Development of android-based educational games about the domain of educational technology

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Abstract

This research aims to produce an Android game product containing TP Domain material that is feasible as an alternative learning media for Raharja University students. The feasibility value is known through expert assessment, potential users, and learning usability. Product development was carried out through five main stages: preliminary study, planning, design, development, and evaluation. Data collection was carried out by preliminary study interviews, learning style identification, expert validation, potential user validation, and experimental testing. The number of respondents consisted of one lecturer, two media and material experts, and 60 students. The results showed that the developed product has met the eligibility criteria of media validation, material, prospective users, and usability testing. The material expert’s assessment falls into the very feasible category, while media experts and prospective users fall into the feasible category. The product is also proven to have usability based on the difference in the average pretest and posttest scores of the two test groups, so that the comparison of the gain values shows a significant difference. Keywords: Educational Game, TP domain, Android.

1. Introduction

In 2021, technological advancements have had a significant impact on our lives, including in the field of education [1]. One of the current trends is the use of educational games based on smartphones, which have the potential to improve time efficiency and provide engaging learning experiences [2]. However, it should be noted that not all games available on the market have a clear educational concept. Previous research has also revealed that a
majority of digital games contain elements of violence, which can be a tool for public manipulation. Therefore, the development of educationaI games that align with learning needs becomes crucial.

In this context, this research focuses on the development of an Android game based on the Domain TP subject matter for students at Raharja University. As a university committed to providing quality education, Raharja University recognizes the importance of using innovative and effective learning media. Through the development of this educational game, it is hoped that students can master a wide range of materials in a more engaging and interactive manner [3].

This research is based on the principles of behaviorist and cognitivist learning, which focus on forming associations between stimuli and responses and the information processing by individuals [4]. In game development, the Unity development platform is used, which has the ability to create games with various high-end features and compatibility with the Android platform. This enables the development of the Android game Domain TP that utilizes multimedia characteristics such as text, images, sounds, animations, and interactivity.

Furthermore, this research also takes into account students' learning styles as an important factor in learning effectiveness [5]. The visual, auditory, and kinesthetic (VAK) learning styles are the primary focus in designing this educational game. Through previous research, it has been found that the majority of students at Raharja University have diverse VAK learning style preferences. By combining these aspects, this research aims to produce a high-quality and tailored Android game based on the Domain TP subject matter for students at Raharja University. The use of this educational game is expected to expand learning opportunities, enhance understanding of the material, and provide an engaging and effective learning experience for students [6].

2. Research Method

This study is a research and development (R&D) study, also known as Research & Development. The Android game Domain Universitas Raharja is developed through stages that include analysis, planning, design, development, and evaluation. Each stage consists of several work steps adapted and selected from the Alessi & Trollip (2001, p. 410) multimedia learning development model, which is relevant to computer-based multimedia learning development. This model consists of three attributes: standards, continuous evaluation, and project management, as well as three phases: planning, design, and development [7].

The research and development of the Android game Domain Universitas Raharja took place over 8 months from December 2021 to August 2022. This research was conducted within the environment of Raharja University. The main respondents in this study are students from relevant study programs at Raharja University. The research respondents include several stages, including needs analysis involving course lecturers and program coordinators, VAK
learning style surveys for all students in the relevant study programs, alpha formative testing involving media experts and subject matter experts, beta formative testing involving students from the study programs, and summative evaluation through experimental testing involving students from the study programs.

The procedure for the research and development of the Android game Domain Universitas Raharja includes a preliminary study involving needs analysis, interviews, and literature review. Next, planning is carried out by determining the scope, identifying users, and conducting selection and collection of references [8]. The design stage involves creating a work concept, storyboard, flowchart, interface design, selection of supporting devices, as well as evaluation and design revisions [9]. In the development stage, content and multimedia preparation, supporting materials, content and multimedia integration, and design implementation are carried out. The evaluation stage includes expert validation (alpha formative), initial revisions, user validation (beta formative), final revisions, and experimental testing (summative). Finally, the final product is implemented and published [10].

The testing/evaluation procedure for the Android game Domain Universitas Raharja involves several processes, both formative and summative. Formative evaluation consists of feasibility tests by media experts, subject matter experts, and testers. Summative evaluation involves usability testing through a series of experimental tests [11]. The data obtained in this research are descriptive, qualitative, and quantitative in nature [12]. Descriptive data are obtained from needs analysis interviews.

