

Augmented Reality Learning Media Application In Computer Networking Courses

Novi Hendri Adi^{1)*}, Arina Luthfini Lubis²⁾, Ali Basriadi³⁾, Ika Parma Dewi⁴⁾, Yera Wahda Wahdi⁵⁾

^{1,3,5)}Teknik Informatika, Universitas Ibnu Sina, ²⁾Manajemen Divisi Kamar, Politeknik Pariwisata Batam,

⁴⁾ Prodi Pendidikan Teknik Informatika, Universitas Negeri Padang

¹⁾novi.hendriadi@gmail.com*, ²⁾a.luthfinilubis@gmail.com, ³⁾ali.basriadi@uis.ac.id, ⁴⁾ika_parma@ft.unp.ac.id,

⁵⁾wahdawahdiyera@gmail.com

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Abstract: In computer network learning, there is still little use of media which has an impact on students' understanding of device material and computer network topology. Augmented Reality (AR) based learning media can answer these problems by providing dynamic visualization and interactive simulations. The research objective is that AR applications can be used to help visualize abstract concepts for understanding and structure of an object model. The development method used is MDLC (Multimedia Development Life Cycle) which consists of six stages, namely concept, design, material collecting, assembly, testing, and distribution. The results of the AR application research show that the value of the learning media application in terms of material is declared valid at 0.85 and in terms of design it is declared valid at 0.86. The AR application was also stated to be very practical, this can be seen from the responses of lecturers and students with the practicality of the learning media application being 87% as seen from ease, motivation, attractiveness, and usefulness. From the results of this research, the AR learning media application is very practical to apply to students, especially in computer networking courses

Keywords: *Augmented Reality, Learning Media Application, MDLC, Computer Network*

INTRODUCTION

Technological developments have had a broad and deep impact on various aspects of daily life, from communication, education, and health, to industry and entertainment. This change is driven by ongoing innovations in fields such as computing, telecommunications, artificial intelligence, and biotechnology. Each of these advances brings new challenges and opportunities, affecting nearly all aspects of human life and preparing society for a rapidly changing future. The Industrial Revolution 4.0 in almost all fields has seen a gradual shift to computer digitalization and automation. These changes require readiness to face the future (Adi et al., 2023). The challenges and opportunities of the Industrial Revolution 4.0 also have an impact on aspects of education, including vocational education, which is required to be more innovative and balanced with four 21st-century skills, namely creativity, critical thinking, communication, and collaboration. In the 21st century, digital transformation has changed the way businesses operate. The development of the internet, big data, and cloud computing has enabled Companies to optimize their operations, increase efficiency, and expand their market reach globally. Educational technology (EdTech) has revolutionized the way people learn. E-learning platforms, educational apps, and AR/VR-based learning tools have made education more accessible and interactive (Sudira, 2017). In the 21st century, lifelong learning is key, with technology supporting people to continue developing their skills throughout life (Daryanto & Karim, 2017).

The closest technology now is smartphone device technology. In learning activities, lecturers should be able to pay attention to the use of media, therefore the use of media in conveying material must also be more creative and innovative, as well as making learning activities more enjoyable so that students are motivated (Adi, Wahdi, et al., 2022). Learning media are physical means, communication is used for learning purposes to carry messages that can convey learning material including technology (Adi, Dewi, et al., 2022). There are several types of learning media such as print media, displays, audio media, motion pictures, web-based media, and multimedia (Zaus et al., 2018)

Computer Networking is one of the learning activities at the Faculty of Engineering, Ibnu Sina University. This learning aims to develop students' abilities in installing computer networks. Learning activities on campus still use little media, but if learning media is needed, only the Microsoft PowerPoint application is used as a medium in an

*name of corresponding author



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effort to utilize technology. However, learning media using smartphones is still rarely used as a medium to support student learning. Learning multimedia that utilizes technology can be a supporting medium in improving learning. Observation results show that there are several obstacles in learning activities, such as limited resources for tools and materials because some products are expensive, resulting in learning about the introduction of network devices being limited to explaining and introducing existing devices without looking at them as a whole. Apart from that, the lack of use of learning media also makes students less motivated, resulting in little feedback from students in enjoying learning. Conditions like this require lecturers to be more innovative in delivering teaching material, as well as creative in creating learning media, so that students are motivated and interested in learning activities so that their understanding of the teaching material increases.

