EduLine: Journal of Education and Learning Innovation *ISSN: 2775-6173 (online)*
Vol. 3 No. 3 (2023)
https://doi.org/10.35877/454RI.eduline2004

Development of Augmented Reality-Based Mobile App Learning Media for Computer Network Hardware Material

Ashabul Taufik[a,*], Nur Alamsyah[a], & Andika Saputra[b]

[a]*Universitas Islam Makassar, Jl. Perintis Kemerdekaan No.29, Makassar and 9024, Indonesia*
[b]*STKIP YPUP Makassar, Jl. Andi Tonro No.17, Makassar and 20223, Indonesia*

Abstract

The objective of this research is to create a mobile app-based augmented reality learning media for computer network hardware. The specific aims are to describe the application model design, application functionality, feasibility, and effectiveness of using augmented reality-based mobile app learning media on computer network hardware. The research methodology employed in this study is Research and Development (R&D). The development stages include research, data collection, planning, draft product development, product validation, revision based on product validation results, field testing, revision based on field testing results, final product refinement, and dissemination. Furthermore, to assess the improvement in learning outcomes, the Independent Sample T Test statistical method is used. The results obtained in this research show a significant difference in the experimental class compared to the control class, where the average score in the experimental class is higher. Therefore, it can be concluded that learning computer network hardware material using augmented reality has successfully improved student learning outcomes.

Keywords: Learning media, augmented reality, mobile apps, computer network hardware.

1. Introduction

Basic computer and network are lessons on computer hardware and software, starting from assembling, installing the operating system, BIOS, peripheral drivers, LAN, WAN, and MAN networks, to IP addresses. One of the fundamental and important subjects in this learning process is hardware. The application and utilization of technology in the learning process are considered ideal for accommodating students' activities in understanding abstract concepts and for increasing interest, motivation, and learning enthusiasm (Alamsyah et al., 2019). Based on a case study, monotonous learning causes many students to have difficulty understanding computer network hardware material. This is because there is still a lack of computer network materials and equipment, making it difficult for students to imagine the actual forms. As a result, students do not fully grasp the material, and their ability to think abstractly is not well honed. To address this issue, an augmented reality-based mobile app learning media for computer network hardware material has been developed.

According to (Fajriansyah & Widodo, 2022), Augmented Reality, commonly abbreviated as AR, is a technology that combines virtual objects with real-world objects. AR can generate visual representations of virtual objects, such as 3D objects or animals, making them appear real. AR can be used as an enjoyable learning medium because it connects, informs, and delivers information, thereby creating a more effective and efficient learning process.

Learning with mobile apps for computer network hardware material has been widely conducted, but it has not been developed using augmented reality technology. By utilizing this technology, the visualization of three-dimensional shapes appears more realistic. Additionally, according to (Taufik & Saputra, 2023), it is stated that smartphone users in Indonesia are inversely proportional to the optimal utilization of smartphones, especially in the field of education. Among students themselves, smartphones are primarily used for accessing social networks such as Facebook,

* Corresponding author.
E-mail address: xxxx@xxxxxx.edu (Fullname of corresponding author)

Instagram, and Twitter, thus playing a less significant role in education. Therefore, the researchers aim to develop augmented reality-based mobile app learning media for computer network hardware material. This media is based on Android smartphones, which almost everyone possesses and most people prefer opening their smartphones over reading books. Furthermore, to enhance literacy skills and in line with the fourth industrial revolution, augmented reality-based learning media for Android smartphones has been designed.

The advantages of using this media are that the learning material can be updated, it is cost-effective and time-saving, can be used by anyone in need, and most importantly, it can reach all areas anywhere and anytime, as well as being easy to use and practical. Therefore, this research is crucial in order to enhance the abilities and skills of students in the era of the digital-centric fourth industrial revolution.

