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FRACTIONS AND GEOMETRY MATH MATERIAL IN EDUCATION APPLICATION

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ABSTRACT : The increasing number of Covid 19 cases from 2020 to 2021 has made work and teaching and learning activities carried out online. In conducting online learning, it is not uncommon for students to become bored. On the other hand, mathematics is a subject that most students often fear. Especially about fractions and geometry, many students and even prospective teachers have difficulty in doing calculations. Therefore, the application of mathematics education, fractions, and geometry with the gamification method was designed and built. The application has been successfully designed and built using the Unity game engine and the C# programming language. The Fisher-Yates Shuffle algorithm was also applied during application design to randomize quiz questions and answers. The application has been successfully evaluated by 33 (thirty-three) respondents using the End User Computing Satisfaction (EUCS) method and the Likert scale. Based on the results of the evaluation, it was found that 90,99% of the users were satisfied and accepted the application that had been designed and built.

KEYWORDS - Fraction, Geometry, Education Application, Gamification, and Mobile application

I. INTRODUCTION

The development of technology today is very rapid, making technology inseparable from modern human life. Almost everyone from various circles must have an electronic device, for example, a smartphone. Having a smartphone is a common thing to have nowadays to communicate with each other. Moreover, in the era of the internet of things (IoT) in the industrial era 4.0, gadgets are an integral part of daily life [1]. In the world of education, technology also plays a vital role in increasing knowledge of information in the era of globalization. In addition, the learning system has also changed. Especially from 2020 until 2022, Indonesia is still hit by the COVID-19 virus which requires each individual to keep their distance from each other.

Under these conditions, learning activities are hampered. One solution to deal with this is to implement online learning. There are two types of online learning: synchronous online learning and asynchronous online learning. Synchronous online learning is using a computer or cellphone as a medium that occurs simultaneously, in real-time. Synchronous online learning can be in the form of text chat and video chat. At the same time, asynchronous online learning is learning to use a computer or mobile as a medium and is carried out in a delayed manner. Asynchronous learning is learner-centered, like self-study using the necessary online resources [2]. In practice, both types of methods (synchronous & asynchronous) can indeed be implemented and run well. However, there are still some shortcomings in the level of effectiveness. With this synchronous & asynchronous learning system, students are not uncommon to experience setbacks in their motivation and enthusiasm for learning. Based on the results of research conducted on Biology Tadris IAIN Jember students, it was found that 73% chose the answer "yes" which indicated that they experienced learning boredom during the implementation of online learning [3], [4].

Most students have feared mathematics. In a study entitled "Difficulties with Basic Mathematics" written by Mulwa (2015), it is stated that the subject of Mathematics itself can cause fear and anxiety for students [5]. Fractions and geometry are the basic materials of mathematics that are considered quite complicated. Based on the results of research by Novita et al., as many as 66.35% of 104 seventh-grade students at SMP Budi Luhur Samarinda experienced difficulties in using the mathematical principles of fractions [6]. Likewise, the results of a study conducted by Irfan Fauzi & Andika Setiawan entitled analysis of student learning difficulties on geometry material in elementary school, showed that the percentage of learning outcomes of students who answered the circumference of flat wakes correctly was 15.3%, and answered the flat wake area correctly was 3.8%. These results show that students make many mistakes in solving geometry problems [7]. In addition, based on the results of other studies, 29% of prospective teachers were obtained who could determine the triangle's height [8].