There are various types of learning media, including computer-assisted learning media such as using the Microsoft PowerPoint application as presentation media, Android-based and website-based mobile learning applications, or e-learning. Several types of media contain novel learning media by visualizing the abstract into concrete through Augmented Reality. The media developed should organize teaching materials with visual elements so that students' imagination power increases (Novita & Harahap, 2020). It can be seen from relevant research that researchers are increasingly successful in using augmented reality media as a learning medium (Damayanti et al., 2021). Apart from that, lecturers can also use smartphones as learning media which contain teaching materials, 3D displays for display, and questions for evaluation. Augmented reality has the potential in the development of interactive applications (Batubara et al., 2021). The development of smartphones is getting better with the camera features they have, many smartphone device application developers have emerged, and nowadays many Android-based application developments use the Vuforia Software Development Kit (SDK) (Dewi, Mursyida, et al., 2021). Vuforia is a software development by Qualcomm that focuses on Computer Vision Focus Image Recognition. Vuforia works using markers (Mubai et al., 2020).

Augmented Reality development applications include marketing, education, medical, industrial training, games, and tourism. The opportunities for Augmented Reality in the field of education are very large, with augmented reality abstract teaching materials can be visualized to be more concrete, and objects are projected through 3-D simulations so that objects can be seen in real-time by students (Riyanda et al., 2021). Another benefit of using Augmented Reality is that it can help lecturers to explain the delivery of material well and the teaching material is easy for students to understand (Tasrif et al., 2020). Augmented Reality learning media is expected to produce learning media for students, to be a solution to boredom and ineffective delivery of material so that the smartphone they own has added value, and students are motivated by its attractiveness because the presentation is not only in the form of text but also 3D display multimedia elements that are visualized to make it easier to understand the material. The hope of this research is that the learning media provides information about network devices. Developing learning concepts using Augmented Reality media in an effort to motivate students and increase student activity in order to increase students' understanding of the material and have an impact on learning outcomes. Helping students choose alternative media as flexible and motivated learning sources in learning activities. It is hoped that teachers will be more encouraged to develop Augmented Reality learning media in developing creative and innovative learning media (Dewi, Sofya, et al., 2021). The product specifications developed include the development of media containing material content for computer network devices in the form of 3D displays, text, images, and quiz content to help with assessment using this media. The extension. apk application can be installed on Android-based smartphones. Media development using the Unity application and Vuforia SDK as supporting tools for Augmented Reality (Irfan & Huda, 2022).

This research aims to answer these challenges by developing and evaluating AR-based learning applications specifically designed for computer networking courses. The main goal is to increase students' understanding of network concepts, improve their practical skills through interactive simulations, and assess the validity and practicality of AR as a learning medium in this context. By incorporating AR into computer networking teaching, this research seeks to provide students with a more engaging and effective learning experience. AR applications will allow students to visualize and interact with network components and processes in real-time, facilitating a deeper understanding of the Course material.

LITERATURE REVIEW

Augmented Reality (AR) has been recognized as a potential technology for enhancing learning experiences in various educational fields. Validity and practicality are two important aspects that determine the success of implementing AR applications in education. Validity refers to the extent to which an AR application can achieve the desired learning objectives, while practicality focuses on the ease of use and implementation of the application in an educational environment. Based on research (Chang et al., 2015) found that the use of AR in biology learning helps students visualize the structure and function of human body organs, thereby increasing their understanding of the subject matter. According to (Billinghurst & Duenser, 2012) noted that AR applications can increase student engagement in the learning process through direct interaction with virtual objects. Students are more motivated to learn when they can interact with the learning material in a real way. (Di Serio et al., 2013) reported that students

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who used AR applications showed higher levels of motivation and were more interested in the subject matter compared to students who used conventional learning methods.

