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# Augmented Reality (AR)-Based Learning Media on the Subject of Computer Network Installation

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## Abstract

*This study aims to design and build Augmented Reality (AR) - Based Learning Media on the Subject of Computer Network Installation, and analyze the validity and effectiveness of the media developed. The development model used in this study is the 4D (four-D) development model that starts from the defining, designing, development and disseminate stages. Media validation was carried out by experts namely lecturers of the Department of Informatics Education, Department of Electronics Engineering, Faculty of Engineering, State University of Padang, who took the practical work subject of Computer Network Installation in the semester on January-June 2020. The results of this study are in the form of a blue print of media design, a job sheet book of AR-based Computer Network Installation and its application which is published on the Google Play Store under the name AR\_JARKOM\_INFORMATIKA-UNP. AR - Based Learning Media of Computer Network Installation is able to present practical work devices in the form of 3D virtual objects and video tutorials, so that this learning media has good mobility, independence, and interactivity in supporting independent learning. Furthermore AR - Based Learning Media on the Computer Network Installation is categorized valid from the design side with a value of 0.875 and valid from the material side with a value of 0.827. Then the use of AR-based learning media is more effective than print-based learning media based on trial data with a practical success rate of 71.79% for AR-based media and 60.92% for print-based media. So based on data from the results of this study, the learning media of AR-based Computer Network Installation is categorized as an appropriate and effective learning media to be used in practical work learning of Computer Network Installation.*

**Keywords:** Computer Network Installation; Augmented Reality (AR); 4-D (four-D);

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## Introduction

Education is an important indicator of the progress of a nation in supporting the development of civilization. Education is inseparable from efforts to form competent human resources (Ramdani, 2018). The existence of human education can change the potential that exists in itself into competence to face and solve problems in life. The learning process certainly has many problems, but the core of all these problems is the learning outcomes (Sari et al., 2016).

Learning outcomes are influenced by internal and external factors of students. Internal factors come from within students which include physiological and psychological factors, while external factors come from outside students called the student environment (Ardila & Hartanto, 2017; Karwono & Mularsih, 2018; Slameto, 2013). Among the external factors that greatly affect student learning outcomes is learning media. This is because learning media play an important role in influencing the learning process which will later have an impact on learning outcomes (Dalu & Rohman, 2019).

Learning media is an intermediary carrying a message or information that aims as a tool with the intention of teaching between the source and recipient of subject matter, (Arsyad, 2019). Effective learning media will determine whether or not learning information is conveyed to students (Ramli, 2015). Effective learning media will also be able to encourage students to learn independently which has an impact on increasing the

achievement of learning goals, (Daryanto, 2016; Kanti et al., 2018). But in its implementation there are still many learning media that are still not effective in the learning process (Hakim, 2017; Kustiawan, 2009). This is due to many things, among them because there is no media technology-based development that is used (Hakim, 2017).

As a result of observations by researchers to the academic community of Education of Information and Computer Engineering (PTIK) Department of Electronics Engineering, Faculty of Engineering, State University of Padang located in the city of Padang, West Sumatra, Indonesia. Observations were made for students and lecturers who carry out learning in the course subject of Computer Network Installation. The results of observations on the Computer Network Installation course which is a practical course using instructional media in the form of job sheets and practical tools directly. The form of the job sheet used is presented in Figure 1.

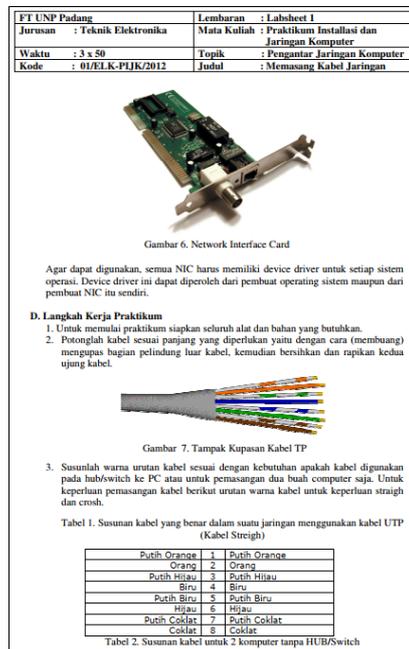


Figure 1. Job sheet for the Course subject of Computer Network Installation

Learning media used in the learning process of Computer Network Installation are in the form of job sheet. In the use of job sheets, students need material and practical tools to understand the subject matter that is on the job sheet. Problems arise when learning is carried out outside the laboratory. Meanwhile, to rely on job sheets alone, it is not enough to be able to explain the learning material in real and clear, because the job sheet only contains explanations with narrative text, 2D drawings and print-based as in Figure 1.

