



vol. 16 / 2023



The 7th International Conference on Science Technology

organized by
Faculty of Social Science and
Law Universitas Negeri Manado and
Consortium of International Conference
on Science and Technology

The Innovation Breakthrough in Digital and Disruptive Era

Distinctive Features and Design for Mathematics Learning Mobile Games in Elementary School Students

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Abstract. This paper assesses the implementation of the framework for building new Distinctive Features and design mathematics games. We explain how to design a typical mathematics game according to the learning needs of elementary school students. Next, we explain how to build new Distinctive features that are unique to students' needs and can be run in math games. We explain the importance of constructing mathematics game features and designs that suit the characteristics of primary school students. We conclude that the selection of distinctive features and game design according to students' needs are the most important aspects in building an interesting mathematics learning experience. This conclusion was obtained from the results of usability tests on elementary school students. This paper has broad implications in the development of elementary school games.

1. Introduction

Learning mathematics in elementary school is not an easy subject. Students always have great difficulty when learning it. This is a serious problem faced by elementary schools. This difficulty has been experienced by students when learning face to face with teachers in class, where teachers can directly guide the learning process. This problem is even more difficult when the COVID-19 pandemic forces students to study from home virtually via video conferencing. Teachers can only guide virtual learning without directly dealing with students. This psychologically guides the spirit of student learning, motivation, and student attitudes. This has made it increasingly difficult for students to understand mathematics learning in elementary school.

The temporary solution is to organize learning in the classroom or virtual class in an interesting way. But this is of course not easy. It is necessary to increase skills and information technology literacy for teachers and parents learning companions for students. Creativity in learning that can improve the ability to learn mathematics is to create interesting math games [1]. Games are proven to significantly improve mathematics learning [2]. Games can also increase creativity and motivation in learning mathematics for elementary school students [3]. Not only mathematics, but games can also improve skills in other subjects such as the formation of motivation and learning achievement in history lessons [4]. Games can also improve English language skills that are played with mobile devices [5]. Games also have an influence on understanding religious learning materials [6]. In general, it can be seen that games have a significant [7]. Game

in the form of games that run on digital devices including mobile phones. This can be a solution for learning during the covid-19 pandemic.

The COVID-19 pandemic has created friction in learning models, from traditional learning to learning that uses digital media. Covid-19 has made traditional media learning and created a digital dependency. This digital dependence has forced the creation of digital learning content, including digital learning media using games. Game development must be in line with the behavior of game users so that the game can be adopted easily [8]. It is not easy to build a game according to user behavior, because game users are very diverse and different in terms of knowledge, culture, skills, mindset, and experience. It takes the ability and creativity independently for users to be able to adapt learning content in the form of games [9]. Games played in elementary schools must have the basic principle of being easy to play and creating fun when playing them [10]. This is an important factor for building a game that is also used as a vehicle for learning. The serious problem here is how to use the right techniques and methods for increasing new features and design for learning behavior. This problem is important to solve because elementary school students get bored very quickly and switch to other rides if the rides are less interesting to play. Learning vehicles that are built through games must be really suitable for elementary school students. The challenge is how to design the game and develop new features embedded in the vehicle so that it is easy to play and creates fun at the same time for learning mathematics. There have been many games that have been built for this purpose by embedding several technologies such as virtual reality [11], or by building an avatar character in the game personally [2]. But it still poses a serious problem in developing countries where there are limitations on equipment, technological infrastructure, and the ability to afford more modern games. A solution is urgently needed to create games that match the behavior of elementary school students who have limitations in accessing and operating technological devices for sophisticated games.

An in-depth study is urgently needed to identify barriers to the new feature and design of prospective digital platforms amid COVID-19 recovery. This paper attempts to conduct a study to implement a simple framework in producing distinctive features and designs for mathematics learning mobile games in elementary school students. It is hoped that this framework can be tested and produce ways that can be implemented to build games that are in accordance with the conditions and behavior of students in developing countries who have many limitations to implementing a game technology.

2. Method

Game development that suits the needs of elementary school students requires the same method for designers and players. Researchers see an appropriate framework for elementary school math game implementation is the MDA agency diagram framework developed by Duarte [12]. This model framework is very appropriate for designing games and building new features in math games. The MDA Agency framework model can be seen in figure 1. This study took a sample of elementary schools in Indonesia, especially in the province of North Sulawesi. The sample involved 100 elementary school students in North Sulawesi who have a mobile phone / Smartphone with the Android operating system.