In research, Radu (2014) stated that one of the keys to the successful implementation of AR in education is its ease of use. AR applications designed with intuitive and easy-to-use user interfaces are more likely to be accepted by students and teachers. However, in several studies related to augmented reality applications, there are also several gaps that occur, including many studies that only involve small and unrepresentative samples, pointing out that most studies were conducted on specific groups of students, often in experimental settings that do not reflect real classroom conditions. Further research is needed with larger and more diverse samples to generalize the findings regarding the effectiveness of AR. Most studies measure the impact of AR in the short term. noted the need for longitudinal research that can evaluate the long-term effects of AR use on students' understanding and retention of information. The importance of collaboration between technology developers and educators to ensure AR content is contextual and appropriate to the lesson material. The importance of intuitive and easy-to-use interface design to minimize technical barriers for students and teachers recommends testing user interfaces by involving end users (students and teachers) in the design process to ensure ease of use (Huang et al., 2019).

Based on the literature above, it shows that to increase the validity and practicality of AR applications as a learning medium, solutions are needed that include improving research methodology, developing relevant content, integration with active learning methods, user-friendly interfaces. By overcoming these challenges, AR can be adopted more widely and effectively in education, providing significant benefits to the learning process.

METHOD

The research method used is the Multimedia Development Life Cycle (MDLC). The MDLC development method is a multimedia system that is carried out based on six stages, namely concept, design, material collecting, assembly, testing, and distribution. These six stages do not have to be sequential in practice, they can interchange positions. Even so, the concept stage must be the first thing to be done (Roedavan et al., 2022).

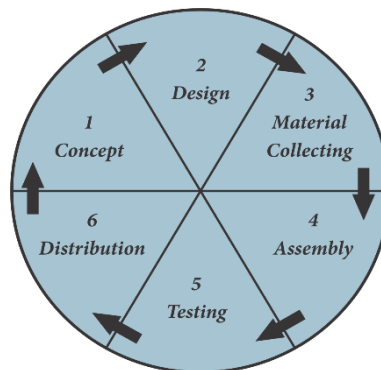


Fig. 1 Stages of the Multimedia Development Life Cycle Method

The development stages in the Multimedia Development Life Cycle (MDLC) are as follows:

Concept

Formulate the basics of analysis for the application to be created and developed. Especially on the purpose and type of application to be created. At this stage, the author determines the purpose of creation, determines user identification, determines the form of the application, and determines other general specifications. The research subject in developing the learning media AR application involved four media validators, two material expert validators, and two media expert validators to determine the validity of the learning media AR media application. Then to determine the practicality of the AR application using respondents, lecturers, and students who will use the AR application as learning media. The class used for practical respondents was class 3F with 20 students.

Design

The design stage is the stage of making specifications regarding application architecture, style, appearance, and requirements or materials for the application. At the design stage, a design will be created for each scene using a storyboard from one scene to another using a navigation structure and interface design.

Material Collecting

It is a process for collecting everything needed to make this application. Regarding the material to be presented, then multimedia files such as audio, text and images will be included in the presentation of the application.

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Assembly

The materials and multimedia files that have been obtained are then assembled and arranged in such a way that they match the design that has been created.

Testing

After the results of the visualization are ready, a trial needs to be carried out. The trial was carried out by applying the results of the application. This is intended so that what has been created previously is correct before it can be applied in mass publications. Then a product trial is carried out to see whether the product that has been developed is valid or not, to see whether the learning media that has been developed is valid and can be applied to computer networking courses. Validity Analysis The learning media obtained in the research will be analyzed descriptively. Data is classified into quantitative data in the form of numbers and qualitative data expressed in words. Next, the results of data analysis will be used to assess learning media in terms of validity. Scoring each validated item on a scale of 1-5. In adding up the scores from each validator for all indicators using Aiken's V statistics it is formulated as (Bashoor & Supahar, 2018):

$$V = \sum s / [n(c - 1)]$$

Information:

$$s = r - lo$$

lo = The lowest validity assessment number (= 1)

c = The highest validity assessment number (= 5)

r = A number given by an appraiser

Tabel. 1. Category Validity of learning media

No	Achievement Level	Category
1	0 – 1,00	Valid
2	< 0	Invalid

Distribution

The stage of duplication and distribution of results to users. This visualization needs to be packaged well according to the media for its distribution, whether via CD/DVD or other media. Then, the practicality test of the AR-based learning media application was carried out. Practicality test data was obtained from data provided by lecturers and students. Of all the item scores obtained, they are then tabulated and the percentage is found using a formula (Riduwan, 2010):

$$\text{The Value of Practicality} = \frac{\text{Total score of answers to each item}}{\text{number of item scores}} \times 100\%$$

The scores resulting from the analysis of practicality by lecturers and students are grouped into the following categories:

Table 2.