This makes the job sheets used have not been able to support independent learning, so students only rely on the learning process in the laboratory. When students only rely on the learning process in the laboratory, it has an impact on the number of failures in practical implementation (Hakim, 2017; Kustiawan, 2009; Sumardani et al., 2019) . As an example of the results of practical work from several lecture meetings is described in Table 1.

Table 1. Success Rates of Practical Work in Class 2F1, 2 Semesters on January-June 2019

Learning Materials	Number of Students			
	2F1		2F2	
	Successful	Failed	Successful	Failed
Network Media	7	6	9	7
Local Area Network	10	3	11	5
Netmask Subnetting	8	5	8	8

Source: lecturer of courses in Computer Network Installation (Mubai et al., 2020).

Table 1 explains that the average success rate of each practical work in class 2F1.2 semesters on January-June 2019 is 60.92% of each meeting. The problem is still an average of 39.08% or 5 to 6 students who fail during the practical work in each class. Students who fail are required to repeat the practical work. Repetition of this practice increases the demand for material and time, even though its availability is limited.

As a recommendation of this problem, there is a need for learning media that support independent learning. So, learning media that is able to support independent learning, must have good mobility, independence, and interactivity (Arjuna et al., 2020; Hendikawati et al., 2019; Maita et al., 2018). Developing learning media that supports independent learning is expected to be able to facilitate individual student learning first at home. So when learning is done in a laboratory, the learning material that students learn is no longer new to them, so it is expected to reduce the failure rate of practical work and improve learning outcomes. With the increase in learning outcomes, the indication of achieving learning objectives will increase (Anggareni et al., 2013; Punaji Setyosari, 2014). Therefore it is necessary to further analysis in finding a learning media format that is suitable with the learning objectives because this is not an easy thing, (Megawati & Utami I.G.A.L.P, 2020).

Further analysis of the development of learning media of Computer Network Installation is adjusted to the needs of students who will use the media. The needs analysis was carried out for 29 students in the study program of Education on Informatics Engineering and Computers that follow the lecture of Computer Network Installation of the semester on January-June 2019. The results of the needs analysis are in the following table 2.

Table 2. Results of Analysis of Learning Media Needs for Computer Network Installation

Question Analysis	
1	100% of students answered that they already have and can use a smartphone device
2	52% of students answered the difficulties in carrying out the practicum because the learning media used did not support independent learning
3	69% of students answered the difficulty in understanding practicum material with learning media in the form of 2D-based lab sheets
4	38% of students answered the difficulty in learning practicum material with the lab sheet media outside the laboratory because the media supporting the lab sheet in the form of practical tools cannot be used
5	69% of students want user-friendly and mobile learning media that they can use anywhere
6	45% of students want a learning media that is interactive and practical
7	48% of students want learning media that is able to present practical tools and materials in the form of virtual 3D on their smartphones

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8	76% of students want a learning media that is able to present practicum stages in the form of videos on their smartphones
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Source: Data of observation result, (Mubai et al., 2020).

The results of the analysis of students' needs indicate that 52% of students have difficulty in carrying out practical work of Computer Network Installation with existing learning media, thus requiring the development of learning media used. Based on the results of the analysis of media needs of Computer Network Installation, the development of learning media needed is learning media that supports independent learning. This certainly requires technology-based learning media, because the use of technology will facilitate the delivery of learning material so that the learning atmosphere is more effective and efficient, (Afriansyah, 2018; Menrisal, 2019). The technology that is able to meet this need is the technology of Augmented Reality (AR).

Augmented reality is a technological concept that combines digital information (images, video, audio, text) into a virtual environment and is displayed in real time (Abdul & Triwahyuni, 2013). With the ability of augmented reality technology that is capable of displaying videos, making learning media using this technology can present learning video tutorials, so that independent learning can be carried out (Hendriyani et al., 2018).

