Educational Platformer Game (OOP-EduGame) to Enhance Student Motivation and Understanding in the Object Oriented Programming Subject

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ABSTRACT

The Object-Oriented Programming (OOP) course aims to impart understanding and knowledge to students regarding basic-level object-oriented programming concepts and the implementation of inheritance, encapsulation, and polymorphism. This subject contains abstract concepts that require a high level of understanding and also a sufficiently strong memory which often makes students feel bored. We consider the need for a learning innovation that can boost student learning motivation and also make it easier for them to understand and remember abstract concepts in OOP material. Based on these problems, we plan to use games in learning activities. Games are a potential tool to support learning activities [1], where games can provide great motivation for students to play [2]. Furthermore, games are one of the 3 most popular applications in Southeast Asia[3], where this data is also confirmed by the Global Mobile Consumer Survey which shows that 47% of the population in Southeast Asia play games through their smartphones. Mobile game applications are also proven to be able to contribute to learning outcomes and student learning motivation. After conducting a review of the literature and analyzing related research, we think that the educational game application can be used theoretically as a solution to the problems we have described. This application is available anytime and anywhere that allows students to look deeper into the materials and to offer a virtual learning environment that is not restricted by the time and place to work together and share ideas for solving programming problems. The educational game that we developed is called OOP-EduGame, this game is a platformer game genre that is one of the most popular game genres. The development method for this application uses the ADDIE model. The results of validation from experts and the responses from users as a basis for measuring the readiness of the application for use in learning activities are also presented.

I. Introduction

In the era of the industrial revolution 4.0, where technology acceleration in the software field maneuvers very quickly, the academic climate in higher education is not only required to facilitate students in learning about these developments but also expected to equip students to be able to adapt and innovate. One of the most prominent developments in the field of software engineering is the change in the conventional programming paradigm, where a programmer is asked to create a program from scratch, turning into an object-oriented programming paradigm, where this paradigm emphasizes efficiency in building a complex program with several modelling that makes it more effective. Moreover, nowadays this paradigm is becoming very popular, where many programmers and even large companies are adopting and using it in software development.

This phenomenon is one of the fundamental reasons for the emergence of object-oriented programming courses in various well-known universities both nationally and internationally, especially those with a focus on software engineering. This course aims to convey understanding and knowledge to students regarding the fundamental of object-oriented programming concepts and the implementation of its main pillars including inheritance, encapsulation, and polymorphism. Given the importance of disseminating concepts and understanding the new paradigm of object-oriented programming which has proven to be more effective than conventional paradigms, many universities have made object-oriented programming courses a compulsory subject.

The State University of Malang, especially the informatics engineering education study program, in its curriculum design, has determined object-oriented programming as a compulsory subject. The process of organizing learning activities in this course is generally carried out using the project-based learning method, wherein this learning method, the lecturer asks students to collaborate in their team then provides several mini-projects which will later be compiled into a large project. Besides, learning activities in this course also often use problem-based learning methods, where the lecturer triggers and guides students to solve some programming problems. These two methods are expected to be able to stimulate and strengthen not only students' programming skills but also the ability to work together in teams and the ability to solve problems.

At that time, the two learning methods are considered quite good in instilling object-oriented programming concepts, however, these two learning methods are very limited by two important variables, namely time and place, where students have not been able to explore in-depth and consult effectively outside of learning hours and off-campus. Also, this course implements abstract concepts that require a high level of understanding and also a strong enough memory which often makes students feel bored and feel this course is very difficult to understand.

We consider the need for a learning innovation that can boost student learning motivation and also make it easier for them to understand and remember abstract concepts in OOP material. Based on these problems, we plan to use games in learning activities. Games are a potential tool to support learning activities [1], where games can provide great motivation for students to play [2]. Furthermore, games are one of the 3 most popular applications in Southeast Asia [3], where this data is also confirmed by the Global Mobile Consumer Survey which shows that 47% of the population in Southeast Asia play games through their smartphones. Mobile game applications are also proven to be able to contribute to learning outcomes and student learning motivation.