Category Practicality of learning media

No	Achievement Level (%)	Category
1	81-100	Very Practical
2	61-80	Practical
3	41-60	Quite Practical
4	21-40	Less practical
5	0-20	Not Practical

RESULT

Concept

Formulate the basics of analysis for the application to be created and developed, especially on the purpose and type of application to be created. Creating Augmented Reality applications for computer network learning aims to increase understanding, and involvement, and provide virtual practical experience to students. The development process requires appropriate hardware and software and goes through steps that include determining goals, identifying users, designing the application form, and determining general specifications. With good planning and proper implementation, AR applications can become highly effective and innovative educational tools. To develop AR applications, proper hardware and software are required. Computer or Laptop as well as Smartphone or Tablet

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that has support for AR (ARKit for iOS, ARCore for Android). The software required is the IDE and Unity Development Software for developing AR applications. Material from computer networking courses adapted to the computer networking curriculum. In developing the AR learning media application, four media validators were involved, two people as material expert validators and two people as media expert validators to determine the validity of the AR learning media application. Then to determine the practicality of the AR application using respondents, lecturers, and students who will use the AR application as learning media. The class used for practical respondents was class 3F with 20 students

Design

The design stage is one of the important stages in developing an Augmented Reality (AR) application, where specifications regarding the application architecture, style, appearance, and material requirements are prepared. At this stage, designers and developers work together to create a visual and functional design of each scene, using storyboards and navigation structures, and designing an intuitive and effective user interface (UI). Scene Design with Storyboard and Navigation Structure is a visual tool that helps in planning each scene in the application, showing how the user will interact with the application from one scene to another. The navigation structure defines the user flow in the application.

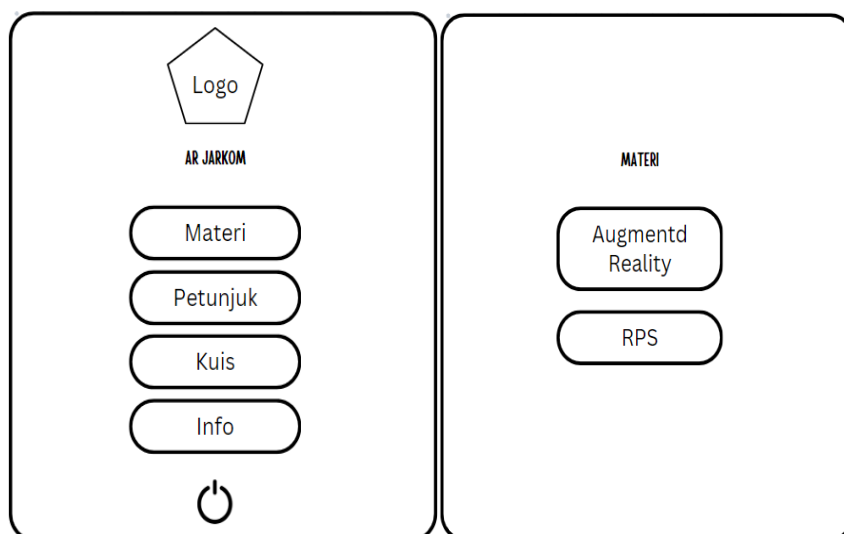


Fig. 2 Augmented reality application storyboard

Material Collecting

Material collection is one of the important steps in developing Augmented Reality (AR) applications for computer network learning. At this stage, the development team gathers all the materials and resources required to build the application. The material collected includes material content taken from computer networking textbooks, text, images, videos, 3D models, and other information that will be used in the application. A structured and systematic process will help ensure that all aspects of the AR application can be built well and support the learning objectives that have been set

Assembly

The preparation and manufacturing stages of all the materials that have been collected are integrated into the Augmented Reality (AR) application for computer network learning. At this stage, the development team works together to bring together educational content, 3D models, and other technical components in a functional and interactive application.

