



## UTILIZATION OF AUGMENTED REALITY TO INCREASE STUDENTS' INTEREST AND CREATIVITY IN COMPUTERS AND NETWORKING SUBJECTS

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## ABSTRACT

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This study aims to examine the use of Augmented Reality (AR) technology in enhancing students' interest and creativity in the Basic Computer and Networking subject at SMK Perpajakan Riau. This subject serves as a fundamental foundation for students in the Computer and Network Engineering major to understand the basic concepts of computer hardware and networking. AR technology was used to present 3D visualizations of six main components-router, switch, motherboard, processor, VGA, and NIC-making it easier for students to understand the material in an interactive and realistic manner. The development of this learning media employed the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), while its functionality testing was conducted using the Black Box method to ensure all features operated as intended. The research methods included field observations, teacher interviews, as well as Pre-Test, Post-Test, and System Usability Scale (SUS) evaluations. The results showed an increase in the students' average score from 59.44 in the Pre-Test to 93.89 in the Post-Test, with an average N-Gain of 0.87 (high category). The SUS score of 94.5 placed the media in the "Excellent" category, indicating a very high level of user acceptance and satisfaction. These findings reflect improved student engagement, interest, and creativity in the learning process, while also creating a more engaging, interactive, and applicable learning experience.

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## 1. Introduction

Basic Computers and Networks is a compulsory subject for tenth-grade students majoring in Computer Engineering and Networking at the Riau Taxation Vocational School. This subject serves as a starting point or foundation for students' understanding of the world of computers. The Basic Computers and Networks course focuses on developing students' potential in designing computer systems and networks. According to [1], [2], mastery of basic computers and networks is an essential foundation for vocational school students to compete in the information technology-based industry.

One of the newest developments in learning media is augmented reality. Augmented reality can combine virtual objects with real-world environments. AR technology can easily visualize what's happening, making it easier for students to understand complex concepts, thus facilitating and improving learning outcomes.

Augmented Reality is a technology that can be applied to learning media. Augmented Reality is defined as a technology that combines the real world and the virtual world, is interactive, and presents three-dimensional animations. Augmented Reality is a technology that allows users to view certain situations in real time[3]–[7]. In learning media, Augmented Reality functions as a tool to increase student interest and creativity, especially in Basic Computer and Networking subjects.

The application of Augmented Reality in education has the advantage of being an educational medium that has a significant impact on students' learning of Computer and Networking material[8]–[12]. With Augmented Reality, students can see or interact directly in real time with 3-dimensional visualizations of computer components or hardware and networks. Research by [3], [12]–[18] shows that the application of Augmented Reality technology to introduce computer hardware structures has been proven to increase student learning interest, as it is able to display concrete visualizations and attract the attention of Vocational High School Computer and Network Engineering (TKJ) students to technical material that is difficult to understand theoretically.

One way to implement Augmented Reality technology in Basic Computer and Networking learning is by using the Augmented Reality tools available in Unity. Unity is a game engine widely used to develop Augmented Reality-based applications due to its comprehensive features and support for various platforms[1], [5], [18]–[21]. In development, Unity can be combined with AR SDKs such as Vuforia, ARKit, or ARCore to create interactive experiences that allow students to see, manipulate, and understand computer networking concepts in greater depth.

Using Unity, developers can create 3D models of network hardware such as routers, switches, motherboards, processors, video graphics arrays (VGAs), and network interface cards (NICs), and simulate how networks work visually and in real time.

Based on observations and interviews with a 10th-grade Computer and Networking teacher at the Riau Taxation Vocational School, it was discovered that students tended to be more interested in Mikrotik networking than other aspects of the Basic Computer and Networking course. This interest was influenced by several key factors from the students' perspective.

Students found practical network configuration using Mikrotik more engaging because it provided an interactive and practical learning experience compared to general network theory. Using Mikrotik allowed students to directly see the results of each configuration, such as IP settings, bandwidth management, and network security.

However, teachers faced several challenges in teaching Basic Computer and Networking. One of these was the limited availability of interactive learning media, which resulted in students lacking a thorough understanding of the material, especially for students and educators. The widespread use of technology as a learning medium has led to students being more enthusiastic about participating in the teaching and learning process.

