THE DEVELOPMENT OF PHYSICS EDUCATION GAME ON DIRECT CURRENT ELECTRIC CIRCUIT FOR LEARNERS

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ABSTRACT

This study is the research of the development of physics education game application. This study has two purposes, namely to (1) developing multimedia for physics learning in the form of a physics education game on direct current electric circuits, (2) knowing the quality of educational game applications that have been produced according to experts, (3) knowing the user's (student's) response to the media of physics learning in the form of educational game applications related to direct current electrical circuit. The development procedure in this study refers to the Luther-Sutopo procedure consisting of the stage of concept, design, material collecting, assembly, testing, and distribution. Data collection techniques in the research in this study using a questionnaire. The research instrument in this study was a validation and assessment sheet which was adapted from the rubric for evaluating C. Stewart's educational game, student response sheets, and the game tester response sheet. Product validation and assessment uses a Likert scale with 4 scales and students' responses use the Guttman scale, while the game tester response sheet uses descriptive analysis. The results of this study are products in the form of simulation physics education game applications in direct current electric circuits, the results of the validation and assessment of material experts and media experts, the educational game application scored 3.8 and 3.3 in a very good category. The results of the user's (student's) response to the direct current electric circuit educational game application developed got an average score of 0.97 with the agreed category.

INTISARI

Penelitian ini merupakan penelitian pengembangan aplikasi game edukasi fisika. Penelitian ini memiliki tiga tujuan yaitu untuk (1) menghasilkan media pembelajaran fisika berbentuk aplikasi *game* edukasi yang berkaitan dengan materi rangkaian listrik arus searah, (2) mengetahui kualitas dari aplikasi *game* edukasi yang telah dihasilkan menurut para ahli, (3) mengetahui respon pengguna (peserta didik) terhadap media pembelajaran fisika berbentuk aplikasi *game* edukasi yang berkaitan dengan materi rangkaian listrik arus searah. Prosedur pengembangan dalam penelitian ini mengacu pada

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prosedur pengembangan multimedia Luther versi Sutopo yang terdiri dari tahap pengonsepan, perancangan, pengumpulan bahan, pembuatan, pengujian, dan pendistribusian. Teknik pengumpulan data pada uji coba dalam penelitian ini menggunakan kuesioner. Instrumen uji coba dalam penelitian ini berupa lembar validasi dan penilaian yang diadaptasi dari rubrik untuk evaluasi *game* edukasi milik C. Stewart, lembar respon peserta didik, serta lembar respon *game tester*. Validasi dan penilaian produk menggunakan skala Likert dangan 4 skala dan respon peserta didik menggunakan skala Guttman, sedangkan lembar respon game tester menggunakan analisis deskriptif. Penelitian pengembangan ini menghasilkan produk berupa aplikasi *game* edukasi fisika berjenis simulasi pada materi rangkaian listrik arus searah untuk peserta didik pada jenjang SMA dengan menggunakan metode pengembangan multimedia versi Luther yang telah dimodifikasi oleh Sutopo. Kualitas aplikasi *game* edukasi fisika yang dikembangkan berdasarkan hasil validasi dan penilaian oleh ahli materi dan ahli media mendapat skor rata-rata sebesar 3,80 untuk konsiderasi pedagogik dan 3,33 untuk konsiderasi pengguna dengan kriteria sangat baik (SB). Hasil respon peserta didik terhadap aplikasi *game* edukasi rangkaian listrik arus searah yang dikembangkan mendapat skor rata-rata 0,97 dengan kategori setuju (S).

I. Introduction

Indonesia is one of the large industrial game markets in the world, ranked top 16 in terms of gamers with 43.7 million gamers. Studies conducted by a research institute of the global game industry, Newzoo, in 2017 found 36% of gamers in Indonesia were individuals aged from 10 to 20 years old. The remaining percentage consisted of gamers aged from 21 until 50 years old [1]. The survey result of Infografis Indikator TIK 2016 Rumah Tangga dan Individu about the internet activity uses by individuals in the year showed 44.10% of Internet users in Indonesia used the internet to play mobile and PC games. Then, 48.40% of the Internet users were mostly students or learners [2].

The data show many Indonesian people especially learners like to play the game. However, most accessible games on the Internet only concern with amusement element. Unfortunately, most educative games were limited to recognizing numbers, letters, colors, animals, vegetables, and fruits. Games that study certain lessons, such as physics or chemistry, are still limited.

