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Research Article

Mobile Game Prototype for Fractional Concept in Elementary School

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Abstract.
This research aims to create a prototype of a mobile game that can be used as an instructional media for mathematics learning in school and then test the effectiveness of the product for the result. This research uses the research and development (R&D) method with the subject of research being 35 students of the third-grade elementary school in Cirebon. The process of creating mobile game prototypes consists of analyzing the user's needs, prototype design, trial and error, evaluation and revision, validation, implementation, and the final result of a prototype. In analyzing a user's needs the following steps were included, analysis of the curriculum, content, concepts, and characteristics of users, in this case, are 3rd-grade students in elementary school. The main content of this research is fraction concepts such as knowing their concept, the symbols, comparing fractions, their equal value, sorting fractions, and adding or subtracting fractions with the same denominator. All the analysis was put into prototype design to create flowcharts, storyboards, and interfaces. The results of the prototype design were then tested by trial and error on small samples. After revision, the final prototype then got validation from expert judgment with notes that can be implemented.

Keywords: elementary school, fractional concept, mobile game

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1. INTRODUCTION

The growth of tech and education is increased rapidly through the industrial revolution 4.0. Education has to be ready to adapt to any current situation, such as the covid-19 pandemic. Minister of Education and Culture Indonesia released the Guidelines for Organizing Learning From Home. This policy made massive changes in our education practical which students had to study at home during the pandemic. Online learning was the only option for the current situation. The use of technology has a vital role in

the success of learning. Teachers have to provide any strategy to make online learning keep interesting for students to attend.

One of the increasing media technology is using the game in conveying teaching materials that facilitate students in the learning process [1]. Games are interactive multimedia that are very popular with children [2]. The frequency of using mobile games for elementary school-age students itself is significantly high. Based on prior research, 52% of respondents age 9 – 10 years old claimed to enjoy mobile games with the frequency of playing mobile games every day after school, and this claim keeps increasing during the pandemic.

In this case, mobile game-based learning can be one of the solutions for online learning during pandemics. Educational games increase motivation to do learning and can be an effective way to improve learning. Games also can be used as learning aids for a subject that is difficult to understand. Math is one of a subject that students think complex to understand. A Survey of 34 participants in third-grade elementary school found that 64,71% of students think math is a complicated subject to learn especially fractional concepts. Among areas of mathematics, fractions seem to be especially important for later success. Fractions understanding also is essential for a wide variety of occupations beyond science, technology, engineering, and mathematics fields [3]. One way to improve conceptual understanding is to use manipulative media and visual representation of fractions. Games help students build comprehension of mathematical concepts [4]. Create mobile game-based learning can be the perfect solution to the facts above.

2. RESEARCH METHOD

This research uses the research and development (R&D) method that aims to develop a product. Product development is using a prototype model that adapts the waterfall model proposed by Roger S. Pressman. This method follows steps such as analyzing the user's needs, prototype design, trial and error, evaluation and revision, validation, implementation, and the final prototype. The main content in this research is fraction concepts. The instruments used in this research are data collection and interviews. The data collection has an indicator that represents each level of fractional concepts. The participant of this research is 35 students of the third-grade elementary school in Cirebon, Indonesia.

3. RESULT AND DISCUSSION

3.1. Analyzing User Needs

The first step for creating a mobile game prototype is analyzing user needs. Analyzing user needs contains the analysis of curriculum, content and concepts, and characteristics of users, in this case, are 3rd-grade students in elementary school. The analysis data collection of this step were collected by observation, interview, study literature, and documentation. This research used Curriculum 2013 with the main content fraction concepts such as knowing fractional concepts, fraction symbols, comparing fraction, fraction equal value, sorting fraction, addition and subtraction fraction with the same denominator. In educational games, the content has to be attractive and can be played by students [5]. The distribution explained in Table 1.

Table 1: The fraction content and concept level of mobile game.

Basic Competencies	Learning Indicator	Level in Game	Cognitive Level
3.4 Generalizing the idea of fractions as part of a whole using concrete objects 3.5 Explaining addition and subtraction of fractions with the same denominator 4.4 Presenting fractions as part of a whole using concrete objects 4.5 Solving addition and subtraction problems with fractions with the same denominator	Knowing the concept of fractions	Category 1	C1 – Identifying
	Knowing the symbol of fractions	Category 2	C1 – Estimating
	Comparing fractions	Category 3	C3 – Classifying
	Understanding equivalent fractions		
	Sorting fractions from smallest to largest or vice versa		
	Adding fractions with the same denominator	Category 4	C3 – Calculating
	Subtracting fractions with the same denominator	Category 5	C3 – Calculating

Table 1 showed that each category/level game included the learning indicator and level cognitive that students will achieve while playing this mobile game. This step is to ensure the content and concept of the game examination to the level of difficulty and understanding of students [6]. The mobile game included four basic competencies

with six learning indicators and five categories following cognitive level until C3. This analysis was chosen based on the problem found in field school.