## 2. Method

This research requires objective data and information to serve as a basis and reference. It is hoped that the data and information obtained can be used in the research to produce quality research. A research method is required to serve as a reference for the ongoing research process from beginning to end, as illustrated below:

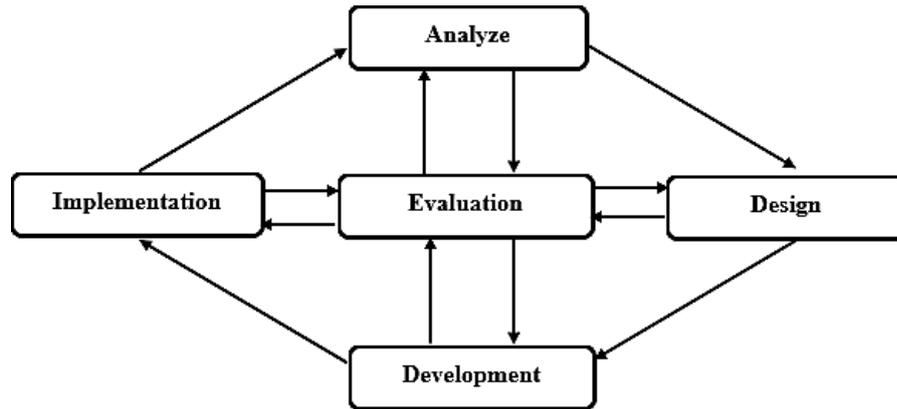


Fig. 1. Research Model Flow

This research uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The ADDIE model is often used in learning media development because it has systematic stages that support an effective learning process.

### 2.1. Analysis

This stage is conducted to analyze learning needs, identify problems, and determine appropriate solutions to increase student interest and creativity in the Basic Computer and Networking subject.

### 2.2. Design

At this stage, the design of Augmented Reality (AR) learning media is carried out by compiling learning scenarios, interface designs, and features that will be implemented. Integral State Feedback Controller consists of Integral Control and State Feedback Control. The design of Augmented Reality learning media is shown in Fig 2.

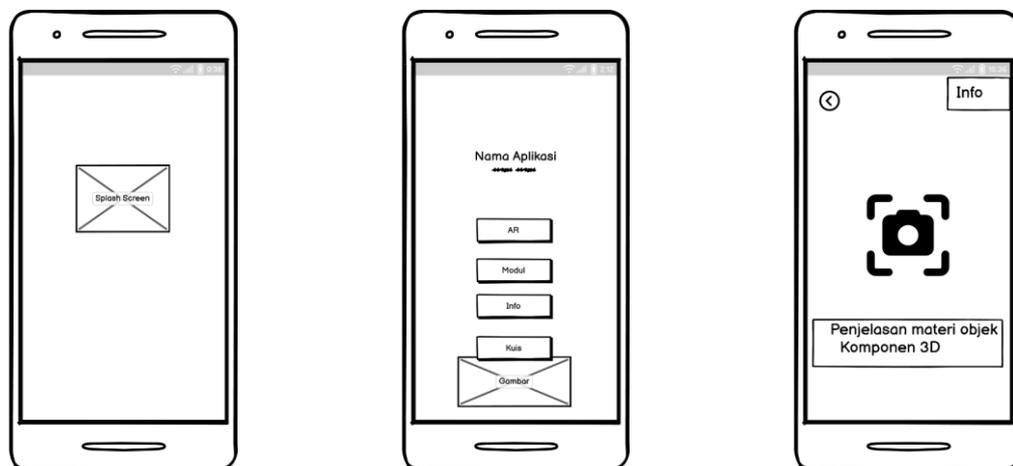


Fig. 2. Design of Augmented Reality learning media

### 2.3. Development

Implementation of the design that has been created into an Augmented Reality application using appropriate software, such as Unity and Vuforia.

## 2.4. Implementation

Testing of the AR application was carried out on class X Computer and Network Engineering (TKJ) students to measure its effectiveness in increasing student interest and creativity.

## 2.5. Evaluation

This stage aims to assess the success of the developed learning media and make necessary improvements based on observations and interviews with students and teachers.

## 3. Results and Discussion

The results of the design process are realized in the form of an integrated system that is developed into an application. At this stage, the designed system is implemented to test its performance in carrying out its designated functions. This process includes design visualization and the steps from the previous chapter, including wireframes created using Balsamiq as a guide for interface layout. The application was developed using Unity, which facilitates page flow and button functions during the system creation process. This system consists of several displays, modules, infographics, and quizzes.