Many types of research about a video game. Some of them correlated video games with violence but some of them proved there was no significant correlation." It meant different games could provide positive or negative impacts for children. It

depended on the portion and how an individual used it. He also explained that appropriate games could provide positive impacts on children. The game could also be designed specifically for learning media [3]. Paul J.C. Adachi (2013) found the correlation between playing games toward the improvement of the problem-solving skills of learners [4]. It indirectly caused the learners' academic skills to improve. Harsono (2014) found a child that played the game would develop reading, mathematics, and problem-solving skills [5].

Based on the game search in Google, September 8, 2018, 19.23, with the applied keywords: physics, physics educative game, physics learning game, game education physics, game physics education, education game physics, education physics game, and physics education game, the researchers could notice the numbers of games labeled as physics games as shown below:

Table 1. The Numbers of the Labeled Games as Physics Game

No	Link	TOTAL (RESULTS)
1	physicsgames.net	977
2	Freewebarcade	865
3	permainan.co.id	560
4	games.co.id	565
5	permainanonline.com	84
6	crazygames.com	491
7	y8.com	1230
8	m.onlinegame.co.id	497
9	gameedukasi.com	13
10	Playstore	254
11	Phyfun.com	998
12	Planeta42.com	27

The table shows many games with the label of physics game. However, the games do not provide physics concepts. The games had the physics label because they used the physics concepts to describe the reality in the game, for example, the Successful Experiment. This game has a mechanic and motion theme. The point of the game is to create the ball moving to the designated point. However, the game does not provide learning about the mechanics and motion materials. The other examples were Angry Bird, Cut the Rope, and Physics Duluxe. They did not provide learning or discussion about physics materials. The physics aspect of the games was used as the side effect to describe the reality in the game, for example, the effect of a rolling ball, parabolic motion, and falling down the object. The games emphasize on amusement element than the education element. From those games, the game that provides physics concept learning is Planeta42.com. It has 17 game selections. Then, gameedukasi.com. It has 2 games but they tend to focus on motion materials, such as Newton law, measurement, energy, and work. Then, a game that brings the material

about a direct current electric circuit was not found. From the explanation, the use of the game for learning physics is seldom to do.

A study conducted by Rahmawati et al (2017) in Islamic Senior High School 1 Jember in its XII Science 1 learning group about the conceptual understanding of the learners on the direct current electric circuit with the sub-discussion of current and Ohm law obtained the percentage of 39.2%, electrical resistance with 42.2%, a simple electrical circuit with 42.7%, and parallel electrical circuit with 50.6%, and power with 43.6% based on Bloom taxonomy indicators [6]. From the results, the learners' conceptual understanding of the direct current electric circuit based on the Bloom taxonomy indicator was very low. A study by Ira Nofitasari and Yuliana Sihombing (2017) in the X-1 of Public SHS 2 Bengkayang found the learners had difficulties on sub-discussion of current, voltage, and electrical resistance with a percentage of 55.35%, Ohm law, and conductor resistance with a percentage of 58.03%, the serial and parallel resistor with a percentage of 53.57%, and Kirchoff law with 71.42% [7]. This finding was also supported by Yustiandi and Duden Sepuzaman (2016) that found 73% of learners at Public SHS Serang, Banten had difficulties in analyzing the current and voltage of a resistor after being added by other resistors that were installed in serial or parallel manners [8]. Then, more than 68% of learners had difficulties analyzing the total resistance in a serial-parallel circuit [8].

II. Research Methodology

The development model

This research is a research and development study. It developed an educative game for learning physics with a Construct 2 application for a direct current electric circuit. The applied method to develop the game was the multimedia development method proposed by Luther-Sutopo.

The development procedures

The procedures to develop adopted the procedures of multimedia development proposed by Luther-Sutopo. The applied method consists of six stages. They are concept, design, material collection, assembly, testing, and distribution [9]. In this research, the procedures of the research method were adjusted with the research needs. The researchers added validation and judgment stages to find the truth of the content and quality of the products based on the experts' judgment. The promoted activities for each development stage of the product were:

1. Concept. This stage consisted of a preliminary study both theoretically and empirically to determine the users of the game, the materials to take, the objectives of the game, and the concept of game presentation.
2. Design. This stage dealt with designing or arranging the storyboard. A storyboard is an initial stage to create a game application. Thus, there were possibilities to

revise the final result of the developed game. A storyboard is used as the reference to create the storyline and navigation path in the game.