Therefore, a solution is needed to complete the synchronous & asynchronous learning method that can stimulate students' enthusiasm for learning mathematics. Gamification is one of the right solutions to overcome this condition. Gamification is the application of elements of game elements in non-game scenarios to have an effect and solve problems [9]. Several gamification elements can be applied to learning, including goals, learning, skills, achievements, challenges, rewards, competitions, and user engagement [10]. About 80% of learners claim that their productivity will increase if their university/learning institution is gamified [11]. Research by Istiono shows that the use of educational games can increase children's interest in recognizing and organizing numbers [12]. Therefore, based on the above problems, this research is conducted to design and build a mathematics education application about fractions and geometry using the Unity game engine with a gamification method that can complement synchronous & asynchronous learning in increasing students' motivation in understanding mathematics. The designed application adopts the combat system found in turn-based games, thus making it different from learning applications that apply other gamification concepts [13]. In addition, this research aims to see the level of user acceptance of math education applications regarding fractions and geometry through a questionnaire that applies the End User Computing Satisfaction (EUCS) method and then measures it using a Likert scale. In this research, an algorithm called Fisher-Yates Shuffle is also used. The Fisher-Yates Shuffle algorithm has a time complexity of O(n), recognizing it as one of the perfect shuffle algorithms that use a random number generator. Based on the tests that have been conducted, the results also show that Fisher-Yates Shuffle Algorithm has a much faster processing time when compared to Riffle Shuffle Algorithm [14], [15].

II. LITERATURE REVIEW

Fraction : Fractions are parts of a certain quantity. Fraction comes from the Latin fractus which means broken [2], [16]. Fractions are generally divided into several types: proper fraction or improper fraction, mixed fraction, and decimals [17]. The following is an explanation of the types of fractions, among others:

a) Proper Fraction

A proper fraction is a fraction whose numerator is less than its denominator. True fractions are fractions that have the same numerator and denominator.

b) Improper Fraction

An improper fraction is a fraction where the numerator is more than the denominator. Improper fractions are fractions that have different numerators and denominators.

c) Mixed Fraction

Mixed fractions are a mixture of whole numbers and fractions. Whole numbers in mixed fractions are generally placed on the front.

d) Decimals

Decimal numbers are a number system composed of the numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 delimited by commas. Examples of this type of fraction are 0.1, 2.5, 5.5, and so on.

Geometry: Geometry is a branch of mathematics concerned with shape, size, the relative position of images, and the nature of space. According to Clements et al. (1992), geometry is an effort to build concepts in identifying shapes and investigating objects in the form of buildings and images such as rectangles, circles, and triangles [18]. Geometry is divided into several types, including plane geometry and solid geometry [19]. Here is an explanation of the two types of geometry:

a) Plane Geometry

Plane geometry deals with flat shapes that can be drawn on a piece of paper. Plane geometry can be in the form of lines, circles, and triangles. Plane geometry only has two measurements, namely length and width.

b) Solid Geometry

Solid geometry deals with three-dimensional objects with measurements of length, width, and height. Building geometry can be three-dimensional objects such as cubes, prisms, tubes, cones, and spheres.

Fisher Yates Algorithm : Fisher-Yates Shuffle Algorithm is an algorithm founded by Ronald Fisher and Frank Yates that serves to change the order of input given randomly. Basically, Fisher-Yates Shuffle Algorithm is an algorithm to perform random permutations of an infinite set or generate random permutations of the numbers 1 – N. The Fisher-Yates Shuffle algorithm has a time complexity of O(n). The steps to use this method is; first, prepare an array of N elements, and after that raise one random number from 1 to N elements that have not been exchanged, next, exchange the array element in the element of the random number with the element to N and last step, repeat from step two until the entire array is selected [20]. The following is an example of the Fisher-Yates Shuffle Algorithm calculation, which can be seen in Table 1.

Table 1. End User Computing Satisfaction (Chin & Lee, 1999)

Range (M)	Roll (N)	Scratch	Result
-	-	ABCDE	-
1-5	5	ABCD	E
1-4	2	ACD	EB
1-3	1	CD	EBA
1-2	2	C	EBAD
Result			CEBAD

III. METHODOLOGY

This section will discuss the research methodology of this research. During the research, various methods were used. The following is the research methodology used during this research:

A. Literature Study: The literature review stage is the stage of reviewing or studying a theory based on the literature of the paper. The literature review is carried out to support the topics discussed in the research. In addition, at this stage the process of formulating the background of the research is also carried out, to answer the question of why this research topic needs to be carried out. After examining the problem through previous studies, it was concluded that as many as 66.35% of 104 seventh-grade students at SMP Budi Luhur Samarinda had difficulty in using the mathematical principles of fractions [6], as well as 15.3% of students who answer correctly the question of the perimeter of a flat shape and 3.8% who answer correctly the question of the area of a flat shape. These results show that students make many mistakes in solving geometry problems [7]. This stage also describes the theories that support the research topic, including fractional numbers, geometry, gamification method, End User Computing Satisfaction (EUCS), Fisher-Yates Shuffle Algorithm, and Likert scale.