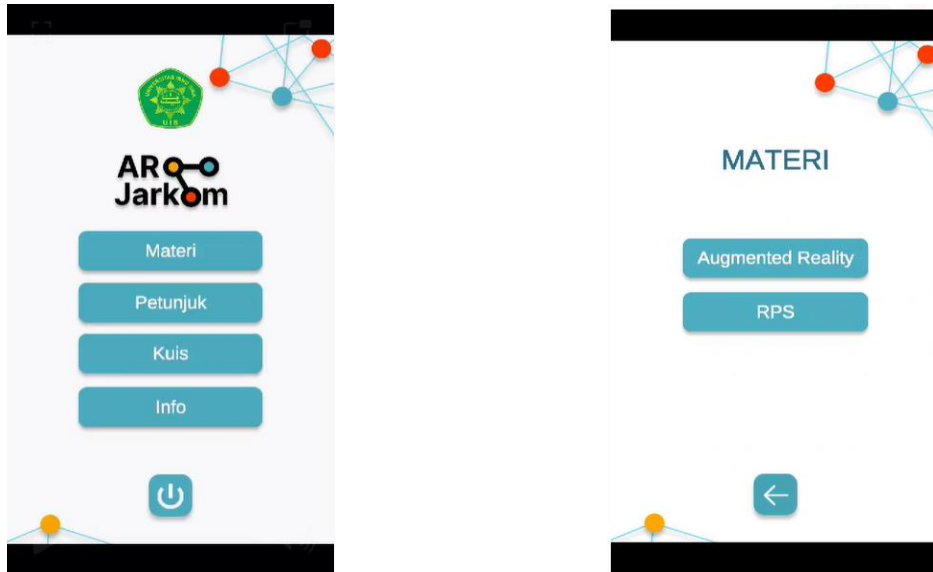


Fig. 3 Main View and Material Display

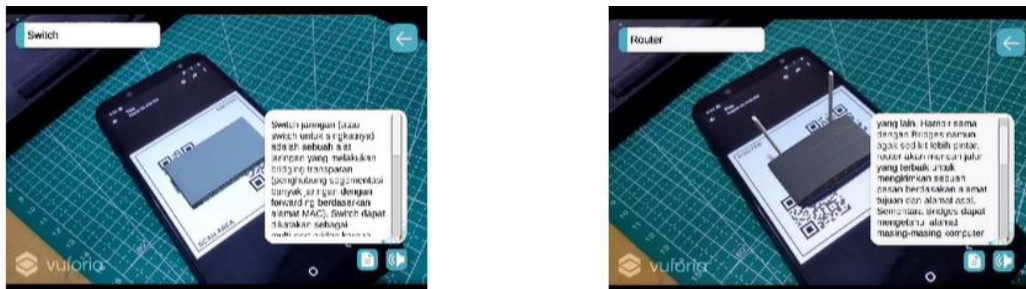


Fig. 4 AR-based Material Display

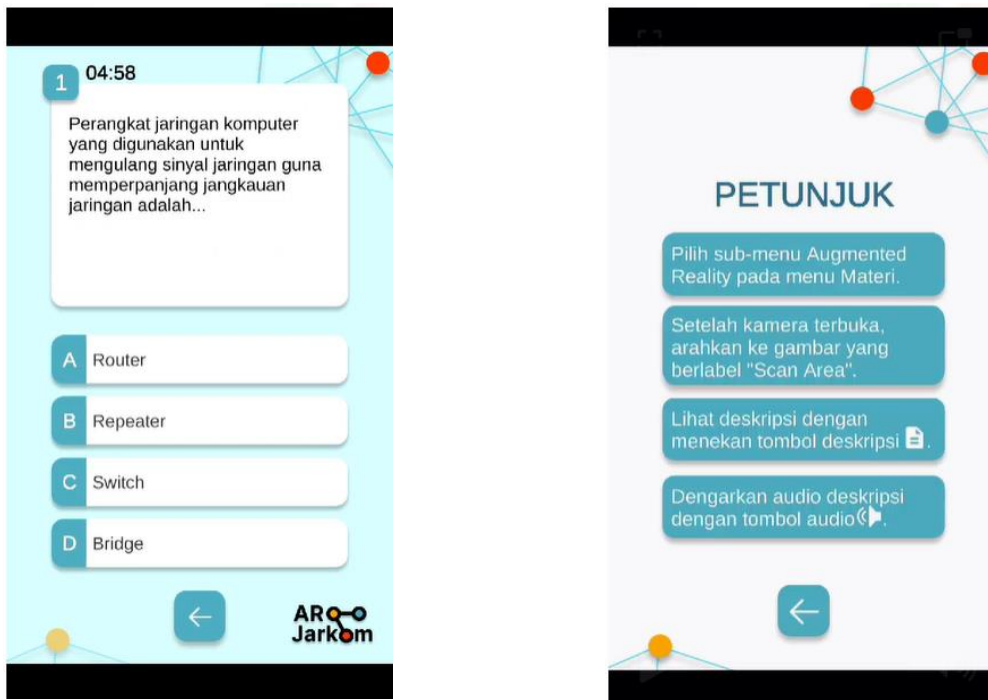


Fig. 5 Quiz view and Display instructions

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Testing

Black box testing is a software testing method in which the tester does not require knowledge of the internal structure or code of the application being tested. The focus of this testing is on the application input and output and the observed functionality. This testing is important in ensuring that the application performs according to functional specifications without requiring knowledge of its internal structure. This method helps ensure that the application under test meets requirements and is reliable by users.

Table 3. Black Box Testing Results

Page	Testing Details	Results
Main course	The Augmented Reality application contains the University Logo, Materials, Instructions for use, Quizzes, and developer information	Succeed
RPS	The Computer Network Semester Learning Plan document will appear	Succeed
AR	Displays 3D images from camera scans of objects and material explanations containing text and sound	Succeed
Contents of the material	Displays the content of device introduction material and network topology as a sub-topic for learning commuter networks	Succeed
Quiz	Display quiz questions as a learning evaluation	Succeed
Score	Displays the results of quiz answers that have been answered by the user	Succeed
Profile	Displays developer information	Succeed
Instruction	Displays information on how to use the AR application as a Jarkom learning medium	Succeed

Apart from testing the software, researchers also tested the validity of the AR application as a learning medium. Collecting data on the validity of learning media as a learning resource is by using a questionnaire. In this case, the researcher gave a questionnaire to 4 validators who would validate the media being developed. For material and design validity tests, the results can be seen in the following table:

Table 4. Validity Test of Material and Media

No	Validator	Indicator	Results	Category
1	Validator 1	Material assessment	0,86	Valid
2	Validator 2	Material assessment	0,85	Valid
3	Validator 3	Design assessment	0,85	Valid
4	Validator 4	Design assessment	0,87	Valid
Average			0.85	Valid