### 3.1. User Interface Homepage

The initial display is the main page displayed after the splash screen and serves as the navigation center for application users. On this page, there are several main menus displayed as buttons: the "AR" button to access the Augmented Reality feature, the "Module" button to open learning materials, the "Info" button to provide the developer's personal information, and the "Quiz" button to access learning evaluations through quiz questions. The design of user interface homepage Augmented Reality learning media is shown in Fig 3.



Fig. 3. Homepage Design of Augmented Reality learning media

### 3.2. AR Page

When opening an AR page, the user is directly connected to the camera. If the camera is pointed at a component object marker, the component can be viewed in 3D and viewed in real time. The design of AR Page Augmented Reality learning media is shown in Fig 4.

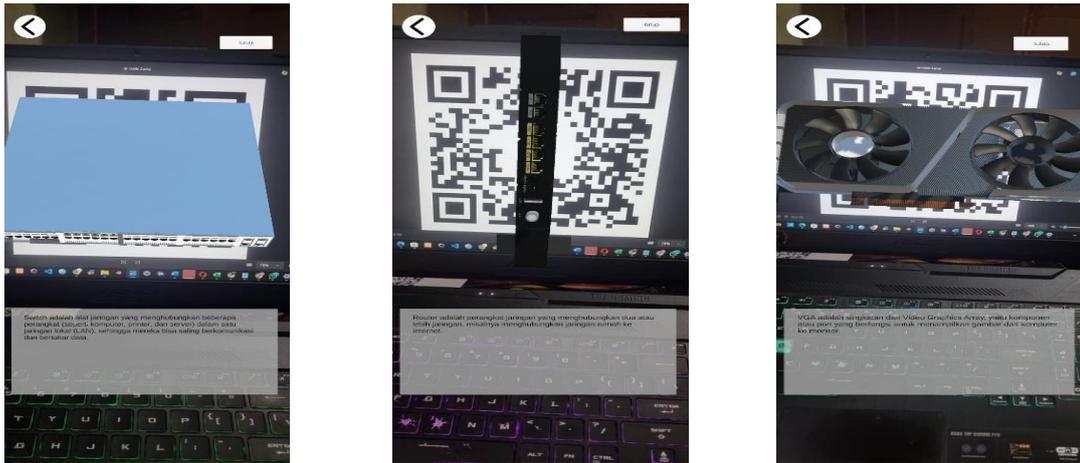


Fig. 4. Homepage Design of Augmented Reality learning media

3.3. Black box test results

Black box testing was conducted to examine the functionality of each menu access and interface within the application, such as the home page, AR menu, learning modules, information, and quiz features. This testing aimed to ensure that all buttons, displays, and navigation within the application functioned as expected. Details of the test results are shown in the table below.

3.3.1. Home Page Functionality Testing

At this stage, black box testing is performed, focusing solely on the entire functionality of the admin page. Table 1. represents black box testing of the home page.

Table 1. Home Page Blackbox Testing

No	Test steps	Action Input	Expected Output	Test Results	Status
1	Running the application	Click the application icon	The splash screen appears	√	Succeed
2	Wait for the splash screen to finish	Wait a few seconds	It will automatically switch to the main menu	√	Succeed
3	Check the function of the buttons on the home page	Click all the menu buttons	All buttons can be pressed and will navigate to the appropriate page	√	Succeed
4	Pressing the AR button	Click the "AR" button.	Enter the Augmented Reality feature	√	Succeed
5	Pressing the Module button	Click the "Module" button.	Displaying learning materials	√	Succeed
6	Press the Info and Quiz buttons	Click the "Info" and "Quiz" buttons.	Displays application information and quiz questions	√	Succeed

3.3.2. Pre-Test and Post-Test Testing

To assess the effectiveness of the Augmented Reality (AR) application as a learning medium, a pre-test and a post-test were conducted on class X-TKJ students at SMK Perpajakan Riau. This testing aimed to determine the students' level of understanding before and after using the AR application. Both the pre-test and post-test each contained 10 multiple-choice questions covering computer and networking topics. A list of the questions used can be seen in the following table. Table 2. Pre-Test and Post-Test Question List.