After conducting a literature review and analyzing previous research, we have the view that the educational game application can theoretically be used as a solution to the problems we have previously described, where this application can be accessed anytime and anywhere which can facilitate students to dive deeper into the materials and provide a virtual learning environment that is not limited by time and place where they can collaborate, exchange ideas and contribute to each other in solving programming problems. For this reason, we developed an educational platform game application that was following the characteristics of object-oriented programming subjects and student characteristics.

II. Literature Review

A. Learning Innovations in Technical and Vocational Education

Efforts to escalate the quality of learning in the technical and vocational fields have resulted in innovative learning products marked by many scientific publications in this field. Some of the innovations that have been produced include the use of interactive learning comics [4], the use of game components for learning activities (gamification), educational games [5], augmented reality [6] and several other learning innovation models that take advantage of the sophisticated of multimedia for learning. Focusing on gamification and educational games, one of the results of research conducted on students and prospective teachers in the vocational field shows that the concept of gamification in learning can enhance student motivation and programming skills [7]. In addition, gamification in learning can also strengthen the ability to collaborate in teams, which was revealed in a study conducted in the field of software engineering [8].

Other research has looked into how gamification influences engineering laboratory activities. Gamification (GM) and non-Gamification (NG) websites are used in this analysis (NG). The

findings indicate that applying gamification to engineering lab activities has a positive effect on motivation, involvement, and performance, as evidenced by the higher number of students who are members of the GM site, the number of answers submitted by the GM group, and the higher GM group exam scores compared to the NG group[9].

B. Educational Game in Computer Programming Learning

The use of educational games in object-oriented programming courses, which was initiated in this study, was inspired by previous studies that demonstrated the great potential of educational games to improve learning quality. Some of these studies have shown that gamification has been applied in teaching computer programming to enhance the understanding of programming concepts, skills and motivation [10]. An innovative education environment based on virtual reality and gamification to learn search algorithms has also been created [11]. This research was evaluated in real-world conditions and the evaluation results show that students' activity, motivation and learning performance have been increased [12]. Furthermore, gamification has great potential to help students gain and develop their performance [13]. The combination of game-based learning and gamification provides the ability of student motivation through an innovative and highly effective learning process [14].

Several educational game applications, including Jigsaw (a learning game that asks players to solve virtual jigsaw puzzles using tools in Adobe Photoshop), were developed which have proven to be effective learning media to complement demonstration-based tutorials [15]. GamiCAD, a gamification tutorial system for Autocad users, is another example of an educational game application [16]. The findings of this study show that Gamicad can improve student engagement and enable students to perform tasks more quickly.

Many education game applications, including Run Marco [17], Robocode, MUPPETS, EleMental and Gidget, are specially designed for computer programming and have proved capable of boosting student motivation for learning [18]. Among the several educational games, two educational games are closely related to this research where both are devoted to object-oriented programming using JAVA programming language, namely Robocode [19] and M.U.P.P.E.T.S [20].

III. Research Methodology

In developing this product, the research and development method is the ADDIE model. In a partnership highly suitable for the development of games and learning media the ADDIE model has been chosen. ADDIE model (Fig. 1) stands for analysis, design, development and assessment [21]. The following information is given on the stage of ADDIE model:

