Jurnal SOLMA, 11*(3), 510–514.

Ermawati, D., & Zuliana, E. (2020). Implementation of open-ended problems on mathematical problem solving skill of elementary school students. *JPSD: Jurnal Pendidikan Sekolah Dasar*, *6*(2), 145–157.

Fatimatuzzahro, F., Masyhud, M. S., & Alfarisi, R. (2021). Pengembangan media pembelajaran komik Matematika Asik (MASIK) berbasis augmented pada materi volume bangun ruang. *Jurnal Ilmu Pendidikan Sekolah Dasar, 8*(1),7–29.

Febriyandani, R., & Kowiyah, K. (2021). Pengembangan media komik dalam pembelajaran matematika materi pecahan kelas IV sekolah dasar. *Jurnal Pedagogi Dan Pembelajaran*, *4*(2), 323–330.

Hidayat, A., & Asmalah, L. (2020). Augmented reality pada smartphone untuk meningkatkan motivasi belajar dan mengurangi kecemasan matematika. *Emasains: Jurnal Edukasi Matematika dan Sains, 9*(2), 187–195.

Khoirina, H. P., Nengsih, M. R., & Riswari, L. A. (2023). Analisis penalaran matematis matematika siswa kelas IV SD di Desa Gondangmanis. *Cartsesioe: Jurnal Pendidikan Matematka, 6*(1), 47–54.

Kholidah, I. R., & Sujadi, A. (2018). Analisis pemahaman konsep matematika siswa kelas V dalam menyelesaikan soal di SD Negeri Gunturan Pandak Bantul tahun ajaran 2016/2017. *Trihayu: Jurnal Pendidikan Ke-SD-an, 4*(3), 428–431.

Larasati, N. I., & Widyasari, N. (2021). Penerapan media pembelajaran berbasis Augmented Reality terhadap peningkatan pemahaman matematis siswa ditinjau dari gaya belajar. *FIBONACCI: Jurnal Pendidikan Matematika dan Matematika, 7*(1), 45–50.

Mulyati, S. & Evendi, H. (2020). Pembelajaran matematika melalui media game Quizizz untuk meningkatkan hasil belajar matematika SMP. *GAUSS: Jurnal Pendidikan Matematika, 3*(1), 64–73.

Mustaqim, I., & Kurniawan, N. (2017). Pengembangan media pembelajaran berbasis Augmented Reality. *Jurnal Edukasi Elektro, 1*(1), 36–48.

Nasrulloh, I., Ridwan, T., & Hidayat, S. (2022). Efektivitas media pembelajaran augmented reality dalam blended learning. *Syntax Literate: Jurnal Ilmiah Indonesia, 7*(1), 1814–1832.

Nugraha, A. C., Bachmid, K. H. Rahmawati, K., Putri, N., Hasanah, A. R. N., & Rahmat, F. A. (2021). Rancang bangun media pembelajaran berbasis Augmented Reality untuk pembelajaran tematik kelas 5 sekolah dasar. *Jurnal Edukasi Elektro, 5*(2), 138–147.

Pambudi, K. H. B., & Buchori, A., & Aini, A. N. (2018). Pengembangan media pembelajaran berbasis Android menggunakan Augmented Reality pada materi bangun ruang sisi datar. *Jurnal Pendidikan Matematika dan Sains, 6*(1), 61–69.

Putra, P., & Sofiana, S. (2022). Implementasi aplikasi augmented reality pembelajaran matematika 3D Geometric Shapes berbasis Android. *OKTAL: Jurnal Ilmu Komputer dan Science*, *1*(8), 1246–1253.

Radiusman, R. (2020). Studi literasi: Pemahaman konsep anak pada pembelajaran matematika. *FIBONACCI: Jurnal Pendidikan Matematika dan Matematika*, *6*(1), 1– 8.

Rusnandi, E., Sujadi, H., & Fauzyah, E. F. N. (2015). Implementasi Augmented Reality (AR) pada pengembangan media pembelajaran pemodelan bangun ruang 3D untuk siswa sekolah dasar. *Infotech Journal*, 1(2), 24–31.

Setyaningrum, S., Ermawati, D., & Riswari, L. A. (2023). Analisis kesulitan belajar dalam memahami konsep pecahan pada siswa kelas V SD Negeri Sidomulyo. *Jurnal Ilmiah Pendidikan Dasar*, *8*(1), 2548–6950.

Syam, A., Ismail, W., & Ali, A. (2021). Pengaruh pengggunaan media pembelajaran Augmented Reality dan media Power Point terhadap motivasi belajar peserta didik. *Jurnal Binomial*, *4*(2), 95–108.

Wahid, A. (2018). Pentingnya media pembelajaran dalam meningkatkan prestasi belajar. *Istiqra*, *5*(2), 1–11.

Wangge, M. (2020). Implementasi media pembelajaran berbasis ICT dalam proses pembelajaran matematika di sekolah menengah. *Fraktal: Jurnal Matematika dan Pendidikan Matematika*, *1*(1), 31–38.

Widayanti, R., & Nuraini, K. D. (2020). Penerapan model pembelajaran problem based learning untuk meningkatkan prestasi belajar matematika dan aktivitas siswa. *Mathema: Jurnal Pendidikan Matematika*, *2*(1), 12–23.

Widyasari, N., & Soptianingrum, M. (2019). Enhancing students' mathematical understanding of three dimension through PABARU tools aid. *Educational Initiatives Research Colloquium 2019*, 82–83.