The purpose of this research and development is to create an augmented reality-based mobile app learning media for computer network hardware material. Specifically, the aims are to describe the design results of the application model, the functionality of the application, its feasibility, and the effectiveness of the developed learning media in improving the learning interest and outcomes of vocational high school students. The problem statement is how the development of augmented reality-based mobile app learning media for computer network hardware material impacts the learning outcomes.

The urgency of the proposed research lies in the need for instructional materials in the learning process. Mobile learning offers a solution for accessing content anytime and anywhere. Augmented reality learning media has not yet been developed for computer network hardware material. Therefore, research and development are necessary for creating learning media for this material in the basic computer and network lessons of the Computer Engineering and Networking Department in vocational high schools.

2. Literature Review

2.1. Learning Media

Learning media generally refers to tools and materials used in teaching and learning by educators and learners. According to (Daniyati et al., 2023), learning media are any means that convey information to learners through various channels, such as visual, auditory, and kinesthetic, in order to facilitate the creation of an effective learning process that enables learners to absorb information and achieve the learning objectives. The benefits of media in learning are: (1) Uniform delivery of subject matter. (2) The learning process becomes clearer and more engaging. (3) The learning process becomes more interactive. (4) Efficiency in time and energy. (5) Improves the quality of student learning outcomes. (6) Allows learning to take place anywhere and anytime. (7) Fosters a positive attitude in students towards the subject matter and the learning process. (8) Shifts the role of the teacher towards a more positive and productive direction (Karo-Karo S & Rohani, 2018). Appropriate learning media greatly assist students in the teaching and learning process. With the presence of learning media, it helps teachers in providing explanations of the learning material. Additionally, learning media also serves to facilitate communication for both the communicator and the recipient (Wulandari et al., 2023).

2.2. Augmented Reality

One of the current renewable technologies that is interesting to develop in media is augmented reality, which can be run on mobile devices. Mobile augmented reality is mobile-based technology that operates on Android smartphones and can effectively visualize three-dimensional shapes, providing flexibility to view three-dimensional shapes from all angles (A. Saputra & Imamn Nurul, 2020). According to (A. M. Saputra et al., 2023), Augmented Reality is a technology that combines the real world with the virtual world. In other words, Augmented Reality (AR) brings objects, such as videos or photos/images, into the real world in the form of three-dimensional models. This type of augmented reality can help in visualizing abstract conceptual ideas to enhance understanding of the structural characteristics of an object. In line with this, (Kautsar & Fauzan, 2023) explain that AR is a technology that merges real-world objects with virtual or digital objects in a real-world setting. Real and virtual objects are combined using suitable technology, and interaction occurs using specific tools and devices. Therefore, mobile augmented reality technology is highly suitable for use in learning media, especially for computer network hardware material.

2.3. Mobile Apps

The term 'application' originates from the word 'application,' which means implementation, submission, or usage. In technical terms, an application is a ready-to-use program created to perform a function for the user or another application and can be used by the intended target (Jainuri et al., 2021). Furthermore, according to (Agusti Elmo, 2022), a mobile application is a web-based resource application that provides access to various relevant information. This application can also be accessed through mobile phones, smartphones, wireless, and other devices. Meanwhile, according to (Rizan & Hamida, 2016), a mobile application is an application that can be used even when users easily move from one place to another without experiencing any interruption or disconnection in communication. Therefore, it can be interpreted that a mobile application or mobile app is an application that can be run on accessible devices anywhere, operated on a smartphone or mobile phone, making it easier for users to obtain relevant and effective information.

2.4. Computer Network Hardware

Network devices are one of the subjects in the computer engineering and networking department. Ramadhan & Ladjamuddin (2022) explain that computer networks are the fundamental medium for conducting activities and productivity utilizing information technology. A computer network is the "interconnection" of two or more autonomous computers, connected through either wired or wireless transmission media (Wongkar et al., 2015). Meanwhile, computer network hardware refers to the devices used in building a computer network. The simplest computer network consists of two computers connected through a cable (Rindri, 2022). Therefore, interconnected hardware devices in an autonomous network include routers, switches, access points, servers, modems, cables, and other supporting network devices.