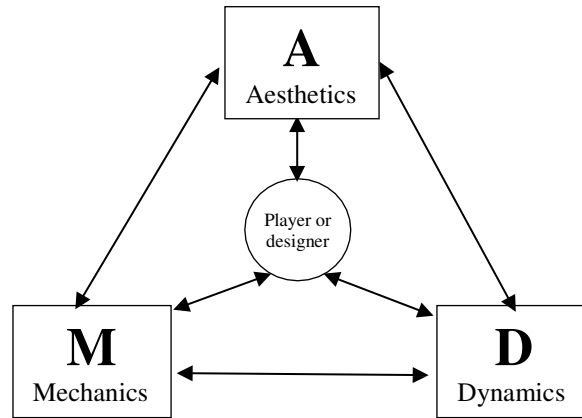


Figure 1. Framework MDA agency diagram from Duarte[12]

From the designer's perspective, the mechanics give rise to dynamic system behavior, which in turn leads to particular aesthetic experiences. From the player's perspective, aesthetics set the tone, which is born out in observable dynamics and eventually, operable mechanics. The Aesthetics component is seen as an important part to build an attractive, beautiful, and in accordance with the preferences or user experience of elementary school students. The Dynamics section describes the dynamics that will be built in the form of a sound system and language that is built in a game design that is produced. Mechanics include how the game works, the system level that will be played, the interaction between the various characters that are built in the game system, and the algorithms used to run the game engine itself.

3. Result and Discussion

The implementation of the MDA framework is done by looking at its components in detail to formulate a game design model that will improve the user experience for this game player. In the Mechanics component, it starts with building a Concept game that will be played. The concept was built with the goal of the game itself in mind. This math game is designed with an educational concept that contains interesting learning material so that it makes the learning process more fun. The game concept design of the game is made with a hierarchical menu structure as shown in figure 2.

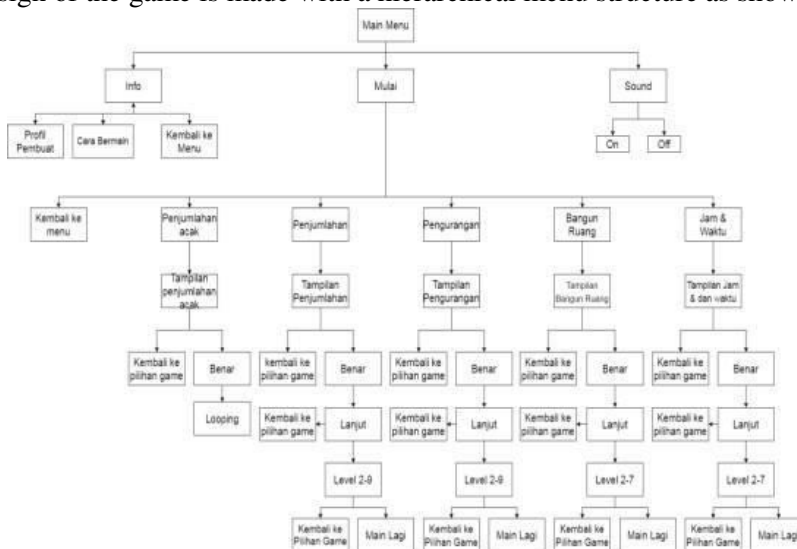


Figure 2. Design concept menu math game

After the Concept is complete, the next mechanical process is the Design stage. This stage includes the design of the storyboard, script, and the design of the hierarchical menu navigation structure. Some designs can be seen in figure 3.

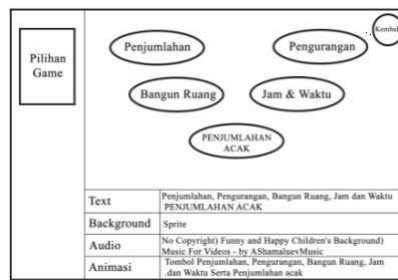


Figure 3. design storyboard

Storyboard design to display feature options in addition, subtraction, and random addition games. This menu is designed by paying attention to learning materials according to the level of learning in elementary school. Some designs are also used to describe learning content such as building space, clock, and time, and other materials such as students giving a choice of right or wrong answers to a mathematical statement.

Stages to build attractive aesthetics by selecting and designing attractive menus and features. The stage begins with building an interesting text by taking examples from various media. As seen in figure 4.

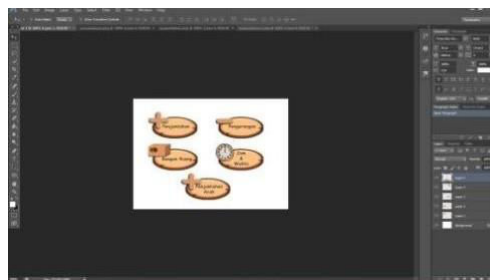


Figure 4. design text for display game selection

Several displays are also designed by taking into account the mechanical components that have been designed previously. The menu is like the choice of building addition spaces, tutorials, and exits. Design aesthetics for building materials as shown in figure 5.

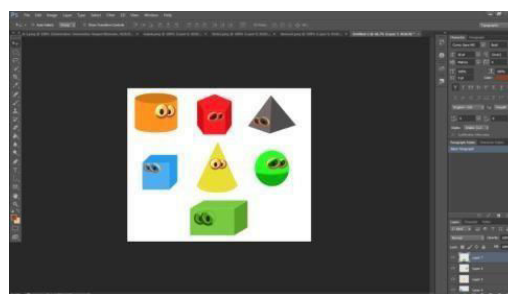


Figure 5. Building menu design

After the aesthetics stage, the components that need to be designed are dynamics. This stage is done by selecting the sound/audio, video and language to be used. Audio is done by building it yourself and some are adopted with a sound that has an open license so that it is possible to use it openly. After all the features and menus have been designed, the next step is processing the Background, Sound, Buttons, Animations, and Images that will be used in making the game. The stage is continued with the process of making games using applications using Construct 2-r275 where all image files and materials are

processed and made into one HTML5 format project. The result of the builder is shown in figure 6 which displays the design results on the main menu.