B. Requirement Analysis: At this stage, the elements needed in the research are identified and determined based on the literature review used. The needs analysis is related to mathematics learning materials in the field of fractions and geometry.

C. Application Design: At this stage, the application design process is carried out which includes designing the gamification concept, application model, application prototype design, and designing the assets needed in the application. After determining the application of the gamification concept, the decision was made that the application would be designed by applying the concept of turn-based games. The application design uses Firebase as a database and authentication tool for the application. The application model applied in the application design can be seen in Fig. 1.

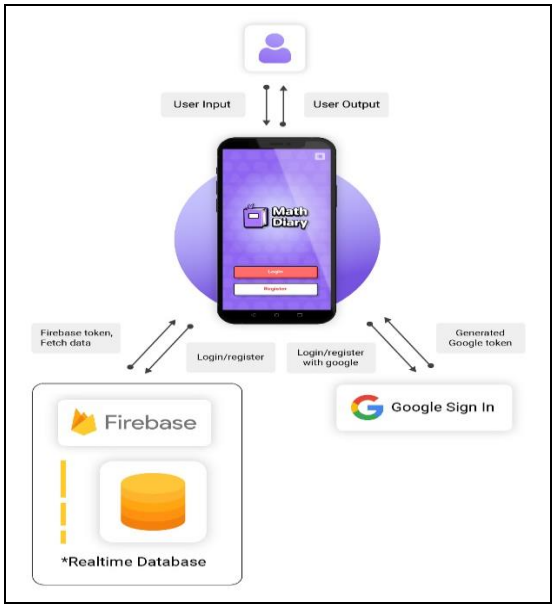

Fig. 1. Application Model

Login can be done using a general email address or using a Google account registered on the user's device. If the user chooses to log in/register using a google account, the application will request a google token. The google token will be used to log in to Firebase. After Firebase successfully receives the google token, Firebase will send a response in the form of a firebase token which will be used by the application to access data contained in Firebase. However, if the user logs in using a general email address, the login process only requires a firebase token. The services used in Firebase are real-time database, authentication, and firebase storage. In addition, Adobe Illustrator was also used in designing the prototype design and application assets.

D. Implementation stage: This stage contains the application of each gamification element and math learning material (fractions & geometry) into the application. The application implementation is carried out using the Unity game engine with the C# programming language, Firebase as the application database, and Google Play Store as a publication medium.

E. Application Testing stage : This stage carried out a series of tests of applications that have been completed to be used by the public. After testing, at this stage the user will be asked to fill out a questionnaire provided in the form of a google form. The questionnaire was made using the End User Computing Satisfaction method.

F. Evaluation of application test result : This stage contains the process of processing data that has been obtained from the application testing stage. At this stage, the data that has been obtained from application testing will be processed using a Likert scale to measure the success rate of the application.

IV. RESULT AND DISCUSSION

In this fourth section, the application implementation results and questionnaire results will be discussed. The results of the application are presented in the form of screenshots on the android simulation contained in Unity. As explained earlier, the application was created using the Unity game engine, C# programming language, and Adobe Illustrator as a tool to design the assets needed in the application. The following is an explanation of the results of the application implementation on each page. The login screen will be displayed after the splash screen has finished loading. On the main display of the login screen there are 2 options, namely login and register. On the top right side of the login screen is a button to view the application's version. The following are the implementation results of the main display of the login screen which can be seen in Fig. 2.