3. Material collection. This stage dealt with collecting the required materials to develop the game, such as figures, animations, and audios based on the needs.
4. Assembly. In this stage, the game was designed with Construct 2. All collected materials were imported to the software and they were arranged based on the storyboard. Then, they were given behaviors based on their roles and functions. After that, each arranged material, the researchers designed the logical function.
5. Testing. This stage consisted of three stages. They were alpha, beta, and theta tests.
   a. The alpha test. In this stage, the researchers did it. It was done in the middle of the assembly process during the creations of logical function in the event sheet. The test aimed to check the logic in the created even sheet whether it ran as expected or not.
   b. The beta test. This stage was done by 10 students. They were from Physics Education Department and Game Design Department as the game testers. They were asked to find glitches or errors in the game. They also had to find what elements to be revised from the non-technical aspect of the game after undergoing the alpha test. Then, the game should be revised based on the review results of the material and media experts.
   c. Validation and Judgment Stage. Before being tested in the third stage, the theta test, the game should be validated and judged by the experts of material and media. It had the purpose to obtain suggestions and advice. After that, the game was revised based on suggestions and advice.
   d. The theta test. This test involved the final users. It was to check the responses from the final target users toward the developed game. The result was the game was eligible during the beta test specifically in its distribution stage.
6. Distribution. The distribution was done online. The application was created in an apk format. It was then distributed via Google Drive, Google+, Whatsapp, and Facebook

Product test

The Trial Test Design. This test was done during the beta test and the theta test. In the beta test, the product was introduced and presented to the game testers. Then, they tried and explored the product and after that, they were given sheets to write their criticisms and suggestions. The beta test was conducted after the game was distributed online. The mechanism of the theta test consisted of (1) distributing the product via social media, WhatsApp; (2) downloading the product and trying the product by respondents, and (3) filling the assessment questionnaire of the product related to the menu interface of the product.

The Trial Test Subjects. The subjects consisted of two experts. They were media and material experts that validated and judged the product. The respondents were 10

game testers of the Physics Education and Game Design Department for the beta test and fifteen learners for theta test.

The Data Type of the Trial Test. The trial test data were grouped into qualitative and quantitative data. The qualitative data showed the quality of the data in terms of situations, processes, events, etc. They were stated into statements or words. The qualitative data were from the material and media experts. They took forms into suggestions and statements about the game quality of the validation and judgment. Here are the scoring system criteria. SB (Very excellent) B (Excellent) TB (Not excellent) STB (Extremely not excellent) The qualitative data of the game testers were suggestions and criticisms during the beta testing. The qualitative data of the learners were suggestions and responses in the form of statements of agreement (S) and disagreement (TS). The quantitative data were then obtained scores from each category scoring result on the validation sheet and the physics education game application judgment filled by the material and media experts. The scoring system applied the Likert scale They were 4=very excellent, 3=excellent, 2=not excellent, and 1=extremely not excellent. The responses of the learners toward the game were based on the Guttman scale with two intervals. They were 1=agree and 2=disagree.

The data analysis technique

The module quality analysis. The data obtained from the game judgment were the results of material and media experts' judgment. The judgment was based on the 4-Likert scale. The analysis procedure applied these stages:

Converting the score results. These score conversion from the qualitative forms into quantitative forms was done during the validation and judgment stage based on the proposed requirement by Widoyoko [10].

Table 2. The scoring regulation

No	Criteria	Scores
1	SB (Very Excellent)	4
2	B (Excellent)	3
3	TB (Not Excellent)	2
4	STB (Extremely Not Excellent)	1

The average score of each judged aspect was calculated with the following equation:

$$\bar{X} = \frac{\sum X}{N.n} \quad (1)$$

with

$\bar{X}$: The judgment average score

$\sum X$: The total judgment score

N : Numbers of assessors

n : Numbers of question items

Calculating the Interval. The interval between the attitude to determine the classification of the attitude toward the product was done by using this equation [10]:

$$\text{Interval Range } (i) = \frac{\text{maximum score} - \text{minimum score}}{\text{number of interval class}} \quad (2)$$

Transforming the average scores. The obtained average scores were in the form of qualitative data. They were transformed based on the applied criteria in Table 3.

