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Development of Augmented Reality Based Learning Media to Introduce Computer Components to students in Senior High School

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ABSTRACT

This research aims to develop Augmented Reality (AR) based learning media as an educational tool to introduce computer components to high school students. AR technology was chosen because of its ability to present information interactively and realistically, so that it can improve concept understanding and motivate students in learning technical material. The research method used is Research and Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). In the development stage, the AR application was designed to visualize computer components in three dimensions (3D), equipped with function descriptions and interactive animations. Product testing was carried out through validation by media experts and material experts, as well as a limited trial to class XI students majoring in Computer and Network Engineering (TKJ) in one of the high schools in Medan City. Data was obtained through questionnaires to measure media feasibility and interviews to evaluate students' responses to the application. The results showed that this AR-based learning media was very valid with an average score of 91% in the expert validation test and received positive responses from students with a satisfaction level of 89%. The use of AR applications is proven to be able to improve students' understanding of computer components, as evidenced by an increase in pretest to posttest scores by 35%. In conclusion, this AR-based learning media is effective and feasible to use as an educational tool in high schools, especially in the introduction of computer components.

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1. INTRODUCTION

The rapid development of information and communication technology has had a significant impact on various aspects of life, including education. Technology has become one of the important components in efforts to improve the quality of learning, both in terms of methods, media, and accessibility. In the context of learning in the digital era, the use of innovative and interactive learning media is an urgent need to support a more effective learning process that is relevant to the needs of students. One of the potential technologies to be implemented in learning is Augmented Reality (AR).

Augmented Reality (AR) is a technology that integrates virtual objects into the real world in real-time through digital devices, such as smartphones, tablets, or specialized headsets. This technology allows students to interact with digital objects in a real environment, thus creating a more engaging and immersive learning experience. In technical learning, such as the introduction of computer components, the use of AR can be a solution to overcome the limitations of conventional media that tend to be passive and less attractive to students.

Computer components are one of the important materials taught to high school students, especially in the Computer and Network Engineering (TKJ) department. This material requires a deep understanding of the various parts of computer hardware along with their functions and workings. However, based on initial observations, many students have difficulty in understanding this material due to the lack of clear visualization and interesting interaction in the learning process. The learning media used today is still dominated by the lecture method and the use of textbooks, which are often less able to facilitate students' understanding optimally. [1]

To overcome these problems, the development of AR-based learning media is expected to provide an effective solution. [2]This media can present three-dimensional (3D) visualization of computer components, equipped with animation and interactive information, so that students can learn in a more interesting, intuitive, and easy-to-understand way. [3] In addition, AR technology can also increase student engagement in learning, as it provides a more realistic and immersive learning experience. [4]

This research aims to develop AR-based learning media specifically designed to introduce computer components to high school students. [5] This research will also test the effectiveness of the media in improving students' concept understanding and evaluate their responses to the use of AR technology in learning. [6]With this learning media, it is hoped that more innovative, effective, and appropriate learning methods can be created in accordance with the needs of education in the technological era. [7]

2. METHOD

This research uses the Research and Development (R&D) method to develop Augmented Reality (AR)-based learning media designed to introduce computer components to high school students. The R&D method was chosen because it allows systematic product development through structured and measurable stages, resulting in learning media that are valid, effective, and practical to use. [8] The development model applied is ADDIE (Analysis, Design, Development, Implementation, Evaluation), which consists of five main stages, namely: [9]

a. Analysis Stage.

At this stage, a needs analysis was conducted to identify existing problems in learning the introduction of computer components. [10] Data is collected through observation, interviews with subject teachers, and questionnaires to students to understand the learning difficulties they face. In addition, a literature study was conducted to determine the specifications of learning media that are in accordance with the learning needs and characteristics of high school students. [11]

b. Design Stage

The design stage involves the initial design of AR-based learning media. The design includes:

Conceptual Design: Determining the main features of the media, such as three-dimensional (3D) visualization of computer components, interactive animations, and function descriptions. [12] Visual Design: Creating storyboards and initial prototypes that illustrate the user interface and student interaction with the media. Instructional Design: Preparation of learning materials and media usage scenarios integrated with the curriculum. [13]

c. Development Stage

At this stage, AR-based learning media development is carried out using certain software, such as Unity or Vuforia, to visualize computer components in 3D. The resulting product is then validated by: Media Experts: Assess technical aspects, aesthetics, and ease of use of the media. Material Experts: Assessing the suitability of the material content with the curriculum and the accuracy of the information. The validation results were used to revise and improve the learning media before the trial was conducted. [14]

d. Implementation Stage

The learning media that has been validated and revised is implemented in class XI students majoring in Computer and Network Engineering (TKJ) in one of the high schools. [15] The trial was conducted on a limited basis to evaluate student acceptance of AR-based learning media. [16] Data collected through: Questionnaire: Measuring the level of student satisfaction with learning media. [17] Pretest and Posttest Test: Assessing the effectiveness of the media in improving students' understanding of computer components. [18]

e. Evaluation Stage

The evaluation stage aims to assess the success and effectiveness of the learning media as a whole. Evaluation is conducted in two forms: Formative Evaluation: Conducted at each stage to ensure the suitability of the product with the research objectives. Summative Evaluation: Conducted after implementation to evaluate the success of the product based on pretest and posttest results, as well as student and teacher responses. [19]

Subjects and Research Location : The subjects of this study were students of class XI majoring in Computer and Network Engineering (TKJ) in one of the high schools in Medan City. [20] The selection of subjects was carried out by purposive sampling method, namely selecting subjects that are relevant to the learning material and research needs. [21] Data Collection Techniques Data collection techniques in this study include:

a. Observation: Observing the learning process using AR media.
b. Questionnaire: Measuring students' perceptions and satisfaction with the learning media.
c. Interview: Exploring teachers' opinions on the effectiveness of learning media.
d. Pretest and Posttest: Comparing students' understanding before and after using AR-based learning media.

3. RESULTS AND DISCUSSION

This research produces an Augmented Reality (AR) based learning media designed to help high school students understand computer components visually and interactively. This media allows students to scan images of computer components using their devices and display 3D models along with explanations of their functions. Implementation and testing were conducted on 50 students from class X in one of the high schools.

1. Validity Test

Based on media and material expert validation, this learning media obtained an average score of 4.6 out of 5, indicating a category of "very valid."

a. Media experts assessed the interface and ease of use, giving an average score of 4.7.
b. Material experts assessed the accuracy of the information and relevance to the curriculum, giving an average score of 4.5.

The validity test is conducted to assess whether the learning media developed is valid or feasible to use based on expert judgment. The following are the steps to calculate the validity test value:

Create a validation sheet or questionnaire to be given to validators (media experts and material experts). Use a Likert scale: 1 = Not Very Good, 2 = Not Good, 3 = Good enough, 4 = Good, 5 = Very Good

2. Calculating the Validity Score.

Total all scores given by validators for each indicator. Use the following formula to calculate the average validity score: $v = \frac{\sum S}{N}$

Where:

v = Average validity score.
$\sum s$ = Total score given by the validator.
N = Number of indicators assessed.

After getting the average score, interpret the results based on the validity category, for example:

4,2 - 5,0: Very Valid (suitable for use without revision).
3,4 - 4,1: Valid (suitable for use with minor revisions).
2,6 - 3,3: Fairly Valid (needs revision).
1,8 - 2,5: Invalid (needs major revision).
1,0 - 1,7: Very Invalid (not suitable for use).

If there are 2 validators with a total of 10 indicators, the score given by the validator is as follows:

Validator 1: Total score = 45
Validator 2: Total score = 47

$$v = \frac{45 + 47}{10} = 4.6$$

These results indicate that the media is in the Very Valid category.

3. Practicality Test

The results of the practicality questionnaire filled out by teachers showed an average score of 4.5, confirming that this media is easy to integrate in learning. Teachers appreciated its ability to increase students' interest in learning.