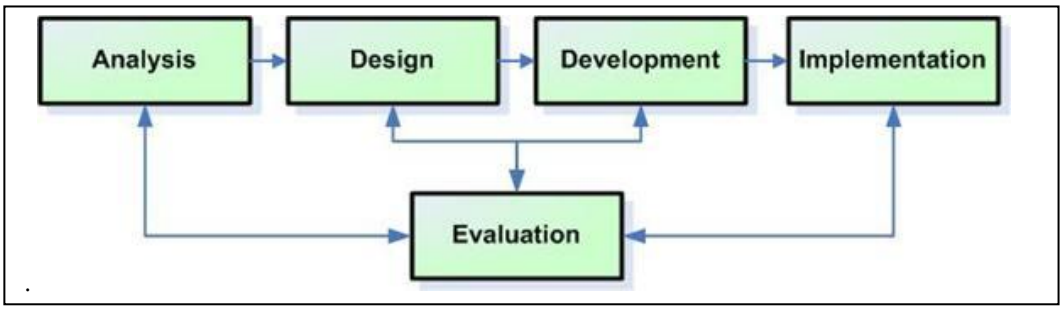

Fig. 1. ADDIE Model

A. Analysis

Analysis and design are first necessary to produce a good educational game. Three key points were analyzed, including: 1) determine the objectives to be achieved, 2) determine the relevant materials for use in development, 3) analyze the abilities and characteristics of students. We also conduct a literature review at this stage intending to gain insight into relevant theories in the development of educational platform games.

B. Design

At the design stage, we design instructions, learning strategies and select learning media to be developed. The main objective of this stage is to find a detailed learning innovation design in the

form of an educational platformer game application for the OOP course. Three important stages in the design phase include: 1) determining how the material will be delivered through educational games 2) determining the method or strategy that will be used to deliver the material 3) determine how to assess or determine the success of participants, wherein educational games this aspect is determined through gameplay and also the scoring techniques developed.

C. Development

The success of the development stage is supported by the existence of important information that has been collected in the analysis stage and decisions made at the design stage. Based on the results achieved at the design stage, we will develop gameplay (game rules) in educational games that are in line with the course and students characteristics, then integrate learning material into educational games. This stage will also focus on the translating of gameplay and the educational game design into program code. So that the educational platformer game prototype is ready for use.

D. Implementation

The ADDIE model is a systematic model for designing, developing and evaluating products. The phase of implementation is the stage where real development results are applied. At this stage, the researcher determines the strategy for using the educational game (OOP-Edugame) in the learning process. The game prototype is then integrated into the Learning Management System.

E. Evaluation

The ADDIE model highlights the need for planning, review and revision for good product results. The assessment stage is to evaluate the efficiency and improvement of the product that is developed. The assessment phase consists of two parts: formative and summative. In every phase of the ADDIE development model, the promotive assessment is carried out. Summative assessment is a test that offers feedback from a number of experts, namely educational game experts, media experts, material experts and testing for the target audience.

IV. Results

A. OOP-EduGame

OOP-EduGame is a platform genre game. The genre is based on the player's movement in a set of levels, ride, climb, jump and other movements which allow the player to reach the desired location [22]. The reason for choosing this genre is because of its popularity among both male and female students. Furthermore, it's also simple and easy to play, so players can play the game without any extra effort. This will naturally encourage players to play this educational game.