Augmented reality technology also uses objects as markers to display images, videos and 3D visual objects, which makes this technology capable of displaying practical virtual tools and materials in 3D and even simulation videos in learning (Adami & Budihartanti, 2016; Arpan et al., 2018; Kamelia, 2015). So that learning media that uses technology of AR have good independence by not depending on tools, materials, and other practicum media. Whereas AR technology markers can be paper, so they can be embedded into existing job sheets (Kamelia, 2015).

Technology of augmented reality when viewed from the cone of Edgar Dale's experience, the augmented reality-based learning media is categorized in the learning media category that can present artificial objects or observations (Arsyad, 2019). Learning media that have a category of artificial objects or observations are in the hierarchy under the category of direct experience, so that the media with technology of augmented reality has a low material abstraction.

Technology of augmented reality is created in a mobile application such as Android or IOS that runs on smartphone devices (Adami & Budihartanti, 2016). By utilizing a mobile-based Android application, it will greatly support independent learning (Hendikawati et al., 2019). On the other hand by utilizing smartphones as learning media, the learning process can be carried out independently with good mobility and interactivity (Arjuna et al., 2020).

Then the use of smartphones as learning media will make the media used requires a little paper (paperless) (Afriansyah, 2018; Yanto et al., 2020). So that the forest reforestation program will be helped, and of course the use of smartphones for learning will increase, which at present smartphones are more widely used by students for entertainment (Hamzah & Kurniadi, 2019). This research aims to design and build learning media-based on Augmented Reality (AR) of technology in the course of Computer Network Installation.

**Material and Method**

The method in the media development procedure in this study uses the 4-D development model (four D models). The 4-D development model consists of 4 stages: define, design, develop, and disseminate (Thiagarajan et al., 1976). The design procedures for developing this research media are in Figure 2.

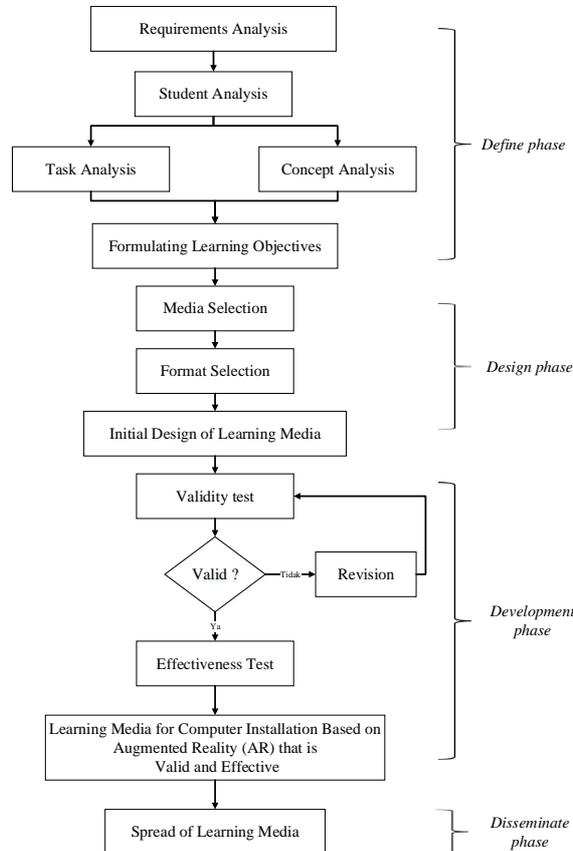


Figure 2. Media Floating Model

Figure 2. The media development model uses a 4-D model that explains the design stages used. At the design stage there are several application designs. The design starts from the design of system requirements. The minimum system requirements for the application system developed are as follows.

Table 3. System Requirement Design

Type	Needs	Category
Processor	ARM-Cortex-M3 atau SC300	Hardware
RAM	7,5 MB	Hardware
Internal Storage	315 MB	Hardware
Camera	Only Internal	Hardware
Android	Jelly Bean (4.1)	Software

Minimum system application requirement developed in table 3 is obtained from the results of testing the system at the time of development. After determining the minimum system requirement then design is by using a use case diagram. Use case diagrams are used to describe the relationship between actors and actors with the application system developed, (Tasrif et al., 2019). The use case diagram design in this study is as follows.