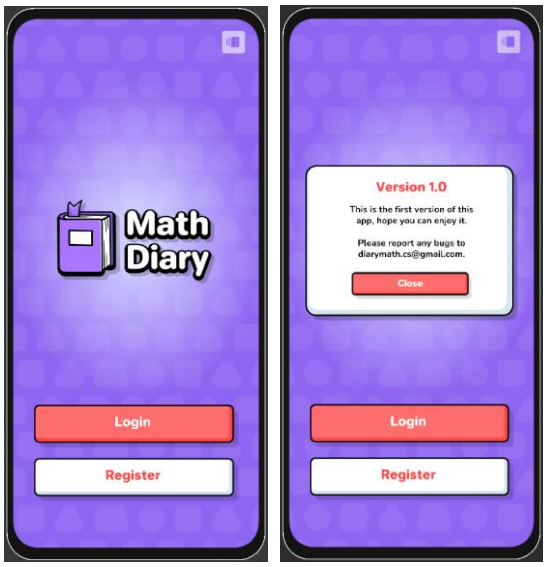

Fig. 2. The Result of the Login Screen Implementation

If the user chooses login, the application will display a display to log in. Likewise, with the register option, which, if the user decides, will show a display to register. Here are the implementation results of the login and register views on the login screen, which can be seen in Fig. 3.

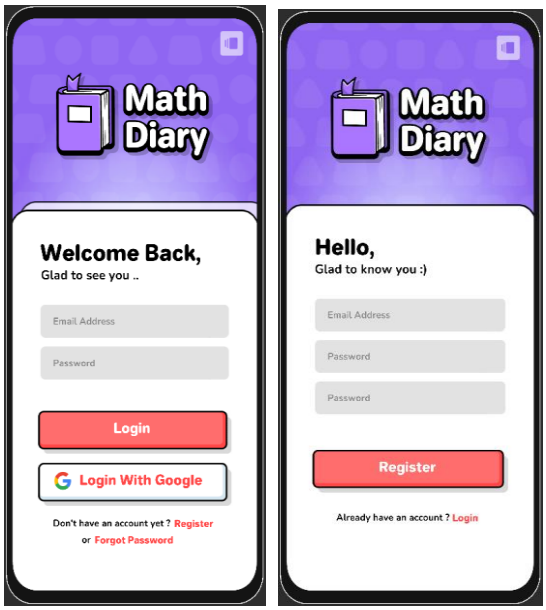

Fig. 3. The Result of the Login & Register View

At the top of the home screen is information about the user, such as a nickname, level, exp, total gold, total silver, and profile picture. Then, at the bottom of the home screen, there is a navigation bar consisting of 5 options: lessons, rank, home, profile, and shop. Users can enter the game by pressing the dream world button on the home screen. On the home screen page, there is also a mailbox button that serves to open the mailbox window. Mailbox window. Here are the results of the home screen implementation, which can be seen in Fig. 4.

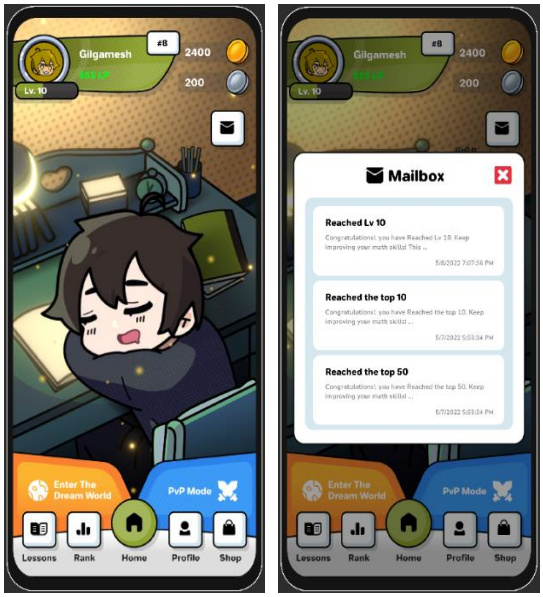

Fig. 4. The Result of the Home Screen

The Lessons screen displays a menu of math subject matter contained in the application, which consists of fractional numbers, flat shapes, and space shapes. The lessons screen also displays a navigation bar. On the lessons screen, users can select one of the materials to be able to display a detailed discussion of the material. In each detailed material discussion, there are 3 navigation buttons: next, previous, and close. The close button closes the detailed discussion, while the next and previous buttons move to the next lesson. Lesson material. The following are the lessons screen implementation results, which can be seen in Fig. 5.

