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Subandi
Member of Interactive Media, Game, & Mobile Technologies Research Group,
Politeknik Negeri Banjarmasin
Banjarmasin, Indonesia
subandi@poliban.ac.id

Aulia Akhrian Syahidi
Chair of Interactive Media, Game, & Mobile Technologies Research Group,
Politeknik Negeri Banjarmasin
Banjarmasin, Indonesia
aakhriansyahidi@poliban.ac.id

Joniriadi
Polytechnic Director,
Politeknik Negeri Banjarmasin
Banjarmasin, Indonesia
joni_riadi@poliban.ac.id

Amran Mohamed
Director of Research and Technology Development,
EON Reality PTE LTD.
Nucleus, Singapore
amran@eonreality.com

***Abstract*—Application of Mobile Augmented Reality (AR) as a learning solution in innovation facing the education era 5.0. for vocational students on the computer network device topic, we promote in this paper. The purpose of this study is to apply AR technology-based applications by maximizing all of its interactions in the learning process about computer network devices so that students can know and understand their functions, then conduct an assessment of User Interface (UI) and User Experience (UX). The detection approach uses a marker-based tracking method, by bringing up 3D objects, rotating and touching, information and tool functions in the form of text, and producing sounds as information clues. A total of 30 students from one of the vocational high schools have been involved to use this application. After being analyzed for the current situation the students were very enthusiastic in following the learning process, then in the analysis of student understanding results obtained an average value of N-Gain was 67.41 which was proven that AR application could improve learning effectiveness, the results of the UI assessment with a value of 98.70% have a very strongly agree predicate to the application interface has been met, and the results of the assessment of the experience of users with a value of 98.94% have a very strongly agree predicate to the experience of using the application has been fulfilled.**

Keywords—augmented reality, education era 5.0, human-computer interaction, user experience, user interface

I. INTRODUCTION

According to [1] in recent years, research on the use of technology in learning has increasingly focused on the application of Augmented Reality (AR), ubiquitous learning (u-learning), mobile learning (m-learning), serious games, and analytical learning. The development and application of the latest technology in the world of education have the main goal of which is to improve user satisfaction and experience. AR is not only limited to the sense of sight. It can be applied to all senses such as hearing, touch, and smell.

Learning innovation with AR technology is an effort to improve the learning process [2], the interaction between the real and virtual world is promoted in the learning process [3]. In recent years, AR technology has been promoted and developed in various fields. One of the applications of AR in the field of culture and tourism is [4] which develops and implements an AR-based translator application to preserve and introduce Banjar regional languages.

Focusing on the field of education especially vocational education, we highlight problems that occur in Indonesia in one of the subjects namely computer network equipment for information and communication technology expertise programs in vocational high schools. Learning innovations are needed to welcome this era of education 5.0, these innovations can be in the form of promising updates of the latest technology, so students can enjoy a better learning process, have abilities that can meet standards and expectations of the labor market/industry. The problems we found in the last few years in the learning process on computer network devices include, [5] found that computer network learning is still focused on theory without practice, learning takes place using modules and pictorial text, the tendency that occurs is a lack of enthusiasm for learning

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from students, vocational education should emphasize practice to improve abilities, moreover learning computer network devices is productive subjects.

Then [6] proved that students' understanding of computer network devices had not yet reached the desired goal, the main obstacle was the lack of availability of practical tools. Also, [7] mentions the cause of the lack of understanding of the topic of computer network devices, because the learning methods used tend to be monotonous, boring, and there is no learning innovation. Furthermore, [8] found the fact that so far the use of learning modules such as textbooks, student worksheets, and simulation modules for the design of computer network devices is still considered less varied in learning.

We also found problems that occurred in several Vocational High Schools in the Banjarmasin City Region, some of these findings were that students tended to experience difficulties in understanding and recognizing computer network devices, low learning motivation, decreased learning outcomes, and inadequate student abilities. Learning innovation must be implemented and will always be improved, updating and utilizing increasingly dynamic technology in collaboration with the education sector, is an effective effort to face the challenges in the education era 4.0 which will be prepared towards 5.0.

This study aims to provide solutions in solving problems faced by developing AR-based applications with many interactions called AR-CoNDe to maximize the learning content of computer network devices, as many as 30 students from one of the vocational high schools in Banjarmasin were involved, then also reported the effectiveness of learning outcomes. after using the application, evaluating the UI, and UX to improve application performance.