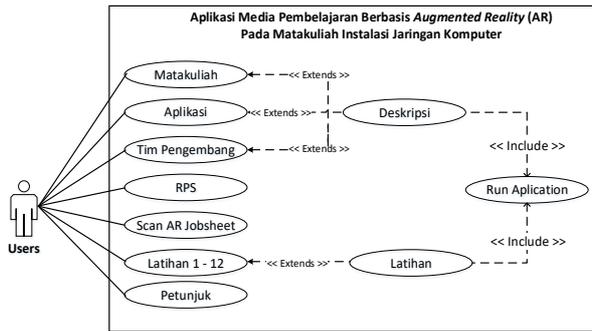
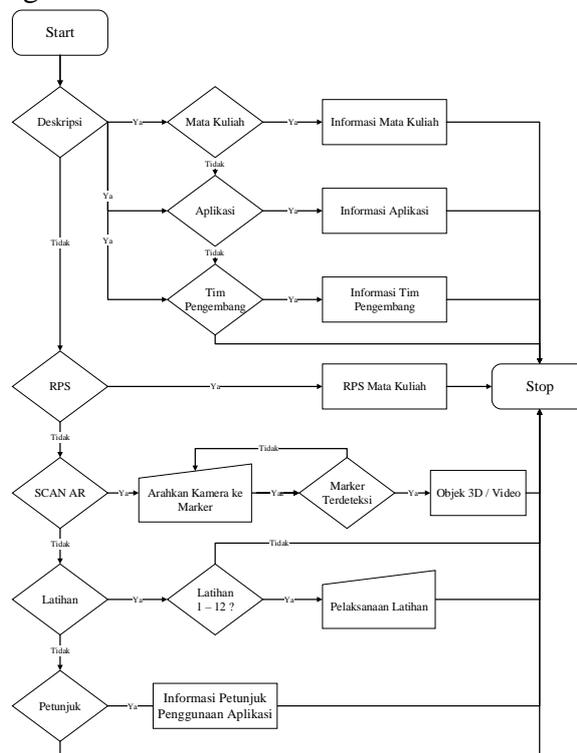


Figure 3. Designing a Use Case Diagram

Figure 3 shows the use case diagram design which explains that the application can be accessed by every user without having to login. Users only need to run the application to get all the features of the learning application. In the user application, services will be provided in the form of application features. These features are the course description feature, application, development team, Semester Learning Design (RPS), scan AR job sheet, exercises, and instructions. Next, the design needed is flowchart of application usage.

Flowchart of application usage is intended to describe the flow diagram of the application system usage. Analysis on the application flowchart serves to ensure all steps of the process run in the order specified, (Tasrif et al., 2019). Application flowcharts describe flowcharts in detail from start to end application usage. The design flowchart of this research media application is in Figure 4.



Design of Flowchart Application Usage

After the design flowchart of application usage is complete, the next design is the application interface design. The design of the application interface in this study is as follows.

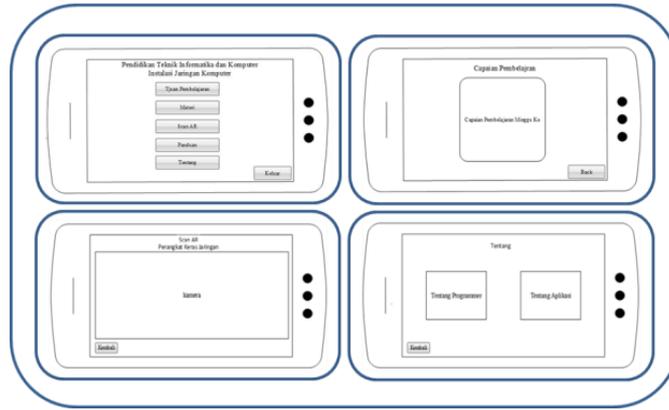


Figure 5. Application Interface Design

Figure 5 application interface design displays various forms of media application interface design developed. In the application interface design, there is a description interface design (courses, applications, and development team), Semester Learning Design (RPS), scan AR job sheets, exercises and instructions. The design of this application will be realized using the Unity, Vuforia, and Blander applications.

## Results and Discussion

### Research Results

The results of the study are adjusted to the stages of the learning media development method that uses the 4D development model. The 4D development model consists of the stages of defining, designing, developing, and distributing. The results of each stage of development are as follows.

