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Development Of An Augmented Reality-Based Android Educational Game For Learning Computer Networking Materials For Class X Vocational School Students

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Abstract

This study aims to develop an Android-based educational game integrating Augmented Reality (AR) and the Fisher-Yates Shuffle algorithm for teaching Computer Networks to 10th-grade vocational high school (SMK) students, while also assessing its feasibility, impact on student learning motivation, and effect on learning outcomes. The study employs a Research and Development (R&D) approach using the ADDIE model, comprising the Analysis, Design, Development, Implementation, and Evaluation stages. Data were collected through expert validation, student response questionnaires, learning motivation questionnaires, and pre-test and post-test assessments. The results indicate that the developed media achieved validation scores of 96% from the subject matter expert, 96% from the test grid expert, and 98% from the media expert, yielding an overall average of 96.67%, which is classified as highly valid. Student responses and learning motivation were rated as excellent and high, respectively, across individual, small-group, and large-group trials. N-Gain results showed figures of 92% for the individual trial, 75% for the small-group trial, and 59% for the large-group trial. Based on these findings, the developed educational game is considered highly valid and suitable for use as an alternative learning medium for Computer Network topics.

Keywords: educational game, augmented reality, fisher-yates shuffle, learning motivation, students understanding

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INTRODUCTION

The development of information technology in the digital era has brought significant changes to education. Technology-based learning media can support more interactive, engaging, and student-centered learning experiences. One technology that has increasingly been applied in education is Augmented Reality (AR), which enables virtual three-dimensional objects to be presented within a real-world environment. This capability allows abstract learning concepts to be visualized more concretely and can support students in understanding learning materials. In addition, Android-based learning media provides flexibility because students can access learning activities through mobile devices.

Computer Network material at the Vocational High School (SMK) level requires students to understand concepts and identify the functions and characteristics of various network devices. Based on observations and interviews conducted at SMK Al-Baisuny Bangkalan, the learning process was still dominated by lectures, textbooks, and presentation slides. Limited laboratory facilities and the suboptimal use of interactive learning media created difficulties for students in understanding the forms and functions of computer network devices. These conditions were also associated with low student motivation and difficulties in understanding the learning materials.

Several previous studies have demonstrated the potential of educational games and Augmented Reality as learning media. Diana et al. (2024), for example, developed an Android-based educational game for teaching internet connectivity materials to Grade X TKJ students and reported that the developed media was feasible for learning. Simaremare et al. (2022) developed an Augmented Reality-based educational game and reported its potential to support students' conceptual understanding through three-dimensional visualization. Similarly, Annail et al. (2025) reported that Augmented Reality-based interactive media could support students' learning motivation. In addition, Nadeem et al. (2023) reported that digital game-based learning can support student engagement and motivation, while Sakr and Abdullah (2024), through a systematic review, highlighted the potential of virtual and augmented reality technologies to support learners' engagement, motivation, and learning experiences. These studies indicate that educational games and AR can provide meaningful support for learning. However, previous studies generally focused on either educational game development or AR-based learning media, while the integration of AR visualization, an Android-based educational game, and a quiz-question randomization mechanism using the Fisher-Yates Shuffle algorithm within a single learning medium remains less explored, particularly for Computer Network materials at the vocational school level.

The Fisher-Yates Shuffle algorithm provides a mechanism for randomly arranging elements in a sequence. In this study, the algorithm is applied to the quiz component to generate varied question sequences for students. Meanwhile, AR is used to visualize computer network devices as three-dimensional objects. The combination of these functions is designed to provide an interactive learning experience in which students can study the material, explore visual representations of network devices, and complete learning evaluations within the same application.

The novelty of this study therefore lies not merely in the use of AR, educational games, or the Fisher-Yates Shuffle algorithm individually, but in their integration into an Android-based learning medium specifically designed for Computer Network learning at the Grade X vocational school level. The study also evaluates the developed product through several aspects, including expert feasibility validation, student responses, learning motivation, and learning gains based on pretest and posttest results. This combination provides an integrated evaluation of the developed learning medium while maintaining the focus of the study as a Research and Development (R&D) project.

Based on the identified problems and research gap, this study aims to: (1) develop an Android-based educational game integrating Augmented Reality and the Fisher-Yates Shuffle algorithm for Computer Network learning among Grade X vocational school students; (2) determine the feasibility of

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the developed learning media based on expert validation and student responses; and (3) describe students' learning motivation and learning gains after using the developed media.