3.2. Prototype Design

A prototype is an explicit representation that helps designers, engineers, and users know the purpose of the system built [7]. Prototype design started with forming a sketch of a plot of each part. The result of data collection combined into prototype design use as material for designing and developing the mobile game. This prototype design includes several stages as produced flowcharts, storyboards, and interfaces of the game. A flowchart is a diagram that represents an algorithm, workflow, or process of a game. The flowchart explains how the game mechanism runs, the choices from each available menu, and the situations faced by players. A flowchart is guidance for constructing the game. Examining the flowchart can be used as a guide and navigation for the programmer to write coding and build game components correctly. The flowchart of this mobile game prototype as Figure 3.

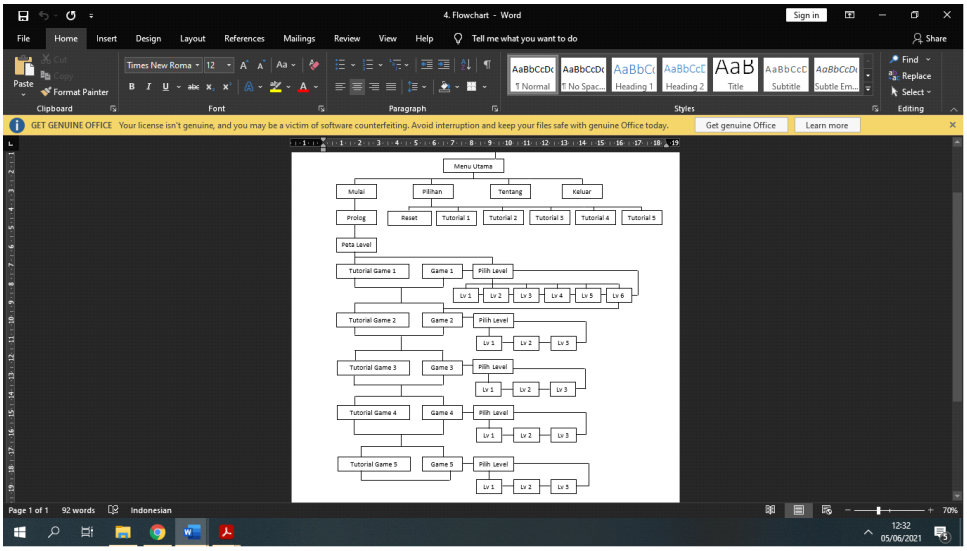

Figure 1: Flowchart of mobile game.

Figure 3 explained how the game runs. Start Menu leads to play the game with Prolog, Map Level, and the game level. Option Menu leads to some buttons to Reset and Tutorial Game. About Menu contains information about the game and creators. And Exit Button to end the game. The flowchart was designed so that users are not confused when operating the software precisely [8]. The designed flowchart then convert into a storyboard. The storyboard is one of the best ways to see a game.. Storyboard creates a sequence of drawings that show the game level shown in Figure 2.

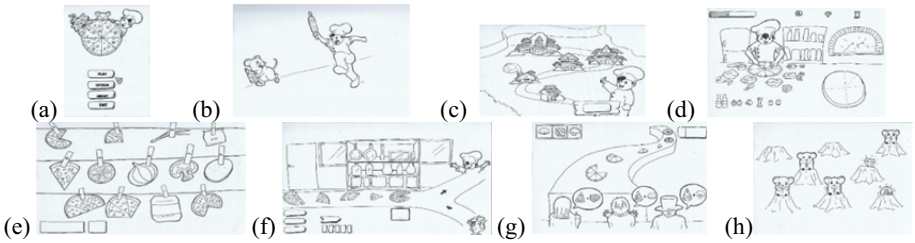

Figure 2: The storyboard.

Figure 2(a) displayed the main menu scene that contains several menus such as play, option, about, and exit buttons. Figure 2(b) pictured the prologue scenes that tells the player the connection between each character and the story of this game. The design of this game consists of five categories level that is adjusted to the learning indicators and must be achieved based on core competencies and basic competencies. The five categories are formed in a level map that points out each learning indicator in Figure 2(c). In each category, the player has to complete several levels. The student/player require to finished the first level to continue or open the next level with more complex problems. Problems in the game usually start easy and then get more and more difficult as the player's skills develop [9] Figures 2(d), 2(e), 2(f), and 2(g) illustrated the game in each category. The last Figure 2(h) portrayed the scene when the player completed each level or category.