3. Research Method and Materials

3.1. Method

The method employed in this research is the Research and Development (R&D) method, following the Borg and Gall development model (1983). This method is utilized to generate a prototype product in the form of an Android-based application implemented in augmented reality (AR) mobile learning media for computer network hardware material.

The population of this research comprises all 10th-grade students at SMK Negeri 3 Makassar. The sample for this study consists of 10th-grade students majoring in Computer Engineering and Networking (TKJ) at SMK Negeri 3 Makassar. In developing mobile app-based learning media, the steps adapted from Borg and Gall in Sukmadinata (2006: 169-170) are utilized, which include (1) Research and data collection, (2) Planning, (3) Developing a preliminary form of the product, (4) Preliminary field testing, (5) Main product revision, (6) Main field testing, (7) Operational product revision, (8) Operational field testing, (9) Final product revision, (10) Dissemination and implementation.

3.2. Materials

The techniques used to collect data in this research are interviews, observations, ISO 25010 testing, questionnaires, and learning outcome tests. Interviews and observations are employed in the data collection phase to identify shortcomings that require solutions and to gain an understanding of what the future product should look like. ISO/IEC 25010 is one of the quality models used as a standard for assessing software quality. ISO/IEC 25010 consists of a software product quality model and a quality in use model (Mulyawan et al., 2021). ISO 25010 testing in this study is focused on usability and functional suitability. ISO/IEC 25010 is used to assess the performance of the application. Questionnaires consist of questions used for validation sheets and to measure students' satisfaction levels in using the learning media. Learning outcome tests are used to measure whether there is a change and improvement in students' learning outcomes after using the Android-based application.

The data analysis utilized includes descriptive statistical analysis and inferential statistical analysis. Descriptive statistical analysis is employed to depict quantitative data, which involves assessing the suitability of using the Android application with a Likert scale. The results from the questionnaire are then categorized into several categories, based on Widoyoko's classification (2014:238):

- Very Feasible = MI + (1,8 x STDEV Ideal) up to The Maximum score
- Feasible = MI + (0,6 x STDEV Ideal) to MI + (1,8 x STDEV Ideal)
- Fairly Feasible = MI – (0,6 x STDEV Ideal) to MI + (0,6 x STDEV Ideal)
- Not Feasible = MI – (1,8 x STDEV Ideal) to MI – (0,6 x STDEV Ideal)
- Very Not Feasible = Minimum score to MI – (1,8 x STDEV Ideal)

The assessment scores for the level of suitability will serve as a reference for the testing results by media experts, subject matter experts, teachers, and students. The scores obtained from the questionnaire will indicate the suitability of the Android application as a learning medium. So, if the average scores from the subject matter experts, media experts, teachers, and student responses fall within the "Suitable" category, then this augmented reality (AR)-based mobile app learning media is considered suitable.

Inferential statistical analysis is used to determine the effectiveness of using augmented reality (AR) application between students taught with and without AR application. The activities in data analysis involve grouping data based on variables from all respondents, presenting data for each researched variable, performing calculations to address the research questions, and conducting calculations to test the proposed hypotheses. Hypothesis testing is carried out to determine whether the hypotheses presented in this research are accepted or rejected. Before testing the research hypotheses, the data is first checked for normality using the Kolmogorov-Smirnov Test. Hypothesis testing is conducted with the analysis of a single independent variable known as the t-test. The purpose of the t-test is to determine the difference in the hypothesized variable (Riduwan & Sunarto, 2012). Learning outcome improvement is analyzed using normalized gain scores. The sample can be considered to have experienced a significant improvement if the obtained n-Gain reaches at least the moderate category, which is greater than 0.3. Meanwhile, the application can be considered effective if the average n-Gain result exceeds 76 in the effective category according to Hake, R.R (1999).