#### *Result of Define Phase*

Defining phase aims to determine the basic problems in the development of this media. The objects analyzed from each of these stages are the students of Informatics Engineering, Faculty of Engineering, State University of Padang who took part in the lecture on practical work of Computer Network Installation of the semester on January-June 2020. The first part of this stage is the need analysis. The results of the analysis of learning media needed are media that are able to facilitate learning independently providing learning media on a mobile basis, able to present practical tools, materials and videos, and are able to display interesting, interactive, and paperless learning materials.

After the need analysis is obtained, the next stage is the student analysis phase. The results of the analysis are students; having diverse economic family backgrounds (low, middle and high); educational backgrounds from high schools; vocational high schools and Islamic boarding schools; smartphones and are able to use them, and having good motivation to gain study.

After the analysis of students is carried out, then enter the analysis phase of the task. As for the results of this analysis phase, students must have the ability to operate the basics of computers and smartphones to use the learning media for developing computer networks. After that proceed with the analysis of concepts that produce that the concept of weekly achievements in learning of Computer Network Installation that is carried out namely

Network Media Installation, Manajemen IP address, Subnetting, Supernetting, Variable Length Subnet Mask (VLSM), Routing Static, Network Address Translation (NAT), Wireless, Hostpot, Management Bandwith, Proxy, dan Virtual Private Network (VPN).

Then the next stage is the formulation of learning objectives. Based on the Semester Learning Design (RPS) of Computer Network Installation courses, the learning objectives are that students are able to build computer networks and manage networks continuously, mastering the basic principles of computer network systems in the development of local network-based systems, virtual local networks, and able think critically, identify the root of the problem, and solve it comprehensively, and make the right decision based on analysis and data.

### *Result of Design Phase*

The purpose of this stage is to prepare a prototype of learning media. This stage starts from the media selection stage. The results of the media selection that will be developed are the media capable of presenting practicum equipment in the form of 3D objects and video tutorials in the learning process. Then the selection of media formats to be developed is a media format that is easy to understand and inexpensive to obtain. For this reason, the media that are able to meet the needs of this design analysis are learning media based on Augmented Reality (AR). The results of the design of learning media of AR-based Computer Network Installation are as follows.



Figure 6. Results of the Design Phase

### *Result of Develop Phase*

Learning media that have been developed are in the form of Augmented Reality (AR) based work sheets and the application is named AR\_JARKOM\_ INFORMATIKA-UNP for the course of Computer Network Installation. The results of this form of media development are as follows.

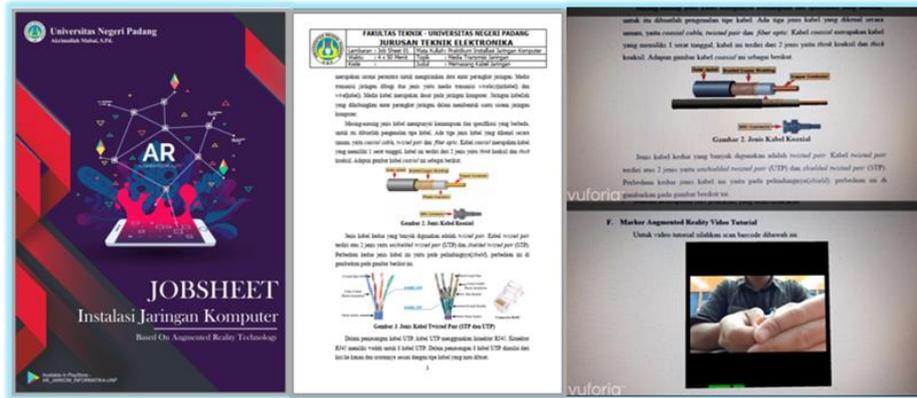


Figure 7. Job Sheet Practical work of Computer Network Installation

Figure 7 shows the results of the develop stage in the form of a job sheet and trial application of AR\_JARKOM\_INFORMATIKA-UNP. Then the media is validated by design experts and material experts. The experts came from the Informatics Engineering lecturer at the Department of Electronics Engineering, Faculty of Engineering, State University of Padang who took courses in Computer Network Installation.