Table 2. Pre-Test and Post-Test Question List

No	Testing Scenario	Weight
1	What is a network device that functions to share connections to several devices in one network?	10
2	Why are switches more efficient than hubs in sending data on a local network?	10
3	A game runs slowly on a computer with an i7 CPU but uses the onboard graphics card. Why is the graphics performance low despite the powerful CPU ?	10
4	If a NIC only supports 100 Mbps but the backbone network uses 1 Gbps, then what?	10
5	The main component of a computer that is the central controller of all processes is?	10
6	The main function of the motherboard is?	10
7	What does the term "GHz" in processor specifications indicate?	10
8	What hardware is responsible for processing and displaying images on the screen?	10
9	Which device is responsible for managing data flow between computers in a local network?	10
10	In a computer, the main function of RAM is?	10

The following is a comparison of the pre-test and post-test scores of class 10-A TKJ students at Riau Taxation Vocational School before and after using the Augmented Reality application. [Table 3. Pre-Test and Post-Test Values](#)

**Table 3.** Pre-Test and Post-Test Question List

No	Name	Pre-Test Score	Post-Test Score
1	Aan Pratama Bonea	90	100
2	Adhe Muhammad Fajar	80	100
3	Aditya Pratama	40	100
4	Agil Setiyawan	60	100
5	Alfian	70	100
6	Ali Syakih Maulana	50	90
7	Andre Stivhen Marbun	60	100
8	Arikson Haykal Siagian	30	70
9	Ayesha Khairunnisa	20	100
10	Farenchiano Wil Laurentio	70	90
11	Fauzi Syahputra	90	100
12	Glorai Graceila Manurung	30	90
13	Lazuardi Pasaribu	50	90
14	Luhur Iswara Laia	60	100
15	Marvel Aurianda P	40	100
16	Muhammad Fadhil Mulyandra	70	100
17	Muhammad Riski	60	100
18	Muhammad Rizki Afdilla	70	100
19	Muuhammad Iqbal Jamil	90	100
20	Nabil Zaki	30	80
21	Nabila Aufa	80	100
22	Nanda Algusti	50	80
23	Naswa	30	80
24	Naufal Atgallah	20	70
25	Nurul Aulia Islami	80	100
26	Parna Raya Sinaga	70	100
27	Pasti Aman Mendrofa	20	90
28	Rahmat Fahlevi Putra	70	80
29	Rama Diokta Riro	50	100
30	Renditagor Situmpul	90	100
31	Rico Aldi Firmansyah	60	80
32	Rino Elvando Matondang	80	100
33	Rosita Indriyani	100	100
34	Suhaeli Alfaredi	70	90
35	Vemas Fahrezi A	60	100
36	Yogi trivaldo	50	100

Average Score

59.44

93.89

To determine the effectiveness of the developed system, a comparison was made between the students' pre-test and post-test results. The results of this comparison are presented in the following bar chart:

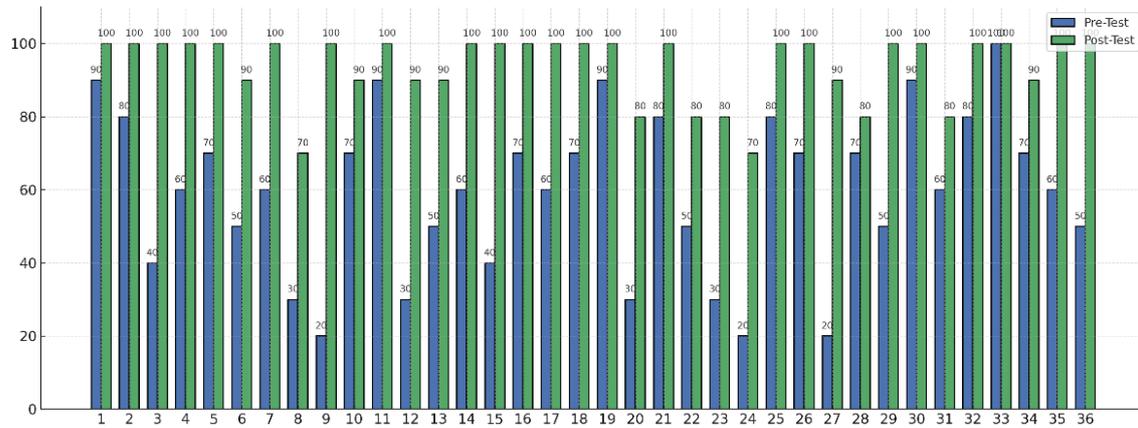


Fig. 5. Bar Chart Graph

Based on the comparison graph of pre-test and post-test scores, a significant improvement was observed after implementing the Augmented Reality application. In the pre-test, some students still received low scores, some only achieving 20–50 points, and only 6 students achieved a perfect score of 100 points. After using the application, the number of students achieving a score of 100 points increased to 23, while students with scores below 70 points decreased drastically. The majority of students then fell into the high score category (80 points and above), indicating that the application significantly improved student understanding, as reflected in the shift in the distribution of scores from the low to the high category.

### 3.3.3. System Usability Scale (SUS) Test Results

The System Usability Scale (SUS) questionnaire was used to measure the usability of the Augmented Reality (AR)-Based Learning Media application. This questionnaire consists of ten statements with five Likert-scale response options, ranging from strongly disagree to strongly agree. The purpose of using the SUS was to determine the extent to which this application can provide an easy-to-use and comfortable learning experience, and increase students' confidence in understanding technical material, such as the structure and function of computer network devices. Table 4. is a SUS Question and Table 5. is a SUS Calculation Results.

Table 4. SUS Question

No	Questionnaire	STS	TS	N	S	SS
1	I find this app easy to use.	0	0	0	8	28
2	I find this app complicated to use. (negative)	28	8	0	0	0
3	I feel like the app's features work well.	0	0	0	8	28
4	I need help from someone else or technical assistance to use this application. (negative)	22	14	0	0	0
5	I feel that most people will be able to learn to use this application quickly.	0	0	0	10	26
6	I find this application confusing. (negative)	33	3	0	0	0
7	I found it easier to understand the material because it was presented visually and interactively.	1	0	0	6	29
8	I feel this app doesn't help me in my learning process. (negative)	33	2	0	0	1
9	I feel this app makes lessons less boring.	0	0	1	5	30

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10	I feel like this app makes it difficult for me to understand the material. (negative)	33	2	0	1	0
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Table 5. SUS Calculation Results

Respondents	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	quantity	SUS Value
1	5	1	5	1	5	1	5	1	5	1	40	100
2	5	1	5	1	4	1	5	1	5	1	39	97
3	5	1	5	2	4	1	5	1	5	1	38	95
4	5	1	5	2	5	1	5	1	5	1	39	97
5	5	1	5	1	5	1	5	1	5	1	40	100
6	4	1	5	1	4	1	5	1	5	1	38	95
7	5	1	5	1	5	1	5	1	5	1	40	100
8	5	1	5	1	4	1	5	1	5	1	39	97
9	5	1	4	1	4	2	5	1	3	4	32	80
10	5	2	4	1	5	1	5	1	5	1	38	95
11	5	1	5	2	5	1	5	1	5	1	39	97
12	5	1	5	1	5	1	5	1	5	1	40	100
13	5	1	5	2	5	1	5	1	5	1	39	97
14	5	1	5	1	5	1	4	1	4	1	38	95
15	5	1	4	2	4	2	5	1	5	1	36	90
16	4	1	5	2	5	1	5	5	5	1	34	85
17	5	1	5	1	5	1	1	1	5	2	35	87
18	4	1	4	2	4	1	5	1	4	1	35	87
19	4	1	4	1	4	1	4	1	4	1	35	87
20	4	1	5	1	5	1	5	1	5	1	39	97
21	5	1	4	1	5	1	4	1	5	1	38	95
22	5	1	5	1	5	1	5	1	5	1	40	100
23	5	2	5	2	5	1	5	1	5	1	38	95
24	5	2	5	2	5	2	5	2	5	2	35	87
25	5	2	5	2	5	1	4	1	5	1	37	92
26	5	1	5	1	5	1	5	1	5	1	40	100
27	5	1	5	1	5	1	4	1	5	1	39	97
28	5	1	5	1	5	1	5	1	5	1	40	100
29	5	2	5	2	4	1	5	1	5	1	37	92
30	5	1	5	1	5	1	5	1	5	1	40	100
31	5	2	5	2	5	1	5	1	4	1	37	92
32	4	2	4	1	5	1	5	1	5	1	37	92
33	5	1	5	1	5	1	5	1	5	1	40	100

### 3.3.4. SUS Calculation Results

A total of 36 respondents completed the SUS questionnaire. Each respondent assigned a score to each of the 10 statements. Scores were then calculated using the standard SUS method: for odd-numbered statements, subtract 1 from the score; for even-numbered statements, subtract 5 from the score. The total score was multiplied by 2.5 to obtain a final score on a scale of 0–100. The

following is a summary of the SUS scores from the 36 respondents. Table 6. is a SUS Calculation Results.