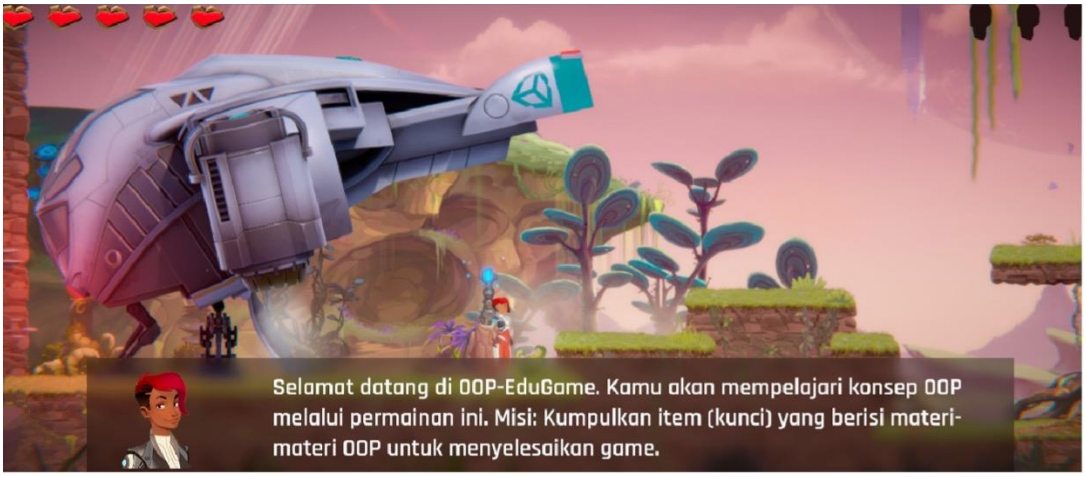

Fig. 2. OOP-EduGame's welcome screen

Free asset from the 2D Game Kit Unity platform, which provides a variety of components for the game was used to develop OOP-EduGame. The gameplay of this educational game is as follows: the player is taken to level 1, where instructions on the main mission are given to the player at this level (Figure 2). On level 1 (Figure 3) we see 5 red heart icons on the upper left, indicating the player's

life. Top right, you can see three black "key" icons showing that the three keys have not yet been collected.

Fig. 3. OOP-EduGame-Level 1

This game's main mission is to defeat the main enemy the player will meet at the last level (Figure 4). If the player succeeds in defeating the main enemy, then the player is said to have finished the game successfully. However, the player must open a magic door, which is still locked, to reach the final level. For a magic door to open, players must have 3 keys that are scattered on each level. To obtain the three keys, the player must explore all of the levels with their corresponding difficulty levels. While exploring, players are also given materials about the OOP concept and examples of how to implement OOP in the game at each level. These materials are presented in the form of an Infopath, which can be found at various points along the player's path.

Fig. 4. OOP-EduGame-Level 5

B. Learning activities in OOP-EduGame

To convey learning content, the game incorporates a variety of learning activities. The following are some of these activities:

- Collecting data: In the game, students can use their game characters to collect various items (coins, keys, etc.). Each of these items informs students about the material covered in the OOP course.
- Overcoming obstacles: In this learning activity, students must control the game character (main player) to jump over obstacles, avoid enemies, and take advantage of existing objects to

reach their destination successfully. Each obstacle in the game will sharpen students' problem-solving abilities.

- Shoot the answer: The player (student) has to control the game character and fight the main enemy. In this learning activity, the enemy will give the player a question and he must shoot the correct answer. If the answer is correct, the main enemy's health points (hp) will decrease. Conversely, if the answer is wrong, the student's health point will decrease.

Moreover, this educational game uses the following supporting functions to support the learning content provided and motivate students while learning:

- Reward system: A special sound effect is played for every correct answer or move a student takes. This allows students to feel good and enhances self-confidence and motivation [23].
- Feedback system: The game provides guidance and further details during the learning process. This helps students to increase their level of knowledge about OOP course materials. According to [24], feedback supports learners in advancing the interactive process of investigating, reacting, hypothesizing and planning.
- Additional difficulty levels: This Educational Game provides many "challenges", which is an important feature of educational games in which the difficulty level gradually increases with each level.

C. Validation and Test Results

The validation test is conducted in four stages: 1) review by educational game experts, 2) review by learning media experts, 3) review by learning materials experts, and 4) field test. Data from educational game experts (Table 1), learning media experts (Table 2), learning material experts (Table 3) and students (Table 4) are collected using questionnaires. The questionnaire was based on a 4-point Likert scale. We use quantitative data analysis techniques (1) to process the data.