To analyze the VAK learning style questionnaire data in the 2021 research, each item is used as a representation of the visual, auditory, or kinesthetic modality activities (Duckett & Tatarkowski, 2021, p. 14). The data from the questionnaire are calculated by summing up the total scores from each item scored by the respondents. Thus, it can be determined which learning style is more dominant overall. Information regarding the items and modalities can be found in Table 1.

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 2</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 3</td>
<td>Question 6</td>
<td>Question 10</td>
</tr>
</tbody>
</table>

Table 1. Calculation of Learning Style Questionnaire VAK
In analyzing the data from the feasibility testing by media experts, subject matter experts, and testers, there are 2 respondents acting as media and subject matter assessors, while there are 7 respondents acting as testers. The data obtained from the feasibility testing use a 5-point Likert scale. The analysis process is carried out by summing up the scores from all items and finding the mean [13]. This calculation is done for each item, aspect, and instrument as a whole [14]. To convert the values into qualitative descriptions, a simplified formula can be used, as shown in Table 2. The validation results collected are used to determine the product's feasibility and make revisions if necessary. In the development of the Android game Domain TP, if the validation results meet the minimum feasibility criteria, it can be said that the product is suitable in terms of material quality, media, and potential users (testers) [15].
Table 2. Data Analysis Assessment Criteria

<table>
<thead>
<tr>
<th>Formula</th>
<th>Average</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X &gt; \overline{T} + 1,8 \times s_{bi}$</td>
<td>$&gt; 4,2$</td>
<td>Very good</td>
</tr>
<tr>
<td>$\overline{T} + 0,6 \times s_{bi} &lt; X \leq \overline{T} + 1,8 \times s_{bi}$</td>
<td>$&gt; 3,4 - 4,2$</td>
<td>Good</td>
</tr>
<tr>
<td>$\overline{T} - 0,6 \times s_{bi} &lt; X \leq \overline{T} + 0,6 \times s_{bi}$</td>
<td>$&gt; 2,6 - 3,4$</td>
<td>Simply</td>
</tr>
<tr>
<td>$\overline{T} - 1,8 \times s_{bi} &lt; X \leq \overline{T} - 0,6 \times s_{bi}$</td>
<td>$&gt; 1,8 - 2,6$</td>
<td>Less</td>
</tr>
<tr>
<td>$X &gt; \overline{T} - 1,8 \times s_{bi}$</td>
<td>$\leq 1,8$</td>
<td>Very less</td>
</tr>
</tbody>
</table>

Description:

$\overline{T} = \frac{1}{2}$ (ideal max score + ideal min score)

$s_{bi} = \frac{1}{6}$ (ideal max score - ideal min score)

$X = $ Actual/empirical score

In the usability testing data analysis technique, the population of University Raharja students in the 2021 cohort is divided into two balanced groups. The first group is the Android game Domain TP users (experimental group), while the second group is the digital module Domain TP users (control group). The first step in this testing is to provide a pretest of understanding the material to the respondents to equalize the starting point of understanding [16]. Then, in the second step, the respondents are given the opportunity to learn using the respective learning media according to their groups. In the third step, the respondents are given a posttest of understanding the material [17]. After all the testing series is completed, calculations are made to compare the obtained scores.

First, a comparison is made between the pretest and posttest scores of each group using a paired t-test [18]. From this calculation, the difference in score improvement in each group before and after learning using their respective media can be determined. Second, the
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3. Findings

In the preliminary study phase, the research findings have been discussed in the introduction chapter, and several key points regarding problem identification and needs have been identified [20]. The initial product development outcome is a learning media in the form of an Android game called "Alumni House of Educational Technology (Definition 1994)" version 1.0. The developed product is an educational game (edutainment) that combines elements of role-playing games (RPG).

The planning results include various technical references, instructional materials, websites, software, and experts [21]. These reference sources include Domain TP materials, information about Android game development (Unity 3D), as well as game assets such as graphics and sounds that have licenses for conditional distribution, allowing them to be obtained and modified as needed [22]. Through brainstorming, new ideas related to further research and development were generated, including the media format, instructional design, packaging of materials, and information related to the sources [23].