4. Results and Discussion

4.1. Result

The augmented reality-based mobile app learning media for computer network hardware material has been successfully developed and implemented. Below are some documentation examples of the developed learning media, which were then run on Android smartphones.

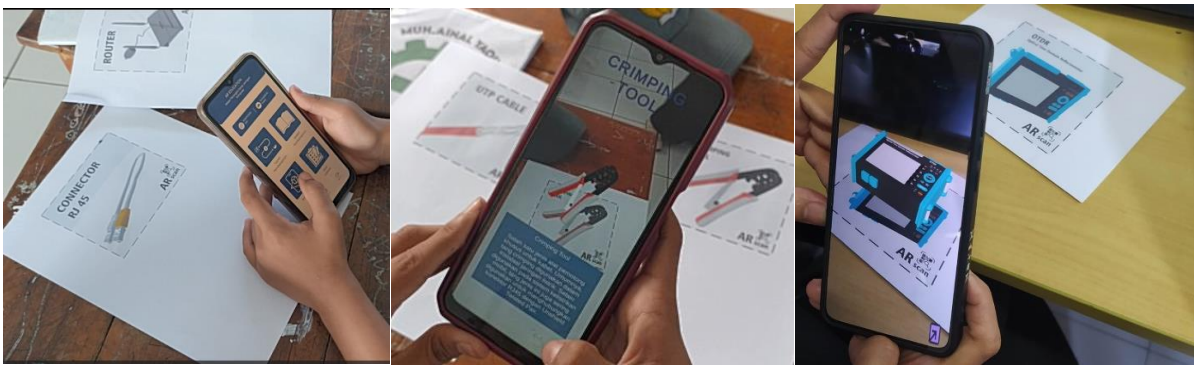

Figure 1. Documentation of the Design and Augmented Reality Display for Computer Network Hardware.

The augmented reality application is packaged within a learning media that features menus and educational content. To activate augmented reality, users select the augmented reality menu from the main menu of the learning media. Once the camera is active, the smartphone is directed towards the printed marker image on paper, causing the 3D image to appear on the smartphone screen, as seen realistically in Figure 1. Figure 2 show some examples of the marker images used.

After the augmented reality learning media has been successfully developed, the next step is to conduct a feasibility test, which is carried out by media experts, subject matter experts, as well as user responses from teachers and students. Below are the descriptive results of the feasibility test of the augmented reality media for users.

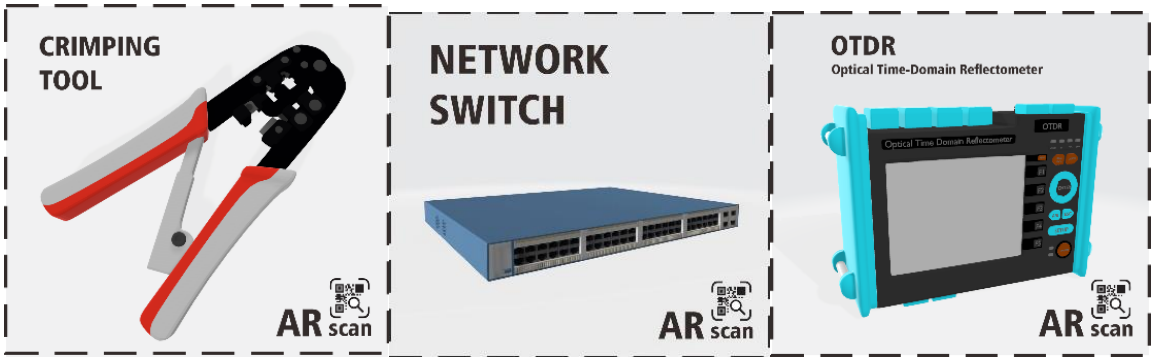

Figure 2. Augmented Reality Marker Media

Table 1. Descriptive Category of Media Expert Feasibility

No.	Score Range	Category
1	$\bar{X} > 105$	Very Feasible (SL)
2	$85 < \bar{X} \leq 105$	Feasible (L)
3	$65 < \bar{X} \leq 85$	Fairly Feasible (CL)
4	$45 < \bar{X} \leq 65$	Not Feasible (TL)
5	$\bar{X} \leq 45$	Very Not Feasible (STL)