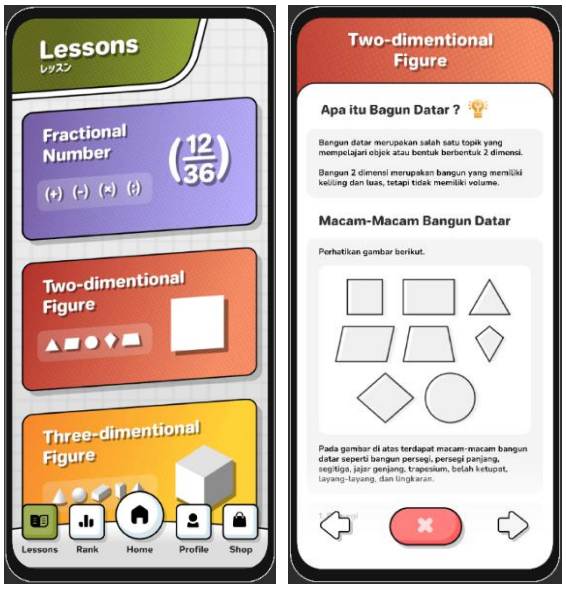

Fig. 5. The Result of the Lessons Screen

The rank screen displays a leaderboard sorted by the highest total LP (Learn Points). The information displayed on the rank screen page includes nickname, level, total learn points, and profile picture. Users who are ranked in the top 3 will be displayed in a special color on the leaderboard. Users listed on the leaderboard are limited to the top 50 only. The following is the implementation result of the rank screen which can be seen in Fig. 6.

Fig. 6. The Result of the Rank Screen

On the profile screen, users can change the avatar they want to use by pressing the change avatar button and then selecting it through the popup avatar list that appears. In addition, at the bottom there is also information about the user's score. Users can also view the achievement list on the profile screen by pressing the achievement button. The achievement list is displayed in the form of a grid view. There are 4 achievement categories: level achievement, LP (Learn Points) achievement, rank achievement, and avatar achievement. The user's achievements will be displayed with 100% opacity (not transparent), while achievements that have not been completed are displayed with 40% opacity (transparent). The following are the implementation results of the profile screen, which can be seen in Fig. 7.

Fig. 7. The Result of the Profile Screen

At the top of the shop, the screen is information on the total gold and silver owned by the user. Then at the bottom right of the shop screen, there are two buttons: the toggle button to change the currency used, and the pull button to gacha the avatar. When the user pulls, the application will check whether the user has enough currency to pull. Gacha avatar uses RNG (Random Number Generator) in randomizing the prizes obtained with a normal avatar rate of 67% and an elite avatar of 33%. The following is the implementation of the shop screen, which can be seen in Fig. 8.