The initial product is also based on the identification of users’ VAK learning styles. Surveys have shown that the majority of students have a visual learning style dominance. The processed data indicate that the total score for visual learning style items is the highest (784), followed by kinesthetic (754) and auditory (722). The number of students based on learning style dominance is 22 visual, 16 kinesthetic, and 11 auditory. Additionally, there are also students who have a mixed dominance of several learning styles. Thus, the visual learning style dominance is evident from the highest scores, the largest number of individuals, and the percentage shown in Figure 1.
3.1 Design Results

In the design phase, several outcomes were obtained, including the media program outline, game storyboard, application flowchart, interface design, adaptation of reference sources, and ideal design through evaluation and design revisions. The application flowchart is based on a diagrammatic design that encompasses the movement of content and internal channels of the game, tailored to user activity procedures. The flowchart's structure can be seen in Figure 2.
3.2 Development Results

In the development phase, the content material and multimedia elements have been prepared. The content material is formed in the form of dialogue scripts delivered visually through an interview-style approach that adapts elements from RPG games [26]. The content is organized sequentially according to the relevant material discussions.

The multimedia elements of the game, such as images, text, and audio, have been prepared as assets to enrich the user experience in the game media. These assets serve as packaging, accompaniment, and explanations in delivering the material [27]. Other supporting content, such as the introduction, learning objectives, program identity, program map, and game quizzes, have also been gathered and are ready for use. The Android Domain TP game project in Unity 3D has been designed and built according to the plan [28].

Furthermore, an assessment is conducted on the content material of the Android Domain TP game [29]. The assessment results show that the content material has received a very good score (4.21), indicating its suitability for further testing with appropriate revisions. This development phase is a crucial step in ensuring that the content material and multimedia elements in the Android Domain TP game are ready for use and meet the established standards. With the positive assessment results, this product is ready for further testing and improvement as needed [30].

3.3 Product testing results

After the development of the Android Domain TP Android game version 1.0, product testing was conducted through alpha and beta testing. The alpha formative test aimed to obtain initial feedback regarding the quality of the content presented in the game. Content validation was carried out by two educational technology experts. The results of the alpha formative test have been processed and presented in Table 3. This evaluation will be used as a reference for revising and improving the content before the beta testing phase.

Table 3. Frequency Distribution of Material Validation

<table>
<thead>
<tr>
<th>No</th>
<th>Assessment Aspect</th>
<th>Assessment Results</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Material Expert 1</td>
<td>Material Expert 2</td>
</tr>
<tr>
<td>1</td>
<td>Material Subject</td>
<td>3,8</td>
<td>3,9</td>
</tr>
<tr>
<td>2</td>
<td>Supporting Materials</td>
<td>4,75</td>
<td>5</td>
</tr>
</tbody>
</table>
The results of the alpha formative test showed that the content in the Android Domain TP game version 1.0 was deemed suitable by both content experts involved. Content Expert 1 stated that the content could be used with minor revisions and provided some comments, while Content Expert 2 stated that the content needed significant revisions and provided several comments. The average validation score obtained was 4.21, which falls under the "Very Good" category based on the qualitative description conversion reference (X > 4.2).

Based on this data, the supporting content aspect received the highest average rating, which was 4.9, falling under the "Very Good" category. Meanwhile, the subject matter aspect and instructional design aspect received an average rating of nearly 3.9, which falls under the "Good" category. The scores given by both content experts for each indicator item only differed by 1 point. The lowest score obtained was 3 for all items, indicating that according to both content experts, the quality of each indicator already meets the "Sufficient" criteria. Based on the results of this evaluation, it can be concluded that the content material in the Android Domain TP game is deemed very good with an average score of 4.21, making it suitable for further testing with the necessary revisions.

Table 4. Frequency Distribution of Media Validation

<table>
<thead>
<tr>
<th>No</th>
<th>Assessment Aspect</th>
<th>Material Expert 1</th>
<th>Material Expert 2</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interface Display</td>
<td>4,14</td>
<td>3,75</td>
<td>3,95</td>
</tr>
<tr>
<td>2</td>
<td>Navigation</td>
<td>4,2</td>
<td>3,8</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Supporting Information</td>
<td>3,88</td>
<td>3,37</td>
<td>3,63</td>
</tr>
</tbody>
</table>
The results of the media validation by the two experts are presented in Table 4. The table contains information regarding the assessed aspects, the scores given by each expert, and the conclusions drawn based on the validation results. Through this validation process, a clear understanding of the suitability and usefulness of the developed media is expected to be obtained.

The results indicate that the Android Domain TP version 1.0 learning game media has been deemed suitable with minor revisions needed. The average validation score obtained is 3.87, which falls under the "Good" category based on the predetermined qualitative description conversion.