METHODS

This study is a Research and Development (R&D) project aimed at developing an Android-based educational game incorporating Augmented Reality (AR) technology. The game focuses on Computer Network topics for 10th-grade students majoring in Computer and Network Engineering (TKJ) at SMK Al-Baisuny. The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model was employed. The research was conducted at SMK Al-Baisuny Bangkalan during the even semester of the 2025/2026 academic year.

The research stages based on the ADDIE model are illustrated in Figure 1. The Analysis stage involved observations, interviews with the subject teacher, curriculum review, analysis of student characteristics, and identification of learning media requirements. The Design stage encompassed the creation of flowcharts, storyboards, the application interface, learning content, and the evaluation plan. The Development stage involved building the application using Unity, integrating Vuforia as the Augmented Reality Software Development Kit (SDK), and implementing the Fisher-Yates Shuffle algorithm for the quiz feature. The developed product was subsequently validated by subject matter experts, media experts, and assessment instrument experts. The Implementation stage was carried out through individual, small-group, and large-group trials involving 10th-grade TKJ students. Finally, the Evaluation stage utilized the results from expert validation and student implementation trials as a basis for refining the developed learning media. Figure 1 shown research stages using the ADDIE Model.

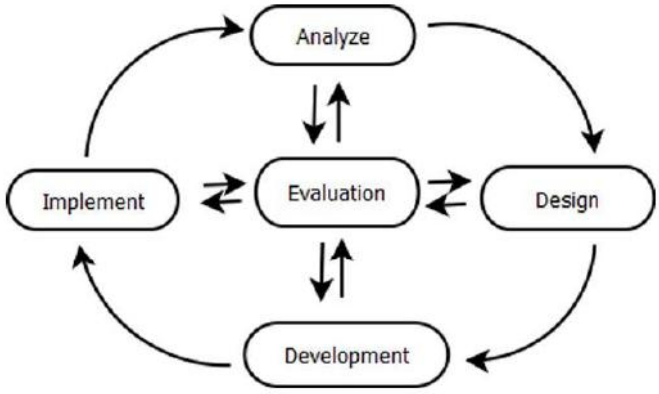


Fig 1. Research stages using the ADDIE

The implementation trial involved 30 Grade X TKJ students at SMK Al-Baisuny. The process comprised an individual trial with 2 students, a small-group trial with 5 students, and a large-group trial with 23 students. While the thesis documentation lists the number of participants and the trial stages, it does not explicitly report a formal sampling technique; therefore, the participants are described based on the product trial stages documented in the study.

Data collection techniques included observation, interviews, expert validation, student response questionnaires, learning motivation questionnaires, and pre-test and post-test assessments. Research instruments consisted of validation sheets for subject matter experts, media experts, and test blueprint experts, as well as student response questionnaires, learning motivation questionnaires, and learning outcome test items. Expert validation instruments were used to determine the feasibility of the developed learning media, whereas student response questionnaires, learning motivation questionnaires, and pre-test and post-test assessments were used to describe student responses, learning motivation, and improvements in learning outcomes following the use of the developed media.

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Expert validation involved subject matter experts, test blueprint experts, and media experts. Each aspect was evaluated using a five-point Likert scale ranging from 1 to 5. A score of 5 represented "Highly Feasible," 4 "Feasible," 3 "Moderately Feasible," 2 "Not Feasible," and 1 "Highly Not Feasible." The resulting percentages were calculated using Equation (1):

$$P = \frac{\sum X}{\sum X_i} \times 100\%$$

Description:
P = percentage of assessment results (%)
$\sum X$ = total score obtained
$\sum X_i$ = maximum total score

The percentage results were interpreted using the validation criteria presented in Table 1. These criteria were applied to the assessments from material experts, question-grid experts, media experts, and student responses.

Table 1. Expert validation and student response criteria.

Percentage	Validity Categories	Remarks
80% < P ≤ 100%	Highly Valid	Very feasible, no revision required
60% < P ≤ 80%	Valid	Feasible, minor revision
40% < P ≤ 60%	Quite Valid	Requires revision
20% < P ≤ 40%	Less Valid	Requires major revision
0% < P ≤ 20%	invalid	Not feasible

Source: Adapted from Selindawati et al. (2024).