From Table 4 you can see the results from Validator 1 and Validator 2, related to material assessment indicators, namely 0.86 and 0.85 in the Valid category. Then the results from validator 3 and validator 4, related to the assessment of learning media design, are 0.85 and 0.87 in the Valid category. From these results, it can be concluded that the material included in the application and the design of the AR-based application as a learning medium is declared valid for use.

Distribution

The dissemination stage is the stage where the Augmented Reality (AR) application for computer network learning is ready to be launched and available to end users. This process includes various steps to ensure the application can be accessed, downloaded, and used by target users. It is important to ensure that AR applications for computer network learning are accessible and usable by the target audience. With careful preparation, effective marketing strategies, and ongoing support, apps can achieve success in the market and provide maximum value to users. After being disseminated, the AR learning media application is then tested for practicality. The practicality test data for learning media for Introduction to Computer Network Devices and Topology was taken from a

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questionnaire that was distributed to lecturers and students. Practicality is related to the ease of using the learning media developed. Practicality data was obtained through a questionnaire filled in by two practical people.

Table 5. Lecturer Response Results

No	Assessment Aspects	Valuation Percentage			category
		D1	D2	Rata2	
1	Technical	90	89	89,5	Very Practical
2	Design	86	88	87	Very Practical
3	Contents	86	80	83	Very Practical
Total Average				86,5 %	Very Practical

Based on the table, it can be seen that there are three aspects of assessing the practicality of learning media based on the results of lecturers' responses via questionnaires. The average percentage of assessments for Lecturer 1 (D1) and Lecturer 2 (D2) with an average score of 89.5% based on the technical aspect, 87% from the design aspect, and 83% from the content aspect, with a total score of 86.5% media very practical use. The practicality of learning media also requires input in the form of responses from students. This data was obtained after learning was carried out, through a questionnaire given to students.