$$percentage = \frac{\Sigma x}{\Sigma xi} x\ 100\% \quad (1)$$

Σx = *score from respondents*
Σxi = *ideal score*

Table 1. Results of Eligibility Judgement from Educational Game Experts

No	Assessment Aspects	X		∑x	∑x_i	%	Status
		1	2				
1.	The appropriateness of educational games with learning objectives	4	4	8	8	100	Valid
2.	The Attractiveness of educational game design (interface, graphics, etc.)	3	4	7	8	87.5	Valid
3.	The educational game is easy to use	4	4	8	8	100	Valid
4.	The rules of the game are clear and understandable	4	4	8	8	100	Valid
5.	The font used in the game are suitable and easy to read	4	4	8	8	100	Valid
6.	Design levels and challenges in the game are not monotonous	4	4	8	8	100	Valid
7.	The game is fun to play	4	4	8	8	100	Valid
8.	The material presented in the educational game conforms to the learning goal	4	3	7	8	87.5	Valid
9.	Educational game in accordance with the characteristics of object oriented programming courses	3	4	7	8	87.5	Valid
10.	The educational game has a positive impact on learning activities in the OOP course.	4	4	8	8	100	Valid
11.	The educational games is efficiently used in learning	4	4	8	8	100	Valid
12.	Educational games can motivate students	4	4	8	8	100	Valid
	TOTAL			**93**	**96**	**96.9**	**Valid**

Tables 1–3 present the findings of several expert assessments. The OOP-EduGame assessment involved a total of 6 experts, with each category of assessment carried out by two experts. The 47 question items spread across four questionnaires were used to evaluate some of the most important aspects of the educational games developed. According to the results (Table 1-3) the highest percentage of 96.9 percent is obtained in the assessment of educational game experts, while the lowest value of 93.8 percent is indicated by the results of the expert judgment on the material.

However, all of these results are still above 90%, indicating that OOP-EduGame is valid and suitable for use in field testing (Table 6).

Table 2. Results of Eligibility Judgement from Learning Media Experts

No	Assessment Aspects	X		∑x	∑xi	%	Status
		1	2				
	Language Eligibility						
1.	Readability level in learning media	4	4	8	8	100	Valid
2.	The type of font used is easy to read	4	4	8	8	100	Valid
3.	The use of sentences is in accordance with Indonesian standards	4	3	7	8	87.5	Valid
4.	The sentence structure is easy to understand	3	4	7	8	87.5	Valid
	Appearance Feasibility						
5.	The appearance of the educational game is appealing and not monotonous.	4	4	8	8	100	Valid
6.	The educational game layout is not confusing	4	3	7	8	87.5	Valid
7.	The navigation and functions are simple to use	3	4	7	8	87.5	Valid
8.	The flow of the educational game is uncomplicated	3	4	7	8	87.5	Valid
9.	Fast response time	4	3	7	8	87.5	Valid
10.	The material, in the form of educational games, is presented in a visually appealing manner	4	4	8	8	100	Valid
11.	The educational game has interesting animations	4	4	8	8	100	Valid
	Graphic Feasibility						
12.	The game's image and letter layout is aesthetically pleasing	4	4	8	8	100	Valid
13.	The title color stands out more than the background color.	4	4	8	8	100	Valid
14.	The material is delivered using a combination of text, images, and animation.	4	4	8	8	100	Valid
15.	The font used is simple and does not have many variations.	3	4	7	8	87.5	Valid
16.	The image displayed is clear and not hazy.	4	4	8	8	100	Valid
17.	Animated displays in educational games are clearly visible.	4	4	8	8	100	Valid
	TOTAL			**129**	**136**	**94.8**	**Valid**