Students' learning motivation was measured using a questionnaire administered after they had used the developed learning media. The questionnaire employed a Likert scale, and the data were analyzed descriptively to determine the level of students' learning motivation. The percentage of learning motivation was calculated using the equation (2).

$$P = \frac{\sum \text{Skor}}{\text{Skor Maksimal}} \times 100\%$$

Description:
P = Percentage of students' level of learning motivation
$\sum$Skor = Number of student answer scores
Skor Maksimal = Highest score × number of statement items

The results of the percentage of learning motivation are then interpreted based on the criteria in Table 2.

Table 2. Learning Motivation Criteria

Percentage	Categories
X < 47%	Low
47% ≤ X < 73%	Medium
X ≥ 73%	Height

Source: Adaptation of Hair et al. (2022).

Student learning gains were analyzed using the Normalized Gain (N-Gain) based on pretest and posttest scores. The N-Gain was calculated using Equation (3).

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$$\text{N-Gain} = \frac{X_{posttest} - X_{pretest}}{X_{maksimum} - X_{pretest}}$$

Description:

$X_{posttest}$ = Posttest score

$X_{pretest}$ = Pretest score

$X_{maksimum}$ = Ideal maximum score

The N-Gain value was converted into a percentage and interpreted according to the effectiveness criteria presented in Table 3.

Table 3. N-Gain Effectiveness Criteria

Percentage	Categories
≤ 40%	Ineffective
40% ≤ P < 50%	Less Effective
50% ≤ P < 75%	Quite Effective
≥ 75%	Effective

Source: Adapted from Hidayat et al. (2024).

The quantitative data obtained from expert validation, student responses, learning motivation questionnaires, and pretest-posttest assessments were analyzed descriptively. Qualitative data in the form of comments and suggestions from validators were used as a basis for revising and improving the developed learning media. The results of the individual, small-group, and large-group trials were then described to identify differences in student responses, learning motivation, and learning gains across the stages of product implementation.

RESULTS AND DISCUSSION

A. Learning Media Development Results

The learning medium developed in this study is an Android-based educational game that integrates Augmented Reality (AR) technology and the Fisher-Yates Shuffle algorithm to teach Computer Network concepts to 10th-grade vocational high school (SMK) students. The medium was developed using the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation.

During the Analysis stage, observations and interviews were conducted to identify learning issues, student characteristics, curriculum requirements, and learning media needs. The analysis revealed that students struggled to understand Computer Network material, particularly in recognizing the forms and functions of network devices. The limited availability and use of interactive learning media also indicated a need for a medium capable of providing a more concrete and engaging learning experience.

In the Design stage, the learning content, flowcharts, storyboards, user interface, AR components, and evaluation activities were planned. The learning medium was designed to incorporate instructional content, 3D visualizations of Computer Network devices, educational game activities, quizzes, and learning outcome displays.

During the Development stage, the application was built using the Unity platform. Vuforia was integrated as the AR software development kit (SDK), while the Fisher-Yates Shuffle algorithm was applied to the quiz feature to randomize the question order. The developed product was subsequently validated by subject matter experts, assessment instrument experts, and media experts.

In the Implementation stage, the developed medium was tested with 10th-grade students majoring in Computer and Network Engineering (TKJ) through individual, small-group, and large-group trials.

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Students used the application, completed student response and learning motivation questionnaires, and took both pre-tests and post-tests.

The key features of the developed medium include a main menu, learning content, AR-based visualizations of Computer Network devices, an educational game, an interactive quiz, and a learning results page. The AR feature allows students to view three-dimensional representations of network devices via a smartphone camera, while the Fisher-Yates Shuffle algorithm generates varied question sequences for the quiz feature.