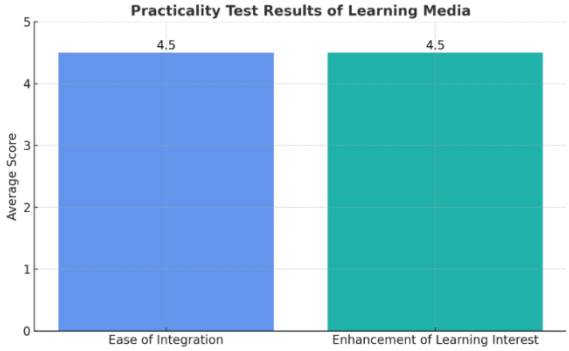

Figure1. Diagram of Practicality Test Results

4. Effectiveness Test
Testing is done by comparing student learning outcomes before and after using AR media.
Pretest: The average student score was 68.4.
Posttest: The average student score increased to 87.2, with an increase of 27.4%.
The effectiveness test aims to determine the extent to which the learning media developed is able to improve student learning outcomes. In the context of this study, a comparison was made between the results of the pretest (before the use of media) and posttest (after the use of media). The following are the steps:
a. Collecting Data
Pretest: The average value of students' initial test results before using AR media. In this example, the pretest average is 68.4.
Posttest: The average value of the test results after using AR media. In this example, the average posttest is 87.2.
b. Calculating Grade Improvement
To calculate the average score improvement, use the formula: Improvement=Posttest-Pretest, Improvement = 87,2−68,4=18,8
c. Calculating the Percentage of Improvement
The formula for calculating the percentage of improvement is:

$$\text{Percentage Increase} = \frac{\text{Improvement}}{Pretest} \text{ x } 100\%$$

$$\text{Percentage Increase} = \frac{18,8}{68,4} \text{ x } 100\% = 27,5\%$$

The following is the process of making Augmented Reality introduction to computer components.

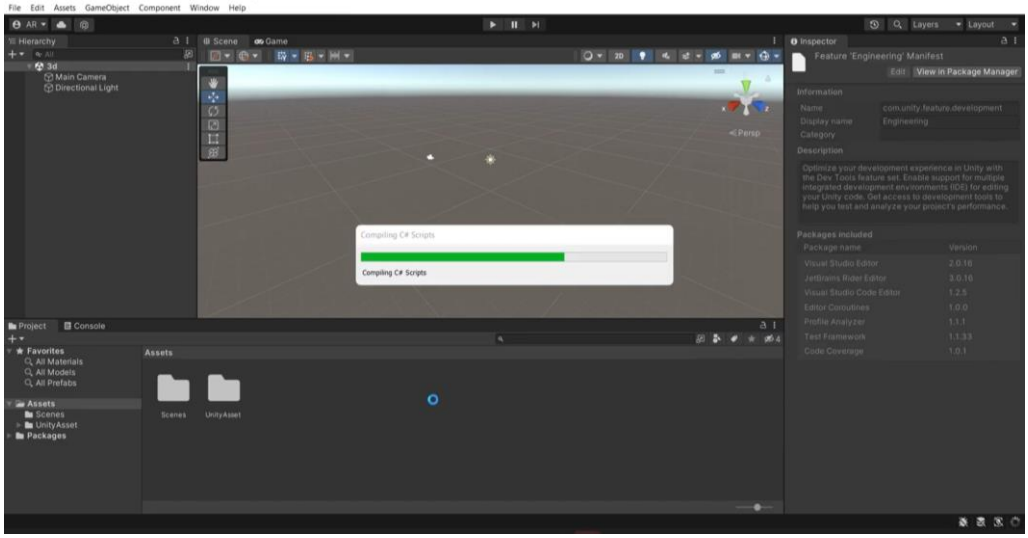

Figure 2. Augmented reality creation process

The following is the display result of Augmented reality:

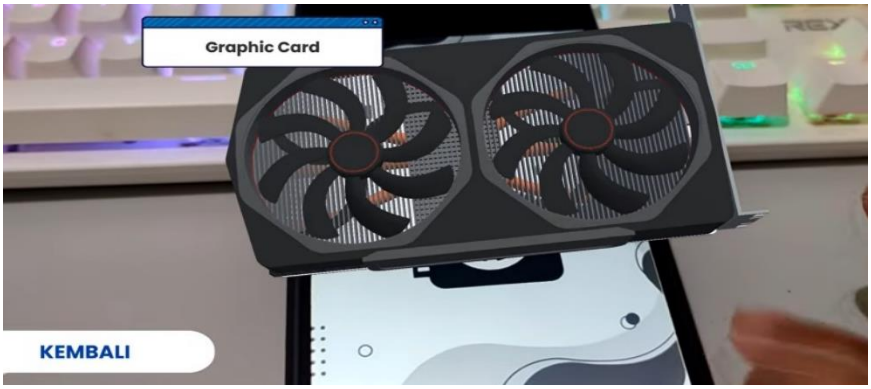

Figure 3. Augmented reality result from mobile phone

The results of this study show that AR-based learning media has a positive influence on students' understanding of computer components. The main advantage of this media lies in the 3D visualization that makes it easier for students to understand the physical form and function of each component in detail.
Some key points to focus on:
a. Increased Interest in Learning:
AR provides a more engaging learning experience than conventional methods. Students are more motivated to learn because this media is interactive.
b. Media Effectiveness:
Analysis of pretest and posttest results proves that AR-based media can significantly improve student learning outcomes. This is in line with previous research which states that AR technology is effective in visual-based learning.
Obstacles and Solutions: The main obstacle was the need for devices with certain specifications to run the AR application. The solution was to provide devices in the school laboratory so that students could use the media in turn. Some students need more time to understand how the application works, so a short training is given before the learning begins.

4. CONCLUSION

This research aims to develop Augmented Reality (AR) based learning media that is effective in introducing computer components to high school students. Testing was conducted to evaluate the validity, practicality, and effectiveness of learning media. The following results were obtained:
1. Validity of Learning Media. The validity assessment was conducted by two experts, namely media experts and material experts, using a validation sheet with a scale of 1-5.
a. Media Expert Validation Results:
The learning media obtained an average score of 4.7, indicating that the design aspects, ease of navigation, and user interface are very good.
b. Material Expert Validation Results:
The average score obtained was 4.5, with positive assessments on the suitability of the material to the curriculum and the accuracy of the information.
The overall average validity score: 4.6 (very valid category). This indicates that this media is suitable for use without significant revision.
2. Practicality of Learning Media. Practicality assessment was conducted through a questionnaire given to teachers. The result:
a. Ease of Integration: The average score is 4.5, indicating that this media is easy to use in learning, both in class and independently by students.
b. Increased Interest in Learning: The average score is 4.5, indicating that students feel motivated to learn by using this media.
c. Overall average practicality score: 4.5 (very practical category).
3. Effectiveness of Learning Media
The effectiveness of the media is measured by comparing the results of students' pretests and posttests before and after using AR learning media: a. Pretest: The average student score was 68.4. b. Posttest: The average student score increased to 87.2. c. Average Increase: 18.8 points or 27.5%.
These results show that AR-based media can significantly improve students' understanding of computer components.

REFERENCES

[1] M. L. Hamzah, Ambiyar, F. Rizal, W. Simatupang, D. Irfan, and Refdinal, "Development of Augmented Reality Application for Learning Computer Network Device," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 15, no. 12, pp. 47–64, Jun. 2021, doi: 10.3991/IJIM.V15I12.21993.

[2] F. Kalyoncu and H. Karal, "Design and development of augmented reality application for basic concepts of computer systems," *Educ Inf Technol (Dordr)*, pp. 1–29, Sep. 2024, doi: 10.1007/S10639-024-12971-X/METRICS.

[3] X. Lin, J. Song, M. An, and Z. Li, "The Application of Computer Augmented Reality Technology to Landscape Design," *Procedia Comput Sci*, vol. 243, pp. 187–196, Jan. 2024, doi: 10.1016/J.PROCS.2024.09.025.

[4] B. Ferdiman, H. Al Akbar, M. R. Faturrahman, and F. I. Maulana, "Development of Augmented Reality Application in Physics through Newton's Laws and Object Interaction," *Procedia Comput Sci*, vol. 227, pp. 699–708, Jan. 2023, doi: 10.1016/J.PROCS.2023.10.574.

[5] A. Revolti, P. Dallasega, F. Schulze, and A. Walder, "Augmented Reality to support the maintenance of urban-line infrastructures: A case study," *Procedia Comput Sci*, vol. 217, pp. 746–755, Jan. 2023, doi: 10.1016/J.PROCS.2022.12.271.

[6] T. Westin, R. Rahmani, M. Palosaari-Eladhari, and M. Romero, "An extended reality platform for inclusion of adults on the autism spectrum: a position paper," *Procedia Comput Sci*, vol. 238, pp. 476–483, Jan. 2024, doi: 10.1016/J.PROCS.2024.06.050.

[7] C. Macariu, A. Iftene, and D. Gîfu, "Learn Chemistry with Augmented Reality," *Procedia Comput Sci*, vol. 176, pp. 2133–2142, Jan. 2020, doi: 10.1016/J.PROCS.2020.09.250.