In this regard, the navigation aspect received the highest rating with an average score of 4, falling under the "Good" category. The interface design aspect also obtained a high average score of 3.95, which also falls under the "Good" category. Meanwhile, the supporting information aspect obtained the lowest average score of 3.63, but still falls under the "Good" category. The significant difference in average scores for this aspect (0.59) is the reason why the average for this aspect is lower compared to the others. Lastly, the instructional design aspect obtained an average score of 3.91, also falling under the "Good" category. Therefore, based on this assessment, the Android Domain TP game media is deemed suitable (3.87) and ready to undergo beta formative testing after the first round of revisions on the content and media.

The first round of revisions is conducted to improve the content and product design according to the assessments, comments, and suggested improvements provided by the experts. All the necessary improvements have been implemented before proceeding to the beta formative testing phase, which will be the next step in the development of this learning media.

The beta testing was carried out by testing the Android Domain TP game product version 2.0 (the new version after alpha) with 7 first-year students from the Educational Technology program at Raharja University. The results of the beta testing are presented in...
Table 5, which will serve as a reference for evaluating the suitability and performance of the revised product.

Table 5. Frequency Distribution of Beta Test

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Tester</th>
<th>Average Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Learning Effectiveness</td>
<td>3.8</td>
<td>3.2</td>
</tr>
<tr>
<td>entertainment values</td>
<td>3.67</td>
<td>4</td>
</tr>
<tr>
<td>comfort of use</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Design features</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3.80</td>
</tr>
</tbody>
</table>

Description Good

Based on the evaluation results, Android Domain TP game version 2.0 is considered suitable for supporting learning with the necessary improvements. The average score obtained is 3.80, which falls under the "Good" category based on the qualitative description conversion reference (X ≥ 3.4). Based on the data, the usability aspect received the highest average rating, which is 3.95, falling under the "Good" category. The entertainment value aspect obtained the second-highest score with an average of 3.90, also falling under the "Good" category. The design features aspect obtained an average score of 3.89, which is also categorized as "Good." The graphic design quality indicator obtained the highest average score of 4.57. The last aspect is the learning effectiveness, which received the lowest average score of 3.46, but still falls under the "Good" category.

Overall, the indicators of learning objectives alignment and content completeness had the lowest average item scores of 3.29. Therefore, these two indicators become the main...
priority in the final revisions. Additionally, the indicators of supporting information completeness and audio element quality are the second priority, with an average item score of 3.43. Three out of these four indicators are related to the effectiveness of learning aspects, so the main focus in the final revision will be given to these aspects.

After going through two rounds of continuous revisions, the final product for usability testing, Android Domain TP game version 3.0, was obtained. This final product will be used as a learning media by the experimental group of respondents. The participants in this study are 30 students from the 2021 TP (Educational Technology) class. Originally, the testing plan involved both classes from the 2021 batch. However, during the implementation, one class was unable to participate due to an urgent final project deadline. Therefore, the testing was conducted with the available class.

Before comparing the pretest and posttest scores in each group, a normality test needs to be conducted to determine the distribution of the data. The normality test results for the control group are presented in Table 6. This normality test aims to ensure that the data used in the analysis have a normal distribution. By knowing the normal distribution of the data, appropriate statistical tests can be conducted to examine the significant differences between the pretest and posttest scores in the control group.

<table>
<thead>
<tr>
<th>Tests of Normality</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistic</td>
<td>df</td>
<td>Sig.</td>
</tr>
<tr>
<td>Pretest</td>
<td>0.220</td>
<td>15</td>
</tr>
<tr>
<td>Posttest</td>
<td>0.166</td>
<td>15</td>
</tr>
</tbody>
</table>

Using the Shapiro-Wilk normality test due to the 30 respondents, the test results show that the p-value for the control group in the pretest is 0.09 and in the posttest is 0.117, where both values are greater than 0.05. This indicates that the data in the control group has a distribution that approximates normality. Therefore, to proceed with further analysis, a paired t-test is conducted. The results of this test are presented in Table 7, which will be used to determine if there is a significant difference between the pretest and posttest scores in the control group.

Table 6. Control Group Normality Test

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41
Table 7. Comparative Test Results of Pretest and Control Group Postes

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. 2-Tailed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretes</td>
<td>-9000</td>
<td>16,9</td>
<td>4,37</td>
<td>-18,372,372</td>
<td>2,06</td>
<td>14</td>
<td>0,059</td>
</tr>
</tbody>
</table>

Based on the results of the paired t-test, the p-value for the pretest and posttest in the control group is 0.059. Since this p-value is greater than the predetermined significance level (0.05), it can be concluded that there is an approaching significant difference between the pretest and posttest scores in the control group after using the digital module as a learning media. Although this difference does not reach the expected level of significance, it indicates the presence of influence or change in the participants’ understanding and knowledge after using the digital module. Furthermore, the normality test results for the experimental group are presented in Table 8.