The validation of the job sheet uses a non-test instrument in the form of a questionnaire to get data from the validator. The data obtained will be calculated using the formula of Aiken’s V, while the formula from Aiken’s V is as follows :

$$V = \frac{\sum S}{n(c - 1)} \tag{1}$$

Explanation:

- V = Validity Index
- S = r – lo
- N = Number of validators
- Lo = The lowest validity rating (in this case = 1)
- C = The highest validity rating (in this case = 5)
- R = The number given by a validator

Then from the calculation value obtained will be obtained between 0 and 1. For a range of  $\geq 0.667$ , it can be interpreted as a high enough coefficient, which can be categorized as valid. To be more complete in determining the validity criteria of media tests, it is explained in table 4.

Table 4. Response Category Criteria.

Category	Qualification
0,67 – 1,00	Valid
$\leq 0,66$	Invalid

Source: (Azwar, 2019).

Furthermore, media validation (design) is carried out by media experts to find out whether the design of the developed media is in accordance with the learning objectives and the rules of media development or not. The results of media validity (design) can be seen in Figure 8.

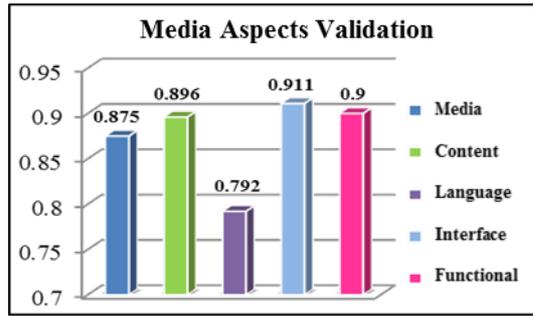


Figure 8. Evaluation of Media Validators

Figure 8 explains that indicators 1 (media) to indicator 5 (functional) obtain valid values with the magnitude of the validity coefficient values (0.875, 0.896, 0.792, 0.911, 0.900) respectively. Based on the category of Aikens validity,  $V$ , Aikens'  $V$  value of 0.875 is in the "valid" category. This assessment was also carried out on all items in indicators 2, 3, 4, and 5 obtaining an average of 0.875. Value  $0.875 > 0.667$  which means that the developed media is valid. Then proceed with the material validity test with the validity results in Figure 9.

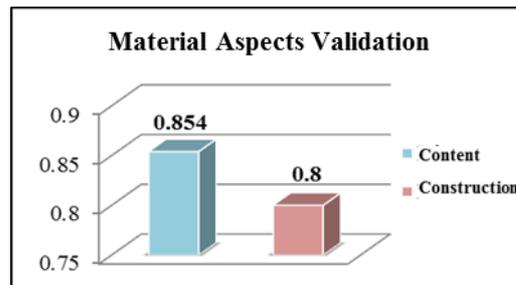


Figure 9. Material Validator Evaluation

Figure 9 assessment of the material validator shows the value of Aikens'  $V$  content indicator that is equal to 0.854 in the Valid category. This assessment is also carried out on construction indicators with an average yield of 0.800 and if calculated with the content indicator an average value is obtained that is 0.827. Value  $0.827 > 0.667$  which means that the material in the developed media is valid. So that the results of testing the validity of the media, then the media based on Augmented Reality (AR) is appropriate for use in learning to install Computer Networks, (Sugiyono, 2018).

After passing the media validity test and improvement in accordance with the results of the expert assessment, then the media trial is conducted which has been developed in several practicum meetings. The trial was conducted on 13 students of class 2F3 who attended the lecture of Computer Network Installation in the semester on January-June 2020. The practical results of the work are as follows.

Table 5. Success Rates of Practices of Class 2F3 Semester on January-June 2020

Learning Materials	Number of Students	
	Successful	Failed
Network Media Installation	10	3
IP Address Management	9	4
Subnetting	9	4

Source: lecturer of courses in Computer Network Installation.

Table 5 explains the results of the trial use of the developed media that affect the level of practicum success with an average of 71.79%. Then after the validity and media trials produce good results, the dissemination stage can be carried out.

### Result of Disseminate Phase

The disseminate phase of media is carried out after passing the validity test. The learning media of Augmented Reality (AR) based Computer Network Installation is published on Google Drive and the Google Play Store under the name AR\_JARKOM\_INFORMATIKA-UNP. The results of the publication are in the following picture.