[8] M. Di Capua, A. Ciaramella, and A. De Prisco, "Machine Learning and Computer Vision for the automation of processes in advanced logistics: the Integrated Logistic Platform (ILP) 4.0," *Procedia Comput Sci*, vol. 217, pp. 326–338, Jan. 2023, doi: 10.1016/J.PROCS.2022.12.228.

[9] A. Iftene, D. Trandabat, and V. Radulescu, "Eye and Voice Control for an Augmented Reality Cooking Experience," *Procedia Comput Sci*, vol. 176, pp. 1469–1478, Jan. 2020, doi: 10.1016/J.PROCS.2020.09.157.

[10] S. M. Satapathy, R. Jhaveri, U. Khanna, and A. K. Dwivedi, "Smart Rent Portal using Recommendation System Visualized by Augmented Reality," *Procedia Comput Sci*, vol. 171, pp. 197–206, Jan. 2020, doi: 10.1016/J.PROCS.2020.04.021.

[11] G. Kostov and J. Wolfartsberger, "Designing a Framework for Collaborative Mixed Reality Training," *Procedia Comput Sci*, vol. 200, pp. 896–903, Jan. 2022, doi: 10.1016/J.PROCS.2022.01.287.

[12] Y. Daineko, D. Tsoy, M. Ipalakova, A. Mustafina, Z. Bolatov, and A. D. Samala, "Development of the Software agent «AIA» in the framework of IITU MetaUniversity Design," *Procedia Comput Sci*, vol. 238, pp. 870–875, Jan. 2024, doi: 10.1016/J.PROCS.2024.06.105.

[13] J. P. Herrmann, A. Atanasyan, F. Casser, and S. Tackenberg, "A Petri Net Architecture for Real-Time Human Activity Recognition in Work Systems," *Procedia Comput Sci*, vol. 217, pp. 1188–1199, Jan. 2023, doi: 10.1016/J.PROCS.2022.12.317.

[14] P. Y. Lin *et al.*, "The use of augmented reality (AR) and virtual reality (VR) in dental surgery education and practice: A narrative review," *J Dent Sci*, vol. 19, pp. S91–S101, Dec. 2024, doi: 10.1016/J.JDS.2024.10.011.

[15] H. N. Mai, Y. G. Kim, S. H. Cho, T. Joda, and D. H. Lee, "Enhancing dental education with a 3D point cloud comparison and augmented reality for auto-evaluation of fixed prosthodontic practice: An in vitro study," *J Dent*, vol. 153, p. 105493, Feb. 2025, doi: 10.1016/J.JDENT.2024.105493.

[16] Z. Zhou, F. Oveissi, and T. Langrish, "Applications of augmented reality (AR) in chemical engineering education: Virtual laboratory work demonstration to digital twin development," *Comput Chem Eng*, vol. 188, p. 108784, Sep. 2024, doi: 10.1016/J.COMPCHEMENG.2024.108784.

[17] B. Upadhyay, C. Brady, K. Chalil Madathil, J. Bertrand, N. J. McNeese, and A. Gramopadhye, "Collaborative augmented reality in higher education: A systematic review of effectiveness, outcomes, and challenges," *Appl Ergon*, vol. 121, p. 104360, Nov. 2024, doi: 10.1016/J.APERGO.2024.104360.

[18] P. L. Lai *et al.*, "Achieving new excellence in an augmented reality dental education system," *J Dent Sci*, vol. 19, pp. S136–S142, Dec. 2024, doi: 10.1016/J.JDS.2024.07.023.

[19] C. M. Rebello, G. F. Deiró, H. K. Knuutila, L. C. de S. Moreira, and I. B. R. Nogueira, "Augmented reality for chemical engineering education," *Education for Chemical Engineers*, vol. 47, pp. 30–44, Apr. 2024, doi: 10.1016/J.ECE.2024.04.001.

[20] J. Dabass, M. Dabass, and B. S. Dabass, "Revolutionizing healthcare and medical education using augmented reality, virtual reality, and extended reality," *Leveraging Metaverse and Analytics of Things (AoT) in Medical Systems*, pp. 209–229, Jan. 2025, doi: 10.1016/B978-0-443-24049-2.00004-2.

[21] K. J. Handoyo, C. J. Wisnuwardana, A. Austen, and F. Permana, "Molecule World: Enhancing chemistry education through web-based augmented reality using Assemblr," *Procedia Comput Sci*, vol. 245, pp. 1249–1258, Jan. 2024, doi: 10.1016/J.PROCS.2024.10.354.