II. RELATED WORKS

The application of AR has a very good influence on vocational/engineering education, has been considered with all its advantages, and is promoted to support the learning process [9]. Research from [10] proposes AR technology on the topic of car care to create collaboration between real and virtual learning so that it has an impact on growing motivation and enthusiasm for learning. Also, [11] implemented AR applications for learning the introduction of hardware and computer assembly for vocational education, with the effect of increasing student achievement, the level of confidence in their abilities, and producing the latest learning innovations. Then [12] developed an AR application to make it easier for vocational students to recognize and understand car features as a basis for designing cars and to support workplace safety. The convenience of the UI has been assessed, students are very helpful, very enthusiastic in learning, and the teachers have agreed that the AR application developed meets the basics in occupational safety practices before using the actual tool.

Research with the same topic is from [5] which proposes an interactive AR-based application to make it easier for users to recognize network components and understand how TCP/IP works clearly. The weakness of this research is that there is no effect testing, UI and comfort also need to be improved, and the addition of an audio element. Then [6] who developed an AR application to make it easier for students to recognize computer network devices and facilitate schools due to the unavailability of adequate computer network devices, this study tends to only test AR applications on marker detection levels (pattern similarity), distance, lighting, and smartphone variations. Furthermore, [7] which proposes AR-based computer network learning media, has tested the distance, angle, and evaluation of the design aspects and application content. However, the AR application is only for desktop devices (cannot be installed on mobile applications). Besides, [8] recommends AR-based interactive media to help students find out the function of computer network devices and only tests the detection of markers such as distances and angles.

III. RESEARCH METHODOLOGY

A. *Learning Effectiveness Method*

The subjects of this study were 30 students of computer network engineering from one of the vocational high schools in Banjarmasin. The school was chosen because it had the highest percentage of problems faced and the need for innovative learning media solutions. The study on the effectiveness of AR-CoNDe as a learning medium for computer network devices to increase student scores (learning outcomes) in this study used a one-group pre-test and post-test design, which consisted of 3 steps, namely:

1. Pre-test.
2. Intervention with the AR-CoNDe application as a learning media for computer network devices.
3. Post-test.

In the design of this study, students were initially given a pre-test. Then, they were given markers from several papers and were invited to install the AR-CoNDe application on their respective smartphones. They have to go through the process of learning this computer network device using the full AR-CoNDe media to get to know and understand. Finally, the post-test is done. We will compare student grades on the pre-test and post-test.

Data normality will be tested. If the data generated is normal, then we use the dependent t-test. If the data are not normal, use Wilcoxon. We use the N-Gain score to find out how big is the difference between the pre-test and post-test as the result of the analysis in finding the effectiveness of using AR-CoNDe as a learning media for computer network devices. We adopted the N-Gain classification from [13] (See Table I).

TABLE I. N-GAIN CLASSIFICATION

Percentage (%)	Classification
N-Gain > 70	High
30 ≤ N-Gain ≥ 70	Average
N-Gain < 70	Low

In Table I is the final benchmark to determine the effectiveness of learning using the N-Gain Classification, whether later classified High, Average, or Low.

B. Evaluate the User Interface Approach

According to Bennet et al. (2012) and Dix et al. (1993) in [14] stated that the User Interface (UI) is one of the areas in Human-Computer Interaction (HCI) that is highly prioritized because an effective UI provides the potential to improve the overall performance of the system. UI design is a big challenge for designers because it requires an understanding of various disciplines such as the user's physical and cognitive abilities, the sociological context, computer science and engineering, graphic design, and the work domain.

The UI is defined as a system and users who interact with intermediaries or commands to operate a system, enter data, and use content in the system [15]. In our view, a system will be felt interesting when the user first sees a system interface that is very good and impressive to look at, and high curiosity about the system. The interface is very closely related to the design and interaction. The UI design has a very important role to connect the visual functions of the system. Furthermore [16] stated that the system interface is very useful as an intermediary to communicate with users in an interactive system.

In principle, UI and UX support each other, so that an application or system is formed which follows the design and interaction level which tends to be said to have a good UI/UX level [17]. To evaluate the UI in the application being built, an instrument in the form of a questionnaire was adapted [18]. End-users filled out questionnaires according to their perceptions and conditions when viewing and using the application, a positive Likert scale with a range of 0 to 9 was used to fill in the questionnaire scores.