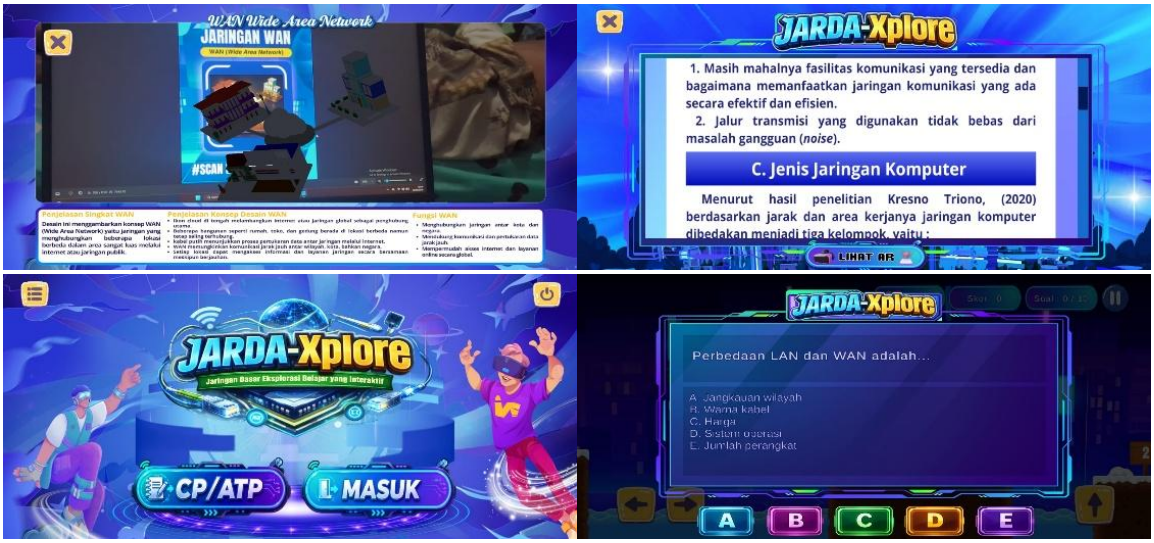


Fig 2. Augmented Reality-Based Educational Game Display

B. Product Validation Results

The developed learning media was validated before being implemented with students. Validation involved material experts, question-grid experts, and media experts. The results are presented in Table 4.

Table 4. Learning Media Validation Results

Validator	Percentage	Categories
Media Expert	96%	Highly Valid
Question Grid Expert	96%	Highly Valid
Media Member	98%	Highly Valid
Average	96,67%	Highly Valid

Source: Data from research results (2026).

Based on Table 4, the developed learning media obtained an average validation score of 96.67%, which was categorized as highly valid. The material expert and question-grid expert assessments each obtained 96%, indicating that the learning content and evaluation blueprint were considered appropriate for the intended learning objectives. The media expert assessment obtained the highest percentage of 98%, indicating that the interface, navigation, and technical aspects of the developed application met the assessment criteria.

The high validation results indicate that the developed media had fulfilled the requirements for implementation in the student trials. The results are consistent with previous research reporting the feasibility of Android-based educational games and AR-based learning media. However, the present study combines AR visualization with an educational game and Fisher-Yates Shuffle-based question randomization within one learning application.

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C. Media Implementation Results

The implementation was conducted through three stages: individual, small-group, and large-group trials. The aspects measured included student responses, learning motivation, and learning gains based on pretest and posttest results.

1. Student Response

The results of the student response questionnaire showed that the media received a very good response at each stage of the trial.

Table 5. Student Response Results

Trial Stage	Percentage	Categories
Individual	86%	Excellent
Small Groups	92%	Excellent
Large Group	90%	Excellent

Source: Data from research results (2026).

The research results shown in Table 5 indicate that student response rates were 86% for the individual trial, 92% for the small-group trial, and 90% for the large-group trial. All three trial stages were rated as "very good."

The increase from 86% in the individual trial to 92% in the small-group trial demonstrates that the media was well-received when used by a small number of students. Although the percentage dipped slightly to 90% during the large-group trial, it remained within the "very good" category. These results show that the developed media maintained a positive level of acceptance when applied to a larger group of students.

This positive response can be attributed to the combination of learning materials, game activities, AR visualizations, and interactive quizzes within a single application. The AR feature presents visual representations of computer network devices, while the game and quiz components provide interactive activities throughout the learning process.

2. Student Learning Motivation

Students' learning motivation is measured using a questionnaire after the learning process is completed.

Table 6. Learning Motivation Results

Trial Stage	Percentage	Categories
Individual	88%	High
Small Groups	84%	High
Large Group	88%	High

Source: Data from research results (2026).