3.3. Developing Prototype

The next step after prototype design is developing the prototype. The game development stage includes interface creation, coding, application testing, publication, and packaging, which are carried out by programmers and discussed with researchers to produce initial products or prototypes. Then tested by a small user sample or called the trial version. After the trial version, the prototype into evaluated and revised. The revised prototype was then validated by experts to assess the design.

3.4. Interface Design

The interface design is the display page in the mobile game formed to images. The interface of the mobile game refers to the storyboard. The program to create mobile game applications is Unity Engine program version 2018.2.2F1 and assisted by programmers with paying attention to game scenarios, flowcharts, storyboards, material content, and evaluation of each work result. Some features of mobile devices are generally cheap,

portable, and flexible [10]. The platform used is Android version 5.1 (Lollipop) with a size of 58.96 MB. The next stage is the creation of game assets that are used in making the game. These assets are game characters, backgrounds, symbols, text, and background music. The detailed interface described in Figure ??.

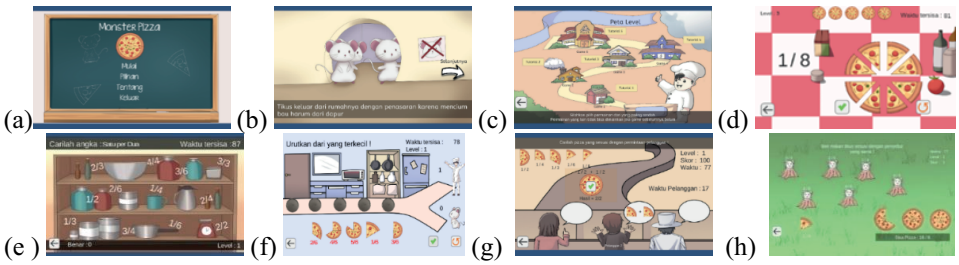

Figure 3: The detailed interface.

These interface images were created and modified from the storyboards. Figure ??(a), 3(b) and 3(c) showed the exact scenes and function with storyboards. Figure ??(d) showed the visualization of the game in category 1, knowing the concept of fractions. The player is given the challenge to cut the pizza according to the given orders. If all levels passed, the next category is unlocked. For knowing fraction symbols, Figure ?? (e) inspired by the finding objects game, players have to find symbols of fractions in the room. Figure ??(f), including comparing fractions, equivalent fractions, and sorting fractions presented in the form of a food bar that showed pizzas in various sizes. The players have to sort pizzas based on their size. In Figure ??(g) is Category 4, the game concept is ordering pizza. The player places an order by selecting the pizza slices according to the number of orders. The Figure ??(h) showed subtracting fractions category with an illustration of the chef having some pizza that cut into several types of shards, the mouse in the hole asked Pizza then the chef shoots the pieces pizza to the corresponding mice in a minute and a half.

3.5. Trial Version Test

One key feature that separates a prototype from a design concept is testing. The trial version was tested on a sample of 3 students to know how students play it and ensure the functions in the game work well. Table 2 shows the results of this trial version test that some features in the game have not run as expected, several features such as tutorials have not been made as user assistance, and found errors. Based on the results of this trial version, it is necessary to make revision/improvements.

Table 2: The result of trial version test.

Description Test	Expected Result	Test Result	Notes
Main Menu Page	All button works well and enter to all the menu (prologue, option, about and exit game)	75%	Some of button works well, option button do not show the setting page, only for resetting game.
Prologue Page	All button works well following the story of game and showed level map	50%	The story text in prologue not showed yet, only picture. There are no next or skip button
Level Map Page	Showed all level that can be open and choose in order categories to play. All button works well.	50%	Players can choose game categories in no order
Game 1 - 5	There are tutorial game, showed level option page, goals of game and all the button works well	70%	There is no tutorial in game, players can choose game level in no order. Game 1, the back button in level 3 and 4 does not work. Game 2, the back button in level 1, 2 and 3 does not work. Game 3, there are no back button and the result of game in each level. Game 4, there are no back button in Level 1 and 2. The result of fraction addition was overleaped. Game 5, dragging pizza to mice does not work.

3.6. Evaluation and Revision

After the results of the trial version, improvements and refinements were made for the feature that did not work properly. These fixes add tutorial features, add or replace text, colors, and buttons in the game. Improvements were also made to the layout, background, and assets at each level for better results in Table 3.

Table 3: The result of revision version.