Figure 6. main menu

The game is then built by developing sections for games, resulting from simple arithmetic operations such as addition and subtraction. As seen in figure 7.



Figure 7. arithmetic operation simple game

In the building menu section, expand the section for the game choosing a builder. As seen in figure 8.



Figure 8. simple game build space

The final step in implementing the MDA framework is to conduct comprehensive testing of the games that have been built. Tests are carried out on various features that have been built, functions that have been running well, and are in accordance with the smartphone device that will be used to play the game.

In addition to testing the game's functionality, the most important test to do is to test usability to ensure the games that have been built can be adopted by elementary school students and will continue to be played in the learning process. The results of the usability test that have been carried out, the results show that 92.14%, states that math games are very useful. The measurement was continued on the Ease

of Use aspect and the results were 91.94%, which means that the mobile-based mathematics education game is very easy to use. In the aspect of Ease of Learning, the results obtained are 96.42%, which means that math games are very easy to learn. In the aspect of Satisfaction, the result is 93.46%, which means that this math game is very satisfying.

Table 1. usability test

No	Usability test	(%)
1	Usefulness	92,14%
2	Ease Of Use	91,94%
3	Ease Of Learning	96,42%
4	Satisfaction	93,46%

An important part of this research is the implementation of the MDA framework for building math games. The results show that games that are successfully designed and produce game features are proven to be well received by game users, namely elementary school students. The game is continuously used by students and teachers in learning mathematics in elementary schools. This result is following research from Balakrishnan, et.al who found that the loyalty of game users will make the game used continuously [13]. The design and features produced in a game must be following the needs and context of its users. This has also been stated by Schmitz. et.al which states that a game for elementary school children must produce sufficient knowledge and also encourage the development of good attitudes for students [14]. In addition to attitudes, games must also encourage good memory of the material and content being played to accelerate the absorption of the material being studied [15]. The game should also have interesting features and can be played in an attractive manner that triggers interest in playing it [16]. Games that are developed with attractive aesthetics, easy to play will encourage higher adoption rates for the game [17]. Thus, paying attention to aesthetics and ease of use must be the main requirements in building an educational game for elementary school students. In building math games, it is necessary to pay attention to basic principles [18] such as the level of difficulty, material concepts, and mastery of the workings of mathematical functions which will be translated into mathematical games that are accurate in producing basic mathematical operations. The use of augmented reality is very appropriate to be adopted to build interesting and attractive games [19], but this technology still has weaknesses in its application in developing countries due to the lack of adequate information technology infrastructure and the lack of teachers and volunteers who have good information technology literacy. These factors make augmented reality technology less developed and less desirable in building games in developing countries.

The knowledge that can be built on the game being played can be used as a vehicle for learning in various fields such as the health sector for malaria learning[20], the field of history[21], the field of herbaceous plants for medicine[22] and also to improve critical thinking skills. [23]. Games must be built, attractively by implementing various good frameworks such as SciTime[24], or MDA[12] Agency framework adopted in this research. Games must pay attention to interesting interactions between users and the game system so that a good experience is built and encourage continued use of the game [25] so that a good experience is built. Math games are very important to pay attention to material, instructional game systems so that games can be played according to what has been previously designed. Obedience to the instructions provided in the game will encourage users to play the game successfully. The game must also ensure error-free stability and integration with game assets[26]. The created rules must run on various platforms including mobile platforms [4][27]. Games must support individual enjoyment for gamers so that they can also be used as a vehicle for refreshing [10] and keep individuals fresh and enthusiastic about learning materials. The game must also be able to encourage individuals to be

involved in teamwork, the results of which can improve the group's performance in doing a task successfully [28].

4. Conclusion

We conclude that it is very important to build a math game to match the user experience of the player. The mechanics, dynamics, and aesthetics techniques in the MDA framework are very appropriate to be adopted to build new designs and features that are suitable for game users. In the conditions of learning mathematics in elementary schools, this framework has proven to be effective and accurate in building math games for elementary schools. This can be seen from the results of the usability test carried out, it appears that the acceptance rate is greater than 91%. This framework has been proven to be easy to implement in building easy-to-use games.

Acknowledgments

We thank the Faculty of Engineering, Universitas Negeri Manado, for supporting this research by granting permission to access a multi-media laboratory for the implementation of this research. In addition, it has issued permits to conduct trials on respondents spread across various elementary schools in North Sulawesi. Thank you also for the funding support that has been used to support the implementation of this research. A good game for developing countries is a game that pays attention to the needs of the mathematics learning system in elementary schools and pays attention to the characteristics of students as learners. A good game should adopt the MDA framework to design games and build features that match the characteristics of elementary school.

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