**Table 6.** SUS Calculation Results

Number of Respondents	Highest SUS Score	Lowest SUS Score
36	100.0	80.0

### 3.4. Discussion

The average SUS score of 94.51 indicates that the application "Utilizing Augmented Reality to Increase Student Interest and Creativity in Computer and Networking Subjects" developed has a very high level of usability. This score is included in the Excellent (Grade A) category, which means this application is very satisfying in terms of user experience. Students found it easy to operate the application, understood the existing functions, and did not experience significant difficulties when using the application independently.

Based on the calculations, the average SUS score from 36 respondents was 94.51. This score indicates that the application is in the Excellent (Grade A) category. This means the application has a very high level of usability, is easy to understand, and is enjoyable to use. Users feel confident and experience no significant difficulties while using the application.

The test results showed a significant increase from the pre-test to the post-test scores after using the Augmented Reality human organ recognition application. The average pre-test score of 59.44 increased to 93.89 in the post-test, with an average N-Gain of 0.878, which is considered high. The majority of students achieved the maximum N-Gain (1.00), indicating that almost all students achieved optimal improvement in their abilities. This improvement indicates that the learning media used was effective in helping students understand the material, shifting the distribution of scores from the moderate to the high category, and minimizing the number of students with low achievement. These findings reinforce the positive impact of integrating AR technology into computer and network learning on learning outcomes.

Learning Basic Computer and Networking requires an understanding of fairly abstract concepts, such as network structure, hardware functions, and data communication flows. With AR-based applications, students can see and interact directly with 3D objects of network devices like routers, switches, and NICs, helping to clarify concepts previously only explained theoretically.

Increasing student interest and creativity is also a positive impact of using this technology. Engaging and interactive visualizations encourage students to be more active in their learning. This finding aligns with observations and interviews with teachers of Basic Computer and Networking subjects at the Riau Taxation Vocational School, who stated that students are more interested in learning that involves Mikrotik and AR technology.

Therefore, the application of Augmented Reality through this application is not only suitable for use as a learning medium but can also be a solution to improve the quality of hands-on and visual-based learning in the vocational school curriculum, particularly in the Computer and Network Engineering major.

## 4. Conclusion

Based on a series of research processes, including literature review, needs analysis, design, development, testing, and implementation of an Augmented Reality (AR) application for Computer and Networking subjects using the ADDIE model, it can be concluded that the use of AR has proven

effective in improving student interest and learning outcomes. This is demonstrated by increased enthusiasm, participation, and an increase in learning outcomes from an average of 59.44 to 93.89, with an N-Gain of 0.87. The developed AR application displays 3D objects of computer hardware and networks interactively and achieved a System Usability Scale (SUS) score of 94.51, categorized as Very Good, thus deeming the media highly suitable for use. Implementation in the 10th grade of the Computer and Networking Technology (TKJ) program at the Riau Taxation Vocational School (SMK Perpajakan Riau) demonstrated that the AR-based learning media has a high level of acceptance from both teachers and students.

Furthermore, this study recommends the development of more comprehensive materials and the expansion of trials in various schools to achieve a broader evaluation scope. Furthermore, it is recommended that the application be developed for various platforms, such as iOS and Windows, so that its use is not limited to Android-based devices. Further development may also include the addition of interactive features such as quizzes, network configuration simulations, or integration with other technologies such as Virtual Reality (VR) to enrich the learning experience and increase learning effectiveness.

Provide a statement that what is expected, as stated in the "Introduction" chapter, can ultimately result in the "Results and Discussion" chapter, so there is compatibility. Moreover, it can also be added the prospect of the development of research results and application prospects of further studies into the next (based on result and discussion).

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