C. Evaluate the User Experience Approach

User Experience (UX) according to the International Organization for Standardization (ISO) in the study [19] states that UX is defined as the results of people's thoughts and responses based on the results of using a system, product, or service. Investigation of UX, especially on mobile-based applications, has been done by [20] explaining that five categories affect UX arising through interactions with applications including user factors, social factors, cultural factors, the context of use, and product-related factors. Then by category, specific attributes are also mentioned that include motivation, user emotions, norms, social involvement, time, place, usefulness, and size.

The concept of UX presented in the study [21] states that the extent to which users are comfortable in using a product with a variety of specific objectives is most likely determined by effectiveness, efficiency, and satisfaction in the context of use. In [22] there are 26 question items for UX evaluation which are covered in six main factors namely Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. In the present study, to evaluate the User Experience Questionnaire (UEQ) was used which was adapted from [22] and [23]. For filling out the UX questionnaire, the end-user also conveys perceptions and conditions experienced when using and interacting with the application, the scale used on the UX questionnaire ranges from one to seven with a positive Likert scale.

IV. Results and Discussion

A. Learning Effectiveness Results

The data was collected through a test process by students. AR-CoNDe has facilitated the process of tests that are run on every student's smartphone. Initially, students have to open the application, understand the simulated topic through AR with many interactions, after which students select the test button.

The test process is divided into two parts, namely pre-test, and post-test. Based on the results obtained from the pre-test and post-test data, the researchers conducted a data normality test. Because N = 30, which means N <50, the reference used to test the normality of the data is Shapiro-Wilk. According to Shapiro-Wilk is a method that specializes in small samples or <50 [24]. The Shapiro-Wilk is the first test that can detect normally distributed data. By using basic data that has not been processed in a frequency distribution table, then the data is sorted and divided into two groups for amendment. Testing requirements include interval or ratio scale data (quantitative), single/ungrouped data in a frequency distribution table, and data from a random sample [25]. The results of data normality are presented in Table II.

TABLE II. Data Normality Test

Type of Test	Statistic	Df	Sig.
Pre-Test	0.800	30	0.000
Post-Test	0.902	30	0.009

Based on Table II, sig. The pre-test is 0.000 which is less than 0.005 which means that the data is not normal. For the value of sig. post-test is 0.009 which is more than 0.005 can be interpreted that the data is normal. Thus, researchers cannot use independent t-tests but use the Wilcoxon test.

The test results using Wilcoxon obtained that Asymp. Sig. (2-tailed) 0.000 which is less than 0.005. Thus there is a difference between pre-test and post-test. To determine the effectiveness of using AR-CoNDe as an educational medium for computer network devices, in this study the N-Gain test was used. The maximum score obtained by students based on the N-Gain Percentage is 100, and the minimum score is 33.33. The average value of N-Gain is 67.41, which means that the effectiveness of AR-CoNDe as an educational media for computer network devices can increase the average value of student learning outcomes. Most likely because of the recommended renewal of educational media, when learning using these media tends to look very enthusiastic and even better understand the topic so that when the test is over their scores tend to be very good.

B. Evaluation Results of the User Interface Approach

The UI assessment process is carried out after students complete the test process. The results of evaluating the UI to the AR-CoNDe application are presented in Table III.

TABLE III. UI EVALUATION RESULTS

No.	Questions	Total	Mean
General			
1	How likely are you to recommend the AR-CoNDe educational media application to your friends or colleagues?	258	8.60
How satisfied are you with the following:			
2	Quality of AR-CoNDe educational media applications.	262	8.73
3	AR-CoNDe responds to your actions/commands.	269	8.97
4	Availability of customer/user support.	268	8.93
5	The features contained in AR-CoNDe.	270	9
6	AR-CoNDe friendliness of users.	267	8.90
7	User knowledge about AR-CoNDe.	267	8.90
8	All AR-CoNDe educational media applications.	266	8.87
9	How difficult is it to read the writing on the screen?	266	8.87
10	What do you think about the arrangement of information on the screen?	267	8.90
Do you agree with the following statements:			
11	The use of terms throughout the page is consistent.	270	9
12	Laying information on the screen is consistent.	270	9
13	Suggestions for input are clear.	267	8.90
14	The AR-CoNDe application always informs the progress of actions/orders.	263	8.77
15	Error messages are very useful.	269	8.97
How difficult are the following:			
16	Learn how to use the AR-CoNDe educational media application.	268	8.93
17	Explore new features through a trial and error process.	269	8.97
18	Remembering page names and commands that have been used before.	264	8.80
19	To understand the help message on the screen.	267	8.90
20	User-friendliness of the AR-CoNDe educational media application.	269	8.97
21	Correcting your mistakes.	266	8.87
On a scale from 0 to 9, 0 is the lowest and 9 is the highest, please rate the following:			
22	AR-CoNDe educational media application speed.	268	8.93
23	The reliability of the AR-CoNDe educational media application.	268	8.93
24	Quality content available in the AR-CoNDe educational media application.	268	8.93
25	AR-CoNDe educational media application interface design.	266	8.87
26	AR-CoNDe educational media application features.	267	8.90
27	All AR-CoNDe educational media applications.	265	8.83
28	How often do you use the AR-CoNDe educational media application?	255	8.50
Total			249
Mean			8.88
Percentage of UI			98.70%