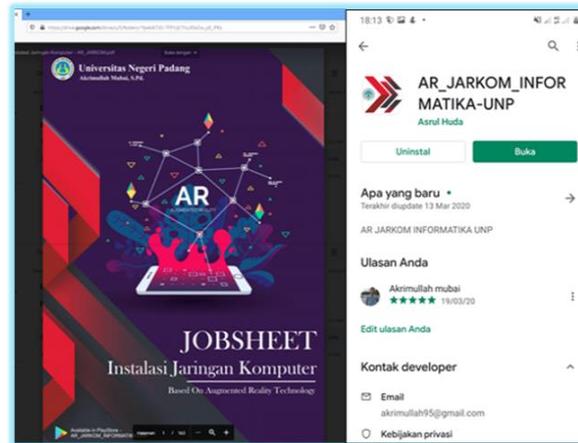


Figure 10. Publication of Learning Media

### Discussion

Preliminary findings in this study are learning media of Computer Network Installation in the form of job sheets using narrative text, 2D images and print-based, which makes this media not yet able to support independent learning. This is because to support independent learning, learning media at least have good mobility, independence, and interactivity (Arjuna et al., 2020; Hendikawati et al., 2019; Maita et al., 2018). So from the results of the use of print-based learning media, it is only able to produce 60.92% success rate of practical work of Computer Network Installation in the semester on January-June 2019.

This is better than the results of the use of learning media Augmented Reality (AR) -based Computer Network Installation which gets 71.79% in supporting the success of practical work of Computer Network Installation in the semester on January-June 2020. Kustiawan (2009) stated that the use of pointer markers on AR systems makes it easy for users to interact naturally and intuitively. The tangible interaction system of AR offers natural interaction styles that are suitable for use in educational applications, such as the introduction of tsunamis in museums. Hakim (2017) found that through Augmented Reality, teachers can create learning media that are fun, interactive, and easy to use. Augmented Reality can also replace learning modules that do not yet exist in schools in a virtual form. Students can still see and use modules like the original modules, but in virtual form. Through this new breakthrough, more variety of learning media can be built to support learning activities in schools, especially vocational schools (SMK) that require practical work learning modules.

The use of Augmented Reality is very useful for interactive and real learning media and directly by students (Mustaqim, 2016) . Besides learning media using Augmented Reality

can increase students' interest in learning because of the nature of Augmented Reality which combines cyberspace that can increase the imagination of students with the real world directly. Augmented Reality is interactive which makes students to see the situation real and directly and can imagine the results of the learning process given by educators to students.

Rusnandi et al., (2016) found that the 3D space building model based on Augmented Reality which was used as a learning medium was able to create a new atmosphere that was more interactive in mathematics learning which usually seemed boring to elementary school students. Suharso's (2012) research results also found this 3D building model based on Augmented Reality turned out to be 90% capable of creating a new atmosphere that is more interactive in mathematics learning which usually seems boring.

Through the results of the Sumardani's research et al., (2019) conducted, it can be summarized that solar learning media based on augmented reality has been successfully developed. This media is included in the excellent category as a learning medium. Based on the results of the validation conducted by the validator obtained an average percentage of 96.6% with the category of Very Good. Based on the results of the validation it was concluded that the augmented reality learning media on the solar posters is already valid for learning.

Some of the research results above show that AR-based learning media is more effective than print-based learning media in learning Computer Network Installation. So with the results of this study, the learning media AR-based Computer Network Installation contributes to increasing flexibility and effectiveness in studying the science of Computer Network Installation independently or in groups.

## Conclusion

This research has produced a blue print, job sheet and its application for the course of Computer Network Installation based on Augmented Reality (AR), and this media is valid in terms of design and material. Then AR-based learning media is more effective than print-based learning media in increasing the success of practical work. This is because AR-based learning media are able to present practical work tools in the form of 3D virtual objects and video tutorials, which gave this Augmented Reality (AR) mobility, independence, and interactivity in supporting independent learning. Furthermore, this media has been published on the Google Play Store with the name AR\_JARKOM\_ INFORMATIKA-UNP for free which is easy and inexpensive to obtain. So the learning media of AR-based Computer Network Installation is categorized as an appropriate and effective media used in learning of Computer Network Installation.

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