Table 3. the Product Judgment Categories

No.	Average scores ($\bar{X}$)	Criteria
1	$3{,}25 < \bar{X} \leq 4{,}00$	Very Excellent
2	$2{,}50 < \bar{X} \leq 3{,}25$	Excellent
3	$1{,}75 < \bar{X} \leq 2{,}25$	Not Excellent
4	$1{,}00 < \bar{X} \leq 1{,}75$	Extremely Not Excellent

The Data Analysis of the Learners

The questionnaire of the learners' responses was analyzed to find out the learners' responses toward the developed game. Here are the applied stages:

Scoring. The applied statements in the Guttman scale were to find the learners' responses whether they had positive or negative responses. The answers were categorized into agreeing (S) and disagree (TS). The scoring was done on the learners' response sheets (Table 4).

Table 4. the Scores of the Learners' Responses based on Guttman's Scale

No	Statements	Scores
1	Agree	1
2	Disagree	0

The score conversion. Converting the obtained average scores into qualitative forms was done based on the judgment criteria in Table 3. It was done by finding the interval score between agree (S) and disagree (TS) with equation (2). Thus, the obtained criteria for learners' responses are shown in Table 5.

Table 5. the Learners' Response Categories

No.	Average scores ($\bar{X}$)	Criteria
1	$0{,}50 < \bar{X} \leq 1{,}00$	Agree
2	$0{,}00 < \bar{X} \leq 0{,}50$	Disagree

If the learners' responses were agreed, the product could be considered as the final product. However, if the learners disagreed, then the e-module had to be revised until it was ready to be the final product.

III. Results and Discussion

The validation of the developed game was done with two experts: the material and media experts.

The validation and material judgment

The material judgment and validation were in the form of criticism.

1. Please add the objective of the game to the menu interface.
2. Please add remarks to put the battery during the simulation.
3. Revise the typing errors in the material and hint parts.
4. Clear the bugs in the simulation selection menu. They were found in the simulation navigation button of the serial-parallel circuit that sometimes did not work properly.
5. Provide an additional explanation for each variable of the equation and the figures for each material.
6. Please add relevant graphics with Ohm law and provide more question examples and figures about Kirchoff law.

It could be concluded that the material judgment of the product was reliable to use with revision. Here are the detailed scores.

Table 6. the Results of Pedagogy Consideration Judgment

Considerations	Categories	Scores
Pedagogy	1	3
	2	4
	3	4
	4	4
	5	4
Total Scores		19
Average score		3,80
Criteria		Very Excellent

The validation and Median judgment

The results of the media validation and judgment were criticism and suggestions.

1. Keep the consistency of the display aspect with a certain theme.
2. Keep the consistency of the foreign term (the English terms), for example, play.
3. Give the animation of a video about how to use the application at the beginning of the application load. Thus, the users can find out how to interact.
4. Please also provide the figures of the resistors instead of the value (ohm).

It could be concluded that the media validation and judgment of the product were reliable to use with revision. Here are the scores.

Table 6. the Results of Users' Consideration

Considerations	Categories	Scores
Pengguna	1	3
	2	4
	3	3
Total Scores		10
Average score		3,33
Criteria		Very Excellent

Testing

The Beta Test. This test involved eight students of the physics education department and two students of the Game Tech department. The beta test was done by filling out the criticism and suggestion sheet from the beta testers of the game. The criticisms and suggestions were: (1) the game did not run well. The white screen appears on some certain smartphones, such as Zenfone, Maxplus, and all Samsung types, (2) the handwriting on material and hint parts are overlapped and difficult to read, (3) there should be material addition about serial, parallel, and serial-parallel circuit set up, (4) there was two background music in one layout that made the background music unclear, (5) the audio effect when a user succeeded or failed to do a level in-game was unclear, (6) the unaccomplished game levels were not saved after logging out, (7) the users could open the game until level 6 (level 7 and so on could not be opened), (8) there were bugs in some navigations, such as material buttons. They were sometimes difficult to press, (9) the bug resistor could not be obtained or moved in some levels, (10) the opportunities to play the game sometimes turned into zero although the users did not do any mistake, (11) It is important to change the game icon in the smartphone to attract.

The suggestion and observed problems by the testers became the principles to revise and improve the product. After all, the product was revised and improved, the product was validated and judged by the experts.