Table 6. Student Response Results

No	Assessment Aspects	Percentage	Category
1	Convenience	88 %	Very Practical
2	Motivation	85 %	Very Practical
3	Attractiveness	86 %	Very Practical
4	Usefulness	88 %	Very Practical
Total Average		87 %	Very Practical

Based on the table above, it can be seen that there are 4 aspects of the practicality of learning media based on student responses via questionnaires. The average percentage is an assessment from students which includes, among others: (1) ease of use obtained 88% in the very practical category, (2) motivation obtained 85% in the very practical category, (3) attractiveness obtained 86% in the very practical category, (4) the usefulness obtained was 88% in the very practical category and the overall average was 87% in the very practical category. These results show that the practical categories developed can make it easier for students to understand the material.

DISCUSSIONS

Computer networking, as a subject, often involves abstract and complex concepts that can be challenging for students to understand through traditional teaching methods. These concepts include network architecture, protocols, and data transmission processes, which are especially important for students pursuing careers in information technology and computer science. Traditional teaching methods, such as textbooks and lectures, may not adequately convey the dynamic and interconnected nature of networked systems. Based on the results of research that has been carried out, the augmented reality application as a learning medium provides benefits and motivation to students in learning computer networking courses. This can be seen from the results of product validity testing which show that the AR application is valid with an average value of 0.85. Then, looking at the practicality of the AR application product, it can also be said to be very practical with an average score of 87% stating that the AR application is very practical to use. In line with the research results (Ibáñez & Delgado-Kloos, 2018) found that the use of AR in STEM education improved students' understanding of complex concepts. In their research, 85% of students reported increased understanding after using AR applications. In terms of student engagement and student motivation, it also shows that AR applications increase student involvement in biology learning, with 90% of students feeling more motivated and involved in the learning process after using AR (Cheong et al., 2022). Also strengthened by research (Huang et al., 2019) shows that 85% of users feel that AR applications that can be accessed via mobile devices increase ease of use and flexibility in a variety of learning environments. In this research, the application of AR as a learning medium has strong validity, with a significant increase in

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understanding, engagement, and mastery of concepts among students. Practicality is also high, with ease of use, good integration with the curriculum, and adequate technical support.

CONCLUSION

Augmented Reality application as a learning medium in computer network courses, especially in the Introduction to Computer Network Devices and Topology material through analysis of the needs required by students and lecturers, which is then designed, developed, and tested for the validity and practicality of the application. Based on the results of the validity test of the Augmented Reality application for Introduction to Devices and Computer Network Topology, it was declared valid for use and the results of the Practicality test for the Development of Augmented Reality Learning Media Applications for Introduction to Devices and Computer Network Topology which was carried out for lecturers and students obtained very practical results for use. This AR application is useful for teachers in applying lesson material, especially in computer networking courses. The limitation of this application is that not all smartphone devices can be used because it only supports the Android operating system, not others. Based on the results obtained, the researcher provides recommendations to future researchers to develop an AR application as a compact learning medium for all types of smartphones and also test the effectiveness of this application on student learning outcomes.