Table 3. Results of Eligibility Judgement from Learning Materials Experts

No	Assessment Aspects	X		∑x	∑xi	%	Status
		1	2				
1.	The appropriateness of content with learning objectives	4	4	8	8	100	Valid
2.	The relevance of learning objectives with learning outcomes	3	4	7	8	87,5	Valid
3.	The suitability of educational games with learning goals	4	4	8	8	100	Valid
4.	The scope of the learning material	4	3	7	8	87,5	Valid
5.	The content clarity of educational games	4	4	8	8	100	Valid
6.	Students' level of understanding of the material	3	4	7	8	87,5	Valid
7.	The material is presented in a systematic, sequential, and logical manner	4	4	8	8	100	Valid
8.	The appropriateness of the language used in the material	4	3	7	8	87,5	Valid
9.	The material's consistency from beginning to end	3	4	7	8	87,5	Valid
10.	Animation's suitability and attractiveness in relation to learning objectives	4	4	8	8	100	Valid
11.	The appropriateness and attractiveness of educational game designs with material	3	4	7	8	87,5	Valid
	TOTAL			**90**	**96**	**93,8**	**Valid**

Table 4. Test Field Results

No	Assessment Aspects	∑x	∑xi	%
1.	The level of interest in learning through the use of educational games	157	160	98,1
2.	The appealing quality of illustrations or images in educational games	156	160	97,5
3.	Animation's suitability and attractiveness in the educational game	158	160	98,8
4.	The appropriateness and attractiveness of educational game designs	158	160	98,8
5.	The use of this educational game can boost learning motivation.	157	160	98,1
6.	Ease of use of educational games	156	160	97,5
7.	The learning material in the educational game is easy to grasp	157	160	98,1
	TOTAL	**1097**	**1120**	**98,1**

A detailed description of the results of the Field Test can be found in Table 4, which obtained the results from 40 participants who took OOP courses. According to Table 4, the educational game

developed has a 98.8 percent attractiveness rate. Meanwhile, the percentage of users who are motivated by educational games is 98.1 percent. The average result from all aspects of the students' assessment was 98.1%, so we can conclude that OOP-EduGame has a positive effect on the motivation of the students.

Table 5. Summary of Validation and Test Results

No	Test		
	Respondents	***Number of Items***	***Results***
1	2 Educational Game Experts	12 items	96.9%
2	2 Learning Media Experts	17 items	94.8%
3	2 Learning Materials Experts	11 items	93.8%
4	40 Students	7 items	98.1%
	Average		**95.9%**

Table 6. Eligibility Level Criteria

Category	Percentage	Qualification	Description
4	80 % - 100%	Valid	No Revision
3	60 % - 79 %	Quite valid	No Revision
2	50 % - 59 %	Less valid	Must be revised
1	0% - 49 %	Not valid	Must be replaced

V. Conclusion

The main research product, an educational game in the platformer genre called OOP-EduGame, has been developed successfully. This educational game has five levels of play, each with a different environment but all with the same theme. At levels 1-4, players must collect materials about OOP and search for three keys to open the magical door. The player is still not confronted with an enemy at levels 1 and 2. Levels 3 and 4 require players to defeat multiple enemies and overcome obstacles to reach the final level (level 5). The player can open a magic door that takes the player to the final level (level 5) after successfully gathering the three keys. At level 5, the player faces the main enemy that attacks the player with several questions. The main enemy health points (hp) are decreased when the player shoots the correct answer. Conversely, the player's health points will decrease if the player shoots the wrong answer. When the player succeeds in defeating the main enemy by shooting the right answer until the main enemy's health points run out, the player is declared victorious.

The OOP-EduGame that was created is thought to be appropriate for use in educational activities. This is demonstrated by the test results (Table 5), which show that the average result obtained from all tests conducted was 95.9%. According to Table 6, overall learning innovations in the form of educational platformer games that have been developed are declared valid, do not require revision, and are ready to be implemented in learning activities. Besides, referring to the results of the field test (Table 4), almost all respondents thought that OOP-EduGame could enhance their motivation and increase their interest in learning OOP material through games. The materials on OOP-EduGame are also considered easy to grasp. These findings are in line with the study's objectives, as OOP-EduGame is expected to enhance student motivation and understanding, particularly in the OOP subject. Furthermore, we realize that the findings of this study are still not perfect, where the results of this preliminary test need to be strengthened by further research with an experimental model to determine the effectiveness of OOP-EduGame in learning activities.

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