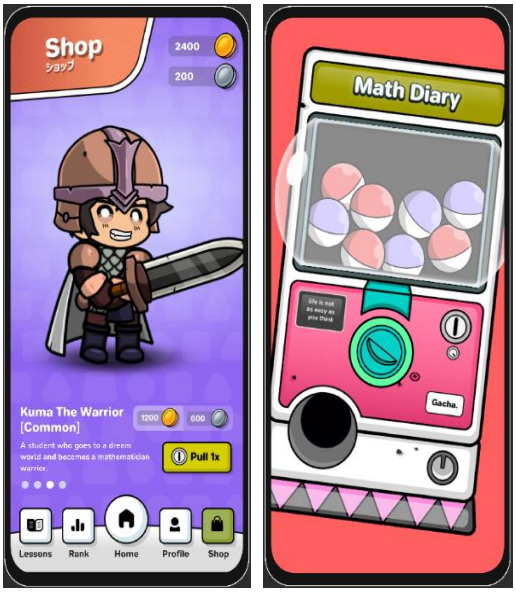

Fig. 8. The Result of the Shop Screen

On the stage selection page, there are 3 stage units that users can select and play, namely unit one, which contains fractional numbers, unit two, which contains flat shapes, and unit three which contains space shapes. Each stage unit is divided into 2 sections. Stages that are still locked will be marked with a transparent color (40% opacity). In addition, the total learns points, total gold, and total silver are also displayed at the top of the stage selection page. At the bottom of the stage selection, there is a close button that serves to return to the home screen page. The following is the implementation of the stage selection screen, which can be seen in Fig. 9.

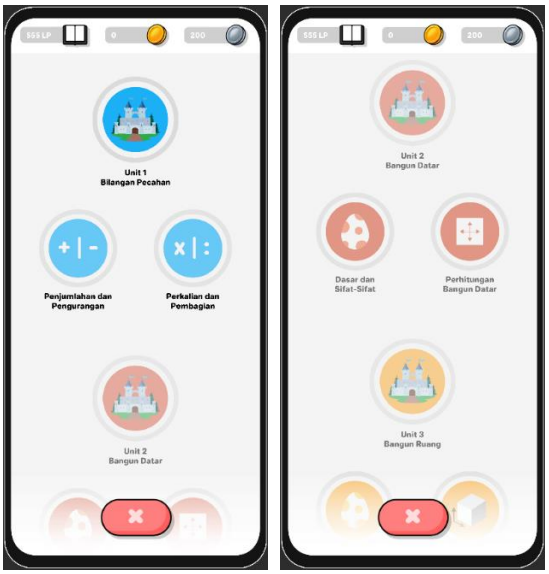

Fig. 9. The Result of the Stage Selection

In general, the battle screen page is divided into 2 parts: the action panel display to select the action to perform (using normal attack, ultimate attack, or skip turn) and the quiz view. On the top right side of the battle screen is information about the avatar and user account, such as total HP (Health Points), exp, user level, and user nickname. Meanwhile, on the top left side of the battle screen is information about the amount of currency the user has. On the battle screen there is also a wake-up button to display a popup that serves to exit the ongoing game. As in the prototype design, there are three options on the action panel: normal attack, ultimate attack, and skip a turn. Especially for the ultimate attack, it can only be used when the total turn has reached 6 turns. Skip turn functions to add the user's total turn by 2, but with the consequence of providing an opportunity for the enemy to attack and reduce the user's HP. The application will display a multiple-choice question when the user chooses to use a normal attack or ultimate attack. The user is required to answer the question before the time runs out. The timer indicator is located on the left side of the battle screen, with the maximum total answer time decreasing with the number of enemies defeated. The following is the implementation of the battle screen, which can be seen in Fig. 10.

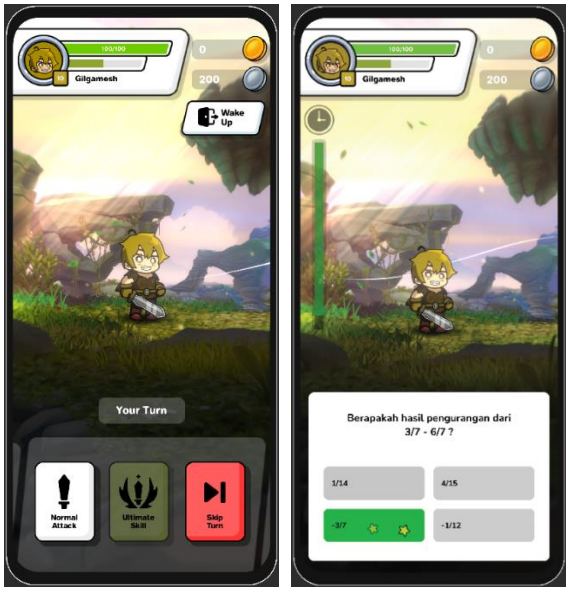

Fig. 10. The Result of the Battle Screen

The result screen displays the user's avatar, nickname, level, and total exp. The user's total exp will increase according to the user's performance in completing the game. On the result screen, there is also a continue button which, if pressed, will direct the user to the result details. The results include information such as total overall score, total correct answers, total wrong answers, and accuracy level. The overall score is determined by the number of correct questions, wrong questions, and the total HP of the avatar when completing the game. Meanwhile, accuracy is the percentage of correct answers from the total number of questions. Then at the bottom of the result details, two buttons are also provided, namely home which functions to return to the home screen, and take another lessons button which functions to repeat the game. The following is the implementation of the result screen which can be seen in Fig. 11.