REFERENCES

- Adi, N. H., Dewi, I. K., Lubis, A. L., Ambiyar, A., & Aminuddin, F. H. (2022). The Development of Computer Network Learning Media to Support Online Learning. *Jurnal Basicedu*, 6(4), 7121–7130. <https://doi.org/10.31004/basicedu.v6i4.3444>
- Adi, N. H., Riyanda, A. R., Nadia, H., Maulana, F., Ambiyar, A., Verawardina, U., & Lapisa, R. (2023). *Model Pembelajaran Kejuruan*. CV WIDINA MEDIA UTAMA.
- Adi, N. H., Wahdi, Y. W., Dewi, I. P., & Samala, A. D. (2022). *The Effectiveness of Learning Media as a Supporter of Online Learning in Computer Networking Courses*. 535.
- Bashooir, K., & Supahar, S. (2018). Validitas dan reliabilitas instrumen asesmen kinerja literasi sains pelajaran Fisika berbasis STEM. *Jurnal Penelitian Dan Evaluasi Pendidikan*, 22(2), 219–230.
- Batubara, H. S., Jalinus, N., Sukardi, S., Waskito, W., Samala, A. D., Ranuharja, F., Devega, A. T., & Dewi, I. P. (2021). Approval Test of Augmented Reality-Based Learning Media on Computer Network Installation Materials. *Jurnal Teknologi Informasi Dan Pendidikan*, 14(3), 223–229.
- Billinghurst, M., & Duenser, A. (2012). Augmented reality in the classroom. *Computer*, 45(7), 56–63.
- Chang, Y.-L., Hou, H.-T., Pan, C.-Y., Sung, Y.-T., & Chang, K.-E. (2015). Apply an augmented reality in a mobile guidance to increase sense of place for heritage places. *Journal of Educational Technology & Society*, 18(2), 166–178.
- Cheong, C. W.-L., Guan, X., & Hu, X. (2022). Augmented reality (AR) for biology learning: a quasi-experiment study with high school students. In *Social and Emotional Learning and Complex Skills Assessment: An Inclusive Learning Analytics Perspective* (pp. 167–185). Springer.
- Damayanti, L., Suana, W., & Riyanda, A. R. (2021). Pengembangan Media Pembelajaran Interaktif Berbasis Augmented Reality Pengenalan Perangkat Keras Komputer. *IKRA-ITH INFORMATIKA: Jurnal Komputer Dan Informatika*, 6(1), 10–19.
- Daryanto, K. S., & Karim, S. (2017). Pembelajaran abad 21. *Yogyakarta: Gava Media*, 267.
- Dewi, I. P., Mursyida, L., & Samala, A. D. (2021). *Dasar-dasar android studio dan membuat aplikasi mobile sederhana*.
- Dewi, I. P., Sofya, R., & Huda, A. (2021). *Membuat media pembelajaran inovatif dengan aplikasi articulate storyline 3*. UNP PRESS.
- Di Serio, Á., Ibáñez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education*, 68, 586–596.
- Huang, K.-T., Ball, C., Francis, J., Ratan, R., Boumis, J., & Fordham, J. (2019). Augmented versus virtual reality in education: An exploratory study examining science knowledge retention when using augmented reality/virtual reality mobile applications. *Cyberpsychology, Behavior, and Social Networking*, 22(2), 105–110.
- Ibáñez, M.-B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 123, 109–123.

*name of corresponding author



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- Irfan, D., & Huda, A. (2022). Design of Augmented Reality As a Learning Media Application On Network Topology and Network Topology Lessons In Vocational Middle School. Syntax Literate. *Jurnal Ilmiah Indonesia*, 7(9).
- Mubai, A., Rukun, K., Tasrif, E., & Huda, A. (2020). Augmented Reality (AR)-Based Learning Media on the Subject of Computer Network Installation. *Jurnal Pendidikan Dan Pengajaran*, 53(2), 213–226.
- Novita, R., & Harahap, S. Z. (2020). Pengembangan Media Pembelajaran Interaktif Pada Mata Pelajaran Sistem Komputer Di Smk. *Jurnal Informatika*, 8(1), 36–44. <https://doi.org/10.36987/informatika.v8i1.1532>
- Riduwan. (2010). *Skala Pengukuran Variabel Variabel Penelitian*. Alfabeta.
- Riyanda, A. R., Jalinus, N., Sukardi, S., Waskito, W., Ranuharja, F., Samala, A. D., Adi, N. H., & Dewi, I. P. (2021). Augmented Reality Technology for 3D Photoelectric Simulation. *Jurnal Teknologi Informasi Dan Pendidikan*, 14(3), 217–222.
- Roedavan, R., Pudjoatmodjo, B., & Sujana, A. P. (2022). Multimedia Development Life Cycle (MDLC). *Teknologi Dan Informasi, Multimedia*.
- Sudira, P. (2017). *TVET Abad XXI Filosofi, Teori, Konsep, dan Strategi Pembelajaran Vokasional*.
- Tasrif, E., Mubai, A., Huda, A., & Rukun, K. (2020). Pemanfaatan media pembelajaran berbasis augmented reality menggunakan aplikasi Ar_Jarkom pada mata kuliah instalasi jaringan komputer. *Jurnal Konseling Dan Pendidikan*, 8(3), 217. <https://doi.org/10.29210/153400>
- Zaus, M. A., Wulansari, R. E., Islami, S., & Pernanda, D. (2018). Perancangan Media Pembelajaran Listrik Statis dan Dinamis Berbasis Android. *INTECOMS: Journal of Information Technology and Computer Science*, 1(1), 1–7. <https://doi.org/10.31539/intecom.v1i1.140>

*name of corresponding author



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