Table 2. Descriptive Category of Subject Matter Expert Feasibility

No.	Score Range	Category
1	$\bar{X} > 67{,}2$	Very Feasible (SL)
2	$54{,}4 < \bar{X} \leq 67{,}2$	Feasible (L)
3	$41{,}6 < \bar{X} \leq 54{,}4$	Fairly Feasible (CL)
4	$28{,}8 < \bar{X} \leq 41{,}6$	Not Feasible (TL)
5	$\bar{X} \leq 28{,}8$	Very Not Feasible (STL)

Table 3. Descriptive Category of Teacher and Student Feasibility

No.	Score Range	Category
1	$\bar{X} > 109{,}2$	Very Feasible (SL)
2	$88{,}4 < \bar{X} \leq 109{,}2$	Feasible (L)
3	$67{,}6 < \bar{X} \leq 88{,}4$	Fairly Feasible (CL)
4	$46{,}8 < \bar{X} \leq 67{,}6$	Not Feasible (TL)
5	$\bar{X} \leq 46{,}8$	Very Not Feasible (STL)

The next step after the feasibility test is to collect data to determine the impact of augmented reality learning media on improving students' learning achievement. Student learning achievement data is obtained by administering an essay-type learning outcome test consisting of 10 questions on computer network hardware material. The test includes a Pretest to assess students' initial abilities, and a Post-test to evaluate students' abilities after the treatment. Table 4 show the descriptive analysis results of the post-test data obtained from the research.

As for the results of the inferential analysis using the paired sample t-test, they are presented in the Table 5 (the analysis was conducted using SPSS Ver. 21).

Table 4. Descriptive Data of Post-Test

Description	Computer Network Hardware Learning Achievement	
	Control	Experiment
Number of Respondents	36	36
Mean	80.69	88.44
Standard Deviation	4.187	3.676
Mode	80	91
Maximum score	70	81
Minimum score	88	96

Tabel 5. The Results of Independent Sample t-test Analysis

Independent Samples Test

	Independent Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Control	80.69	4.187	0.698	-9.602	-5.898	-8.346	70	0.000
Experiment	88.44	3.676	0.613					

Table 6. N-Gain Test Results

	Group	N	Mean	Std. Deviation	Std. Error Mean
percentage of gain	Control	36	62.3167	9.49355	1.58226
	Experiment	36	77.1078	7.27913	1.21319

4.2. Discussion

The descriptive results from media experts yielded an average final score ($\bar{X}$) of 103. Therefore, when placed in the table of ideal category criteria (Table 1), the augmented reality learning media application falls into the 'Feasible' (L) category with a percentage of 82.4% compared to the ideal highest score. Furthermore, from the descriptive results of subject matter experts, an average final score ($\bar{X}$) of 67 was obtained. When placed in the table of ideal category criteria (Table 2), it also falls into the 'Feasible' (L) category with a percentage of 83.75% against the ideal highest score. After the assessment by experts, the descriptive results from teacher respondents yielded an average final score ($\bar{X}$) of 109. When placed in the table of ideal category criteria (Table 3), it falls into the 'Feasible' (L) category with a percentage of 83.85% against the ideal highest score. Moving on, from the descriptive results of the respondents, an average final score ($\bar{X}$) of 108,97 was obtained. When placed in the table of ideal category criteria (Table 4), the augmented reality learning media application is categorized as ' Feasible' (L) with a percentage of 83.82% against the ideal highest score.