Based on data obtained from Table III, there were 28 questions submitted to 30 respondents. The full score is 270 with the average respondent choosing a score of 9. The results with an average score of 8.88 with a very strongly agree predicate that the AR-CoNDe application has a very good UI in the percentage of 98.70%. The full score was obtained in questions number 5, 11, and 12.

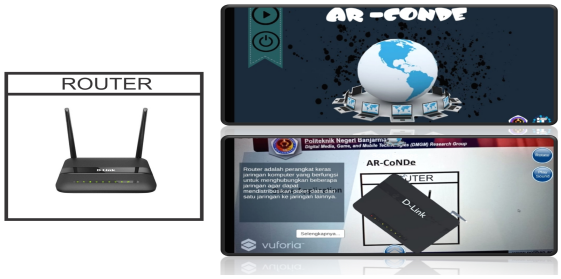

Figure 1. Router simulation on AR-CoNDe

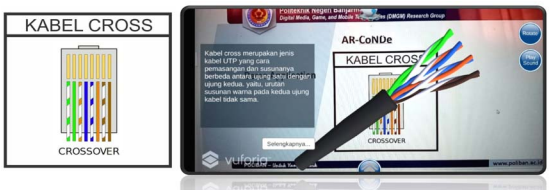

Figure 2. Network cable simulation on AR-CoNDe

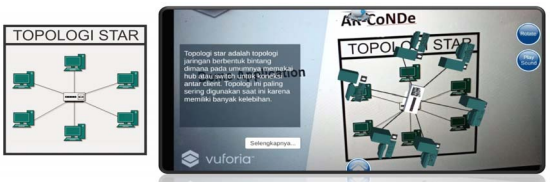

Figure 3. Topology simulation on AR-CoNDe

The interface owned by AR-CoNDe tends to be very alluring and makes the user as if curious about what the interactions are. Choosing the right color combination, layout, and content is very much needed. However, without eliminating the purpose of the AR-CoNDe application as an educational media that has benefits for students. For example, the markers and interfaces of the AR-CoNDe application are presented in Fig. 1, Fig. 2, and Fig. 3.

In Fig. 1, the markers and interface of the Router are presented, visualized the multi-interaction of the Router by rotating, seeing in full, and in more detail. Topics about the router are also included and given audio as a tool. The marker is used as a tool to detect what objects will be raised according to the program databases of the AR-CoNDe application markers that can be printed on paper or in the form of images.

From Fig. 2, a marker and interface have been presented to bring up the visualization results in the form of a network cable with a crossover type. Users can also multi-interact by rotating, sorting cables, and arranging them until they are right. The activity in arranging this network cable sequence is very complicated, will waste a lot of time, and can also consume a lot of cables. But with this solution, slowly tend to be efficient. Next to the presentation of Fig. 3 are the types of topologies that exist in the network, for example, are star topologies with the same type of multi-interaction as before. Then there are several additional questions in the form of essays from the UI questionnaire about the best part of the AR-CoNDe educational UX Evaluation Result application.