The Theta Test. This test involved 16 learners in an online manner after the game was distributed by the developer via social media. The data of the learners' responses toward the application game rangkaian listrik DC adalah sebagai berikut:

Table 7. the Data of Learners' Response Results during the Theta Test

Response aspect	Scores per aspect	Average	Criteria
Users	78	0,98	Agree
Design	29	0,91	Agree
As a reference	48	1,00	Agree
Total	155	0,97	Agree

The data analysis results

The physics game judgment by the material experts referred to the product scoring category criteria (see Table 5). Based on the calculation, the pedagogical consideration of the developed game based on material experts obtained the average score of very excellent (SB). The average score comparisons of each aspect of the material expert's judgment are shown in Figure 1.

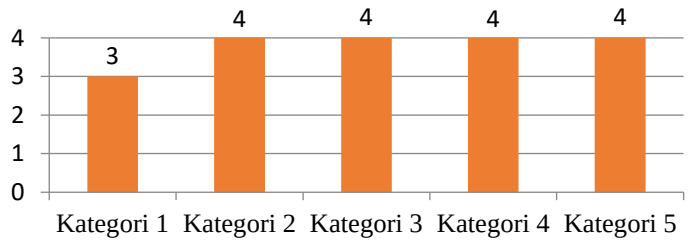

Figure 1. the Graphic of Consideration Judgment Results The pedagogy toward the game application

Remarks

Category 1 : The correlation of the game content toward the learning objectives
Category 2 : Problem-solving characteristics
Category 3 : The science content integration in the game (knowledge content)
Category 4 : The science content integration in the game (system thinking)
Category 5 : Feedbacks

The physics e-module selection of the experts was based on the product judgment category criteria in Table 6. Based on the calculation, the pedagogical consideration of the developed game based on material experts obtained the average score of very excellent (SB). The score average comparison of each aspect could be seen in Figure 2.

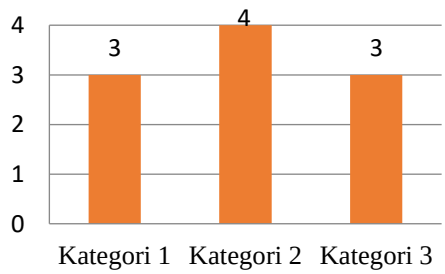

Figure 2. the Graphic of Users' Consideration Judgment Results

Toward the Game Application

Remarks

Category 1 : The easiness

Category 2 : The correlation of the developed game (knowledge) and the game control with the learners' skill levels.

Category 3 : The participation of learners' while playing the game

The learners' response results

The results obtained the average score for the utility aspect with 0.93; the design aspect with an average score of 0.91; and the aspect for reference material with 1.00. Therefore, the learners' responses for each aspect were categorized as agreed. The obtained average score is 0.97 so that the learners' responses toward the game were 'agree' (S). The calculation results could be seen in attachment 9, the calculation of learners' response results.

The strengths and weaknesses of the product. The developed product has strengths, such as:

1. The developed game could be used as an exercise in learning direct current electrical circuits because the game concept is a simple simulation.
2. The developed game was completed by simulation and material menu features so the application users could do an experiment and learn autonomously.
3. The developed game could be run on Android Smartphone with a minimum spec fo 4.0 Android System (Jellybean). Thus, the game could be used for most smartphone types today.
4. The size of the game has a smaller scale, lesser than 50Mb.
5. The game application does not require a high-spec smartphone to run the application.
6. The game application could be run on a laptop or computer by using the browser in a laptop or computer.
7. The regulations to play the game were simple so the game was simple to understand.
8. The game application could be run on a smartphone without the assistance of other applications.

The developed product has these limitations:

1. The game is only about Ohm law and resistor set circuit.
2. The application cannot play videos so players should use the internet to see the tutorial video that is linked to YouTube.

IV. Conclusion

This research succeeded to develop an educative game with simulation type on direct current electric circuit material for SHS learners with multimedia development

proposed by Luther modified by Sutopo. The developed game quality based on the validation results and judgment of the experts obtained the average score of 3.80, the pedagogical consideration with 3.33, and the user consideration with a criterion of "very excellent" (SB). The learners' responses toward the developed game about the given material could improve their achievement with an average score of 0.97, categorized as 'agree."

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