Development of instructional media game education on integral and differential calculus

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Abstract. A differential equation is a compulsory subject that must be contracted by student bachelor of mathematics education program. It is still considered difficult by most students. The difficulty is due to the varied solution and the interrelationship with Integral and Differential Calculus materials. An educational game is one of the creative industry products that can process knowledge into games. This research aims to make an educational game of differential integral calculus which can be used as a learning supplement for students. The design of an educational game is to create a scenario include materials, questions, solutions, and tests on Integral and Differential Calculus. The research model used in this research is using ADDIE (Analysis, Design, Development, Implementation, Evaluation), but not include implementation phase. The initial requirement analysis phase involves observing the students learning difficulties when studying the material of Differential and Integral Calculus. The design phase is the preparation of concepts and questions related to the material of Differential and Integral Calculus. The development stage is to create and develop a game using software RPG game maker MV. The result of this research was as follows (1) educational game was valid, (2) educational game was practical.

1. Introduction
The process of learning mathematics in higher education faces very complex challenges in preparing superior quality students, having mathematical abilities not only oriented to mastering knowledge but also the ability of students to develop thinking skills, interpersonal skills, good adaptability and collaboration skills, of course it will be very needed in solving problems in our life. Mathematics as a basic science plays a very important role in the development of science and technology, because it is a means of thinking to develop the power of reasoning, ways of thinking logically, systematically and critically [1]. Many of mathematics education students feel that differential equation courses are the subjects that are quite difficult to understand. It is because of their analytical nature, requiring mathematical reasoning, characterized by calculations and requiring a standard method of solving. Also, the learning difficulties faced by students tend towards a weak mastery of the basic concepts of calculus and derivatives which are basic prerequisites when studying differential equation courses.

To reduce the problem of student learning difficulties in learning and understanding the basic concepts of calculus, researchers create a learning media in the material of Integral and Differential Calculus (Derivatives) as a basis for studying Differential Equations. As for one of the learning, media is designing a game called the educational game [2].
The software used for educational game is the RPG Maker MV which is one of the latest version of the game engine from Enterbrain which was released in 2015. The advantages of this game maker software are that it supports on various platforms including Windows, Mac OS, Android, and IOS [1]. Based on the background described above, the purpose of this paper is to design a valid and practical educational game as a teaching media and find out the students' response to the practical use of games that have been designed.

2. Methods
The method in this research is a quantitative method, and the research design is development research using ADDIE development model (Analysis, Design, Development, Implementation, Evaluation) [3]. It phase consists of an analysis of student learning difficulties, design of things to be loaded in the game based on the study of literature and facts in the field, educational game making, assessment by experts, and user assessment. This research does not include implementation phase.

The material and questions are about history integral, the utility of integrals, indefinite integrals, definite integrals, drawing area bounded by curves, integrating with substitutions, partial integrals, and integral exponent and logarithmic functions (Table 1). Those materials are taught for a third-year college student.

| Table 1. Game Materials and Questions. |
|----------------------------------------|
| Materials and Questions                |
| a. finds the solution from indefinite integrals \( \int (6x^5 + 9x^2 - 4) \) \( dx \) |
| b. finds the solution from definite integrals \( \int_2^1 (2x^2 - 3)^2 \) \( dx \) |
| c. drawing area bounded by curves \( f(x) = x^2 \) and \( g(x) = x^3 \) |
| d. finds the solution of integral by substitutions \( \int \frac{x}{x^2 - 1} \) \( dx \) |
| e. finds the solution from integral exponent functions \( \int e^{-x} \) \( dx \) |

In the analysis phase, the observation process was carried out on students' learning difficulties when they studied the material of Differential and Integral Calculus. Furthermore, the process of observation and data collection is carried out through facts in the field or literature studies on the role of learning media that can overcome student learning difficulties. At this stage, the concept and questions related to the material of Differential and Integral Calculus are carried out. The drafting and material questions of Differential and Integral Calculus are directed to the method of solving that has been used in Differential Equations courses. After drafting the material and problem concepts, then the scenario of the game is then designed, including maps and event games [4]. The last step is a development that deployed the game to android apk extension. The validation phase was carried out by experts in the field of learning media and the fields of Differential and Integral Calculus. After that, the game practicality test is conducted by the users, namely students. The sheet media validation used five indicators: relevance, systematics dish, conformity of the presentation with the demands of student-centered learning, game design and compatibility [4].

It also tests user practicality by random respondents who are students, teacher, and lecturer. The following user practice sheet is shown in Table 2.

| Table 2. User Practical Questionnaire |
|---------------------------------------|
| Form of Instrument Questionnaire      | Indicator                                      |
| User Practices                       | 1. Relevance                                   |
|                                      | 2. Systematics of Presentation                 |
|                                      | 3. The suitability of the dish with the demands of learning that is continuous to students |
|                                      | 4. Game design                                 |
|                                      | 5. Compatibility                               |
3. Results and Discussion

3.1. Analysis Phase
Based on the results of a questionnaire given to 80 respondents from various types of jobs, 65 respondents stated that integral calculus material was difficult material.

| Job                | Gender | Known Calculus Integral Material | Response to Material | Response to Educational Game |
|--------------------|--------|----------------------------------|----------------------|------------------------------|
|                    | Man    | Woman   | Yes | No | Easy | Difficult | Agree | Disagree |
| Student (College)  | 8      | 28      | 36  | 0  | 1    | 35        | 36    | 0        |
| Teacher            | 8      | 10      | 14  | 4  | 3    | 15        | 18    | 0        |
| Student            | 1      | 1       | 2   | 4  | 3    | 15        | 18    | 0        |
| Lecturer           | 3      | 7       | 10  | 0  | 1    | 9         | 9     | 1        |
| Entrepreneur       | 3      | 1       | 3   | 1  | 1    | 3         | 10    | 0        |
| Other              | 4      | 1       | 5   | 0  | 1    | 4         | 5     | 0        |