Table 8. Group Normality Test Experiment

<table>
<thead>
<tr>
<th>Tests of Normality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kolmogorov-Smirnov</td>
</tr>
<tr>
<td>Shapiro-Wilk</td>
</tr>
</tbody>
</table>
Based on the paired t-test results, the p-value (α) for the pretest and posttest in the experimental group is 0.000. Since this p-value is smaller than the predetermined significance level (0.05), it can be concluded that there is a significant difference between the pretest and posttest scores in the experimental group after using the Android Domain TP game as a learning media. This result indicates that the experimental group experienced a significant improvement in understanding and knowledge after using the Android Domain TP game. The difference also suggests that the game is effective in enhancing learning outcomes compared to the use of the digital module in the control group. Table 9.

Table 9. Comparative Test Results of Pretest and Posttest of Experimental Group

<table>
<thead>
<tr>
<th></th>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>0.206</td>
<td>15</td>
<td>0.089</td>
<td>0.927</td>
<td>15</td>
<td>0.244</td>
</tr>
<tr>
<td>Posttest</td>
<td>0.182</td>
<td>15</td>
<td>0.193</td>
<td>0.924</td>
<td>15</td>
<td>0.224</td>
</tr>
</tbody>
</table>

After obtaining the gain scores for each participant in both test groups, an independent t-test is conducted to compare the gain scores between the control and experimental groups. Before conducting the independent t-test, a normality test is performed.
to ensure the data distribution in both groups, and a homogeneity test is conducted to
determine the equality of data variance. The results of the normality and homogeneity tests
can be seen in Tables 10 and 11.

Table 10. Normality Test of Gain Values of Both Groups

<table>
<thead>
<tr>
<th>Tests of Normality</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>Control</td>
<td>0.169</td>
<td>15</td>
</tr>
<tr>
<td>Eksp.</td>
<td>0.113</td>
<td>15</td>
</tr>
</tbody>
</table>

4. Conclusion

After going through the development, testing, and discussion process, the final
product of this research and development is the Android Domain TP game version 3.0. This
product has an *.apk file extension format with a size of approximately 20 MB, which is
equivalent to causal Android games available in the market. The evaluation focus for the
product is limited to assessing learner responses and attitudes as well as learning outcomes.

In the development of the Android Domain TP game, it is important to design a game
format that aligns with the learning needs analysis, considers learning outcomes, utilizes
appropriate media presentation formats, and caters to the majority of the users’ learning
styles. Additionally, the product should be based on relevant learning theories, digital game
principles, and research. The product development process should involve clear stages, utilize
reliable hardware and software, adhere to implementation designs such as outlines,
flowcharts, and storyboards, and involve continuous evaluation.

The results of the formative evaluation (alpha and beta) show that the Android Domain
TP game is considered suitable by subject matter experts and media experts. In the alpha
test, the subject matter expert provided an assessment that falls within the highly suitable
category, while the media expert provided an assessment that falls within the suitable
category. In the beta test, the student testers provided assessments that fall within the suitable
category. This indicates that the Android Domain TP game, as an alternative learning media,
has quality content and media and is suitable for use by the intended users.

Furthermore, the summative evaluation through a series of experimental tests also proves that the Android Domain TP game has significant benefits in improving learning outcomes. There is a significant difference in score improvement between the Android Domain TP game user group (experimental) and the digital module user group (control), with a probability level of 5% (0.00 sig < 0.05). Thus, the Android Domain TP game has been proven effective in enhancing understanding of the related material.

After production and testing, it is expected that the Android Domain TP game product can contribute sustainably to learning and Educational Technology. The dissemination of the product can be done by distributing it to lecturers, students, and TP practitioners through direct communication and other communication media. Additionally, the product can also be included in online application markets such as Playstore and 9Apps for wider download and usage by the public.

Although this product has been developed and tested, there are some shortcomings that need attention and further development. These shortcomings are related to instructional aspects, content, media models, media components, utilization, and functions of the Android Domain TP game. Therefore, further development support is still needed to enhance the quality and suitability of this product to meet the learning needs.

References


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