TABLE I. UX EVALUATION RESULTS

No.	Questions	Total	Mean
Attractiveness			
1	Do users feel happy using the AR-CoNDe educational media application?	210	7
2	Is the AR-CoNDe educational media application good for use?	203	6.77
3	Do users (students) like the AR-CoNDe educational media application?	210	7
4	Is the AR-CoNDe educational media application convenient to use?	209	6.97
5	Is the AR-CoNDe educational media application attractive?	206	6.87
6	Is the AR-CoNDe educational media application friendly to users?	207	6.90
Perspicuity			
7	Do users (students) find it easy to understand the performance of AR-CoNDe educational media applications?	210	7
8	Do users (students) find it easy to learn how to use the AR-CoNDe educational media application?	210	7
9	Is the AR-CoNDe educational media application simple when it is used?	210	7
10	Is the performance of the AR-CoNDe educational media application clear when used?	210	7
Efficiency			
11	Is AR-CoNDe application performance fast when used?	201	6.70
12	Is the AR-CoNDe application efficient when used as an educational media for computer network devices?	208	6.93
13	Is the AR-CoNDe application practical when used as an educational media for computer network devices?	209	6.97
14	Is the performance of the AR-CoNDe application organized?	208	6.93
Dependability			
15	Can users (students) predict errors that occur when using the AR-CoNDe educational media application?	205	6.83
16	Does the use of the AR-CoNDe application support the learning process of computer network devices?	207	6.90
17	Do users (students) feel they can safely control the interaction of the AR-CoNDe educational media application?	206	6.87
18	Does the AR-CoNDe educational media application meet user expectations?	207	6.90
Stimulation			
19	Is the AR-CoNDe educational media application useful to help learn about computer network devices?	207	6.90
20	Is the AR-CoNDe educational media application fun when used on learning computer network devices?	208	6.93
21	Are AR-CoNDe educational media application interactions interesting to support user convenience?	209	6.97
22	Can the AR-CoNDe educational media application motivate users (students) in learning computer network devices?	210	7
Novelty			
23	Is the interaction of educational media applications AR-CoNDe considered creative as a solution to facilitate learning computer network devices?	208	6.93
24	Is the AR-CoNDe educational media application copyrighted as a solution to make it easier to learn computer network devices?	207	6.90
25	Is the AR-CoNDe educational media application at the forefront as a solution to make it easier to learn computer network devices?	208	6.93
26	Is the AR-CoNDe innovative educational media application as a solution to make it easier to learn computer network devices?	209	6.97
Total			180.10
Mean			6.93
Percentage of UX			98.94%

The result is the respondent chose the option of quality information that is well presented and the features provided are quite complete The respondents also stated that the AR-CoNDe application is very interesting, needs to be further developed, useful, and rich in interactions that can support the learning process.

C. *Evaluation Results of the User Experience Approach*

The UX assessment of the AR-CoNDe application is carried out after the interface evaluation is complete. So the hope is that the users will refocus on the user's experience questionnaire. The results of the evaluation are presented in Table IV. Based on Table IV, 26 questions are mapped based on UX categories/elements. The full value is 210 with a score of 7. The questions with the results of the scores are 1, 3, 7, 8, 9, 10, and 22. Then overall it is obtained that the average value of the evaluation results of UX is 6.93 with a very strongly agree predicate that the AR-CoNDe application has adhered to the elements of user comfort percentage of 98.94%. For the average value of each element in UX namely attractiveness = 6.92, perspicuity = 7, efficiency = 6.88, dependability = 6.88, stimulation = 6.95, and novelty = 6.93.

It should be noted also that the most striking full value lies in the element of perspicuity with question numbers 7, 8, 9, and 10 which contain the understanding that the AR-CoNDe application has excellent convenience and comfort when used. User convenience is an equally important interaction with the interface. Each user has his perception of the application user experience. Users tend to like applications that are easy and convenient to use according to the principles of UX. Users feel the convenience when the computer network device devices are displayed, only with a smartphone that has the AR-CoNDe application installed they can already see, know, and understand it, without having to bring the actual device. Finally, this AR-CoNDe application can be highly recommended as a solution to attract learning interest and provide convenience in learning.

V. CONCLUSION AND FUTURE WORK

The use of AR-CoNDe has been tested with results that can increase the effectiveness of learning with a score of 67.41, then very strongly agree that the application has adopted UI with a score of 98.70%, and very strongly agree that the application has also adopted UX elements with a score of 98.94%. The AR-CoNDe application is considered very attractive in terms of interaction design, UI/UX, and makes students enthusiastic about learning. So it is highly

recommended as a solution to attract interest and provide convenience in learning computer network devices.

The recommended future work is to pilot it in many vocational high schools, make virtual learning spaces that support worker safety, and develop it into Virtual Reality (VR) and Extended Reality (XR) based applications with a touch of control technology such as leap-motion especially in network cable assembly, where large it is possible that if it is still manual it will waste a lot of RJ45 cables and connectors if students make assembly mistakes.

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