From Table 3, the 65 respondents who stated it was difficult: 32 respondents were students, 19 mathematics teachers, and six mathematics lecturers. The material on integral calculus that is considered difficult by students and lecturers is determining the method in finding solutions. In integral calculus material, there are several methods in determining integral solutions. The method that is considered the most difficult is the partial method. Teaching materials used in class are needed to support the delivery of material in class. The results of the questionnaire stated that the teaching materials used by students in learning integral calculus were various, including using lecture modules, textbooks, and e-books. But based on the students’ opinion that the teaching materials used cannot be studied independently but must be guided by lecturers in class face to face. However, not only teaching materials are used to deliver the material but need other learning media such as computer and Android-based educational games. This educational game turned out to be needed in learning, because based on a questionnaire as many as 44 respondents often used computers/laptops/smartphones in learning mathematics and as many as 79 respondents agreed to the existence of teaching media in the form of this educational game. The opinion of respondents who agreed to the use of this educational game in the form of an RPG was very interesting and interactive.

Based on the questionnaire, students agree and consider educational game as instructional media suitable to be applied to integral calculus material. Because, they better understand the concept of integral calculus through pictures/illustrations/animations, writing, and videos that are in educational games. It’s just that some respondents thought that using educational games requires a long time in understanding the material.

3.2. Design Phase
The game story is an inspiration from the story of Sunan Gunung Jati who went to China to study medicine and marry the Chinese imperial daughter. The main character named Egi experiences time travel and returns to the past to meet Sunan Gunung Jati. The main characters and Sunan Gunung Jati agreed to work together to go to China. The main character has a goal to return to his time while the Sunan Gunung Jati has a purpose of studying medicine in China. He also explained that they had to collect sheets of books to help their journey. This map provides information for players about the history of integral developers.

There are 13 maps for this game. The game starts with a prologue that explains the controls in the game as shown in Figure 1.
In the second map starts to enter the game story. The main characters introduced are students who are learning and learning difficulties. The second place is where the main character meets the companion character, Sunan Gunung Jati. In Beach map, players will meet four sailor characters. Three of the four sailor characters must be encountered by the character. On the next map, the main character will pass the Chinese sea border. In this map, a differential sheet will be given and will be taught the integral material of course. In this map, the main character must meet three people to get information about the integral substitution. In this map, the main character arrived in front of the kingdom with two guards who were ready to provide integral substitution questions. In this map, the main character must meet with the prime minister to be given material on exponential and trigonometric integrals. In the last map is the place of the king of differentials, the main character will be given the question of differential equations. The characters used in the game and coding event can be made from software RPG maker MV. The game material includes history integral, the utility of integrals, indefinite integrals, definite integrals, drawing area bounded by curves, integrating with substitutions, partial integrals, and integral exponent and logarithmic functions. Problems and question on the game are made by the material. Next thing to do is deploy the game so it can be played either on PC or android smartphone [5].

3.3. Development Phase
This section will discuss the game, results of media validation and user's practicality.

3.3.1. Game results. Here is an example when the main character is given the material utility of calculus integral. As seen in Figure 2.
Figure 3. Question Utility Of Calculus Integral

Figure 4 is an example when the main character is given a question to find the integral result. As seen in the picture.

Figure 4. Question Integral Result

3.3.2. Media validation results. Media was validated by two validators as media experts and material experts. The result of validation shown in Table 4.

| Validator          | Validation Criteria |
|-------------------|---------------------|
| Media Expert      | 90.20 %             |
| Materials Expert  | 96.42 %             |

The results of the game validation test conducted by two validators obtained the value of validation criteria was very high with an average percentage of 93.31%. So, that it can be said that the Android-based math education game is very valid. Several educational game studies with subjects of senior and junior high school students obtained media validation results above 90% [1,4, 6]. This means that educational games can be said to be very valid as a learning medium for students and college students.

3.3.3. User practicality results. This research also tested user's practicality. Subjects test were students, teacher, and lecturer - the result of user practices shown in Table 5.

| Subject | Percentage |
|---------|------------|
| Student | 75%        |
| Teacher | 72%        |
| Lecturer| 60%        |
The results of the user practicality test are obtained with an average percentage of 78%. It can be said that the value of the practicality criteria for integral calculus education game is practical [6]. Based on the results of Pramuditya's research [4-6] said that the results of practical field trials for senior high school students were 85% and junior high school students were 80%. This means that the media developed is included in the practical category for students and college students.

4. Conclusions
Games have positive and negative effects on students. Some studies provide an overview of games that contain elements of violence can have a negative impact on users [3]. However, some also indicate the positive impact of the game, which can improve a student's cognitive and spatial abilities [7, 8]. Pramuditya [2] created a mathematics education game, which is a game in which there are elements of education and learning and inserted mathematics learning content in the form of questions and material. It has the same result that educational game for students in this research is valid and practical.

Based on the results of data analysis, it can be concluded that the educational game was very valid. Average percentage of media expert and material expert validator is 93.31%. The educational game was practical with an average percentage for students is 94.3%, teacher is 92.2%, and lecturer is 92.2%. Implementation can be done in next research; educational game can be put in instructional plan and combine it with learning model, such as discovery, problem-based learning, etc.

As an implication of this research, the educational game can become the newest instructional media for students in understanding the material and mathematical concepts in general.

5. References
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