As shown in Table 6, learning motivation reached 88% in the individual trial, decreased to 84% in the small-group trial, and increased again to 88% in the large-group trial. All results were categorized as high according to the criteria used in the study.

The results indicate that students reported a high level of motivation after using the developed learning media across all three trial stages. The relatively consistent percentages suggest that the media was able to maintain students' interest and attention during the learning activities. The AR visualization and interactive game components provide students with opportunities to interact with learning content rather than relying solely on conventional presentation of materials.

These findings are consistent with Annail et al. (2025), who reported that AR-based interactive learning media can support students' learning motivation by providing a more interactive learning experience. In the present study, the AR component was integrated with an educational game and quiz

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activities, allowing students to access learning materials and learning activities within the same application.

3. Student Understanding

The effectiveness of learning media was analyzed using the Normalized Gain (N-Gain) value based on the results of the pretest and posttest.

Table 7. N-Gain Analysis Results

Trial Stage	N-Gain Value	Categories
Individual	92%	Effective
Small Groups	75%	Quite Effective
Large Group	59%	Quite Effective

Source: Data from research results (2026).

As shown in Table 7, Tte individual trial produced an N-Gain of 92%, the small-group trial produced 75%, and the large-group trial produced 59%. Based on the N-Gain criteria used in this study, the individual trial was categorized as effective, while the small-group and large-group trials were categorized as quite effective.

The difference among the three trial stages provides an important finding. The individual trial produced the highest N-Gain value of 92%. In this stage, only two students participated, allowing the media to be used in a highly limited trial setting. The small-group trial involving five students produced an N-Gain of 75%, while the large-group trial involving 23 students produced an N-Gain of 59%. The decreasing N-Gain values across the trial stages should not be interpreted as evidence that the media became less useful; rather, the results indicate differences in learning gains among groups with different numbers and characteristics of participants.

The individual trial results also show that both participating students improved from their pretest scores of 35 and 40 to posttest scores of 95. The resulting N-Gain for both students was 92%. In the small-group trial, the individual N-Gain values varied from 55% to 100%, with an average of 75%. This variation indicates that students did not experience identical levels of learning gain after using the media.

The larger variation was observed in the large-group trial. The individual N-Gain scores ranged from negative values to 100%, with an average of 59%. This indicates that the overall group result was influenced by differences in students' individual pretest and posttest performance. For example, several students obtained high N-Gain values, while some students showed limited improvement or decreased posttest scores. Therefore, the large-group average provides a description of the overall learning gain of the group rather than indicating that every student experienced the same level of improvement.

These findings also highlight the importance of considering individual variation when interpreting N-Gain results. The study used a pretest-posttest design without a control or comparison group. Therefore, the observed increases in scores can be described as learning gains following the implementation of the media, but they should not be interpreted as evidence of a causal effect of the media alone.

Overall, the implementation results show that the developed media received excellent student responses, maintained high learning motivation, and was accompanied by positive learning gains across the three trial stages. The combination of Android-based educational games, AR visualization, and Fisher-Yates Shuffle-based quiz randomization provides an integrated learning environment for Computer Network materials.

CONCLUSION

This study developed an Android-based educational game integrating Augmented Reality (AR) technology and the Fisher-Yates Shuffle algorithm to teach Computer Networking to 10th-grade

vocational high school (SMK) students, utilizing the ADDIE development model. Expert validation yielded an average score of 96.67%, indicating that the developed learning medium is highly valid and suitable for implementation.

Implementation results showed positive student responses during individual, small-group, and large-group trials, with approval rates of 86%, 92%, and 90%, respectively. Student learning motivation was high, with scores of 88%, 84%, and 88%. N-Gain results showed figures of 92% for individual trials, 75% for small-group trials, and 59% for large-group trials. These results indicate a positive improvement in learning outcomes following the use of the medium, although the magnitude of improvement varied across the trial groups.

This study was limited to a single school and the 10th-grade Computer and Network Engineering curriculum, and it did not involve a control or comparison group. Consequently, the findings reflect the feasibility, student response, motivation, and learning outcome improvements observed during implementation, rather than establishing a causal relationship regarding the use of the medium. Future research could involve more diverse schools and participants, a broader scope of learning material, and a comparative research design to examine the learning outcomes associated with the developed medium in greater depth. Future development could also consider the use of markerless Augmented Reality and the addition of interactive features.

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