# Development of Educational Mobile Game for Interactive Learning Media

**Sukirman[1*], Irma Yuliana[1], Sujalwo[1]**
[1]Universitas Muhammadiyah Surakarta, Pendidikan Teknik Informatika,
Jl. Ahmad Yani 15, Surakarta 57162, Indonesia
*sukirman@ums.ac.id

## Abstract

Numerous games are developed today, it leads people to easily obtain many kind of games, for example from online application store such us Google Play and Apple store. This paper reports the development of mobile game application containing educational content for primary school students who study mathematics. The game is called JarMat. The students can learn about addition, subtraction, multiplication, and division by doing tasks that are interactively provided by the game. The tasks are randomly generated by the game system, and players should finish it within a limited time. The game will be over when they fail three times, then the score will be accumulated and stored. Reward will be given if they finish the task before the end of time limit and get a higher score. The difficulty level of the task is determined by the ability of players which depends on experience and time to finish the task. The research of this game development is conducted through reference studies and similar educational games. The game is expected to provide