Furthermore, from Table 4, it is known that there are a total of 36 respondents in the control group and 36 individuals in the experimental group who took the post-test. In the control group, the average score obtained is 80.69 with a standard deviation of 4.187. The mode or the most frequently occurring value in the control group is 80, with a maximum score of 88 and a minimum score of 70. Meanwhile, in the experimental group, the average score obtained is 88.44, with a standard deviation of 3.676. The mode is 91, with a maximum score of 96 and a minimum score of 81.

From the calculation results and the SPSS output in Table 5, it can be observed that the comparison between the scores of the control group and the experimental group yields a significance value (2-tailed) of 0.000, which is less than 0.05 or (0.000 < 0.05). Therefore, it can be concluded that the scores of the control and experimental groups

differ significantly. Since the results of the experimental group show a significant statistical difference where the mean of the experimental group is greater than that of the control group, it can be concluded that learning computer network hardware material using augmented reality successfully improved students' learning achievement, especially in computer network hardware material.

Next, the results of the N-Gain test in Table 6 show an average value for the experimental group of 77.1078. Based on the categorization and interpretation of effectiveness, a N-Gain value of 77.1078 > 76 falls into the 'Effective' category. Therefore, the augmented reality-based mobile app learning media proves to be effective when used in the school where this research was conducted. From the above analysis, it can be concluded that Augmented Reality-based Mobile App Learning Media is feasible and successful in improving student learning achievement in computer network hardware material. This is evident from the average score of the control group, which was 80.69 and increased to 88.44 in the experimental group.

5. Conclusion

Based on the results and discussion of the research, it can be concluded that this study has been successfully conducted and has produced a mobile app product in the form of an augmented reality learning media. This product is considered suitable and has been proven to significantly enhance students' learning achievement in computer network hardware material. As a suggestion for further research, mobile augmented reality learning media can still be developed for other learning materials, and the application can be extended into Virtual Reality.

Acknowledgements

We would like to express our gratitude and appreciation to the Information Technology Education Program, Faculty of Education and Teaching, as well as the LP2M (Institute for Research and Community Service) of the Islamic University of Makassar. Especially to the team of researchers and application developers who have collaborated and remained committed until this research was completed. We also extend our thanks to the School Principal, Department Head, and Computer and Network Engineering Teachers at SMKN 3 Makassar for their support and motivation in completing this research, enabling it to be finished on time.

References

Agusti Elmo. (2022). Perancangan Aplikasi Invoice Berbasis Mobile Studi Kasus UMKM. *Jurnal Ilmia Teknik*, 1(1), 19-33. https://doi.org/10.55904/hexatech.v1i01.56

Alamsyah, N., Rosmiati, & Sukirman. (2019). Pengembangan Media Pembelajaran Mikroprosesor Berbasis Robot Terbang Teknik Informatika Universitas islam Makassar. *ILTEK (Jurnal Teknologi)*, 14(1), 2011-2015. https://doi.org/10.47398/iltek.v14i01.359

Daniyati, A., Bulqis Saputri, I., Aqila Septiyani, S., & Setiawan, U. (2023). Konsep Dasar Media Pembelajaran. In Journal of Student Research (JSR) (Vol. 1, Issue 1). https://doi.org/10.55606/jsr.v1i1.993

Fajriansyah, M. A., & Widodo, S. (2022). Augmented Reality Sebagai Media Pembelajaran di Rumah yang Efektif tetapi Menarik. *JUTIS (Jurnal Teknik Informatika Unis)*, 10(3), 173-180.