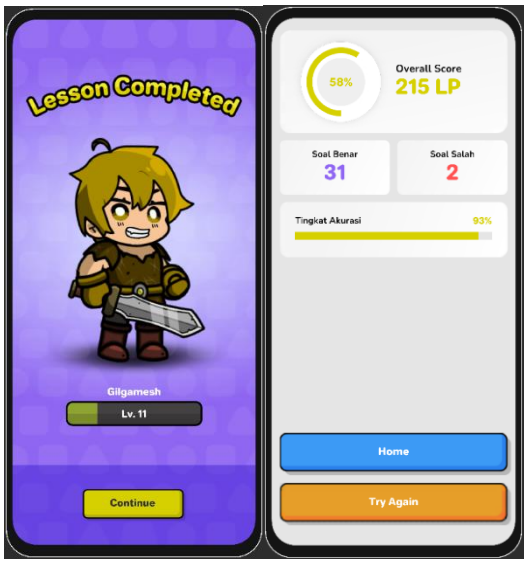

Fig. 11. The Result of the Result Screen

In this research, the survey process was carried out by distributing Google Play Store links and questionnaires in the form of Google forms to the public. The questionnaire was made using the EUCS (End User Computing Satisfaction) method to determine the level of user acceptance in using the fractional number and geometry math education application with the gamification method called Math Diary. Based on the results of the questionnaire conducted, 33 respondents were obtained who had filled out the questionnaire. The following are the results of the average value of each EUCS element contained in the questionnaire questions, which can be seen in Table 2.

Table 2. User Acceptance Test Result

Element	Average Score	Result
Content	90,50%	Totally Agree (TA)
Accuracy	88,89%	Totally Agree (TA)
Format	93,13%	Totally Agree (TA)
Ease of use	92,73%	Totally Agree (TA)
Timeliness	89,70%	Totally Agree (TA)
Total Average	90,99%	Totally Agree (TA)

Based on the results of the calculation of the average percentage of questionnaire answers, it can be concluded that most respondents accept the educational application of fractional number math and geometry with the gamification method to be used as a tool in learning fractional number math and geometry as shown by the total average percentage of answers of 90.99%.

V. CONCLUSION

The application has been successfully designed and built. The application design uses the Unity game engine with C# programming language.

Gamification elements have also been successfully implemented into the application which includes, goals in the form of a stage system, learning in the form of learning materials contained in the application, skills in the form of unique moves owned by each avatar, achievement, challenge in the form of time limits in doing quizzes, rewards in the form of prizes when completing games or achievements, competition in the form of leaderboards and user engagement in the form of turn-based game systems.The application has been successfully evaluated by 33 (thirty-three) respondents using the End User Computing Satisfaction (EUCS) method. This research has also successfully measured the level of user acceptance of the educational application of fractional number math and geometry with the gamification method that has been designed. Based on the evaluation results, the average percentage value of questionnaire answers is 90.99%, identifying that users accept the applications designed and built in this study.

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Biographies and Photographs

Andrio Effendi, received the Bachelor degree S.Kom in computer science from the informatics department, Universitas Multimedia Nusantara, Indonesia, in 2022, and now he currently work in cheap-me, Indonesia as co-founder, and also he develop web and mobile application.

Wirawan Istiono, He is currently a lecturer and researcher and also serves as the head coordinator of the Game Development Laboratory, Department of Informatic, Universitas Multimedia Nusantara, His research interests include requirements engineering in software application development, computer engineering, and human-computer interaction