Description Test	Expected Result	Test Result	Notes
Main Menu Page	All button works well and enter to all the menu (prologue, option, about and exit game)	100%	All button works well.
Prologue Page	All button works well following the story of game and showed level map in the next page	100%	Prologue is equipped with text
Level Map Page	Showed all level that can be open and choose in order categories to play. All button works well.	100%	Players choose games in order
Game 1 - 5	There is tutorial game, showed level option page, goals of game and all the button works well	100%	There are tutorials in the game. The players choose game categories in order, higher-level unlocked when the player completed the game on the previous level.

The final result of the game showed that all the buttons work well. The storyline in the prologue is synchronized, each game category has a tutorial, and players play the game in an appropriate order. The higher level is unlocked when the player has completed the game on the previous level. The results of these steps gave birth to a prototype that is ready to be validated before being applied to research subjects.

3.7. Expert Judgement

Table 4: The result of content expert judgement.

Indicator	Content Quality	Learning Objective	Feedback and Motivation	Eligibility Percentage (%)	Expert Recommendation
Validator 1	40	40	4	98.82	The game was too short, add more and higher levels of the game help students understand the material better.
Validator 2	28	30	5	74.12	For the upgraded version, the game should be add Percent and probability materials so that they can also be applied to high-grade students.

Expert validation determines the feasibility of a product before implementation. The aspects assessed are based on LORI standards. The quality of content, goal alignment, feedback, and motivation have met the feasibility standard of a product with average feasibility of 86.47% and the game appropriate for third-grade students because it can facilitate the provision of fractional material both theoretically and conceptually show in Table 4.

Table 5: The result of media expert judgement.

Indicator	Presentation Design	Interaction Use	Accessi-bility	Reuse	Eligibility Percent-age (%)	Expert Recommendation
Validator 1	40	20	21	5	81.90	There is a mismatch between the interface (UI) in Game 4 which is quite difficult to play.
Validator 2	30	19	24	5	74.29	Add voice over, hints, status, narration in the game. Font and size selection needs to pay attention to neuroscience aspects neuro

Experts in Table 5 show the presentation design, interaction, accessibility, and reuse with an average feasibility percentage of 78.10%. The purpose of creating this mobile game is excellent and can be implemented. In a further development, the game can improve by using voice-over instructions, status, and narration that can help users as clues or signs in the game. The font selection and the button status or features should be clearer.

4. CONCLUSION

Based on the results of the prototype design explained above, it produced a mobile game prototype, named Monster Pizza, for elementary school students. In the development process, several stages such as the needs analysis stage include curriculum analysis, material and user characteristics, the design stage by making flowcharts, storyboards, and interfaces. The development stage includes design implementation into a prototype, trial and error, evaluated and revised, and validated to produce a prototype that is ready to be used. The final results of the prototype used the mobile game platform Android ver 5.1 with sizes 58,96 MB. Mobile game Monster Pizza has an adventure game genre and can be implemented as instructional media or supporting tools in learning fraction concepts in third-grade elementary school students.

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References

[1] Maharbid DA, Maharbid TA, Gumala Y, Herman T. “Mobile game design for understanding fractional conception in elementary school.,” In: International Conference on Mathematics and Science Education of Universitas Pendidikan Indonesia. pp. 836–841 (2018).

[2] Munir. “Multimedia konsep & aplikasi dalam pendidikan.,” Bandung: Alfabeta. p. 2012.

[3] Siegler RS, Lortie-Forgues H. Conceptual knowledge of fraction arithmetic. J Educ Psychol. 2015;107(3):909–18.

[4] ince EY. “Educational games in higher education,” (2018). https://doi.org/10.5772/intechopen.71017.

[5] Delima R, Arianti NK, Pramudyawardani B. “Identifikasi kebutuhan pengguna untuk aplikasi permainan edukasi bagi anak usia 4 sampai 6 tahun.,” Jurnal Teknik Informatika dan Sistem Informasi. vol. 1, no. 1, p. 2015.

[6] Lisa, “Prinsip dan konsep permainan matematika bagi anak usia dini.,”. Bunayya. 2017;3(1):93–107.

[7] Beaudouin-Lafon M, Mackay WE. “Prototyping tools and techniques.” (2002).

[8] Hamari J, Shernoff DJ, Rowe E, Coller B, Asbell-Clarke J, Edwards T. Challenging games help students learn: an empirical study on engagement, flow and immersion in game-based learning. Comput Human Behav. 2016;54:170–9.

[9] Mohammadi M, Sarvestani MS, Nouroozi S. “Mobile phone use in education and learning by faculty members of technical-engineering groups: concurrent mixed methods design.,” Frontiers in Education. vol. 5, p. 2020.

[10] Camburn B, Viswanathan V, Linsey J, et al. “Design prototyping methods: state of the art in strategies, techniques, and guidelines,” (2017). https://doi.org/10.1017/dsj.2017.10.