Hake, R. R.(1999). Analyzing change/gain scores. AREA-D American education research association's devision. D. *Measurement and Reasearch Methodology*. https://web.physics.indiana.edu/sdi/AnalyzingChange-Gain.pdf

Jainuri, Nurasiah, & Hermilasari, Y. (2021). Perancangan Dan Pembuatan Aplikasi Mobile Point Of Sale Pada Outlet Makaroni Judes Berbasis Android. *Jurnal IPSIKOM*, *9*(2), 44–52. https://doi.org/10.58217/ipsikom.v9i2.201

Ramadhan, R. I., & Ladjamuddin, M. (2022). Perancangan Sistem Web Filtering Dengan Metode DNS Fordwarding Pada Jaringan Komputer Berbasis Mikrotik RouterOS. *Jurnal Informatika Dan Teknologi Komputer*, 2(2), 146-157. https://doi.org/10.55606/jitek.v2i2.231

Karo-Karo S, I. R., & Rohani. (2018). Manfaat Media Pembelajaran. Axiom, 7(1), 91-96. https://doi.org/10.30821/axiom.v7i1.1778

Kautsar, M., & Fauzan, M. N. (2023). Literatur Review Augmented Reality Sebagai Media Promosi Dengan Metode Marker Based Tracking. *Nuansa Informatka*, 17(12), 83-93. https://doi.org/10.25134/ilkom.v17i2.16

Mulyawan, M. D., Kumara, I. N. S., Swamardika, I. B. A., & Saputra, K. O. (2021). Kualitas Sistem Informasi Berdasarkan ISO/IEC 25010: Literature Review. *Majalah Ilmiah Teknologi Elektro*, 20(1), 15. https://doi.org/10.24843/mite.2021.v20i01.p02

Riduwan, & Sunarto. (2012). Pengantar Ilmu Statistika untuk Penelitian: Pendidikan Sosial, Komunikasi, Ekonomi dan Bisnis. Alfabeta.

Rindri, Y. A. (2022). Buku Praktis Teknik Jaringan Komputer. Politeknik Manufaktur Negeri Bangka Belitun.

Rizan, O., & Hamida. (2016). Rancangan Aplikasi Monitoring Kamera CCTV Untuk Perangkat Mobile Berbasis Android. *TI Atma Luhur: Jurnal Teknologi Informatika Dan Komputer*, 3(1), 45-51. http://jurnal.atmaluhur.ac.id/index.php/TI_atma_luhur/article/view/220

Saputra, A., & Imamn Nurul. (2020). Mobile Augmented Reality (AR) Learning Media on Distance Material in Three Dimensions. *Daya Matematis: Jurnal Inovasi Pendidikan Matematika*, 8(3), 245-250. https://doi.org/10.26858/jdm.v8i3.16490

Saputra, A. M., Ramadhani, K., & Ramadhani, S. (2023). Penggunaan Media Augmented Reality Pada Pembelajaranpengantar Teknologi Informasi Di Universitas Islam Makassar. *TEKNOS (Pendidikan Dan Teknologi)*, 1(1), 40-52. https://doi.org/10.59638/teknos.v1i1.45

Sukmadinata, N. S. (2006). Metode Penelitian Pendidikan. Remaja Rosda Karya.

Taufik, A., & Saputra, A. M. A. (2023). Media Pembelajaran Berbasis Smartphone Android Mengguanakn Adobe cs 6 Pada Mata Pelajaran Sistem Operasi Komputer SMK Gunung Sari 1 Makassar. *Jurnal Publikasi Teknik Informatika*, 2(1), 68-77. https://doi.org/10.55606/jupti.v1i1.1195

Widoyoko, E. P. (2014). Evaluasi Program Pembelajaran (V). Pustaka Pelajar.

Wongkar, S., Sinsuw, A., & Najoan, X. (2015). Analisa Implementasi Jaringan Internet Dengan Menggabungkan Jaringan LAN Dan WLAN Di Desa Kawangkoan Bawah Wilayah Amurang II . *E-Journal Teknik Elektro Dan Komputer*, 4(6), 62-68. https://doi.org/10.35793/jtek.v4i6.10400

Wulandari, A. P., Salsabila, A. A., Cahyani, K., Nurazizah, T. S., & Ulfiah, Z. (2023). Pentingnya Media Pembelajaran dalam Proses Belajar Mengajar. *Journal on Education*, 05(02), 3928-3936. https://doi.org/10.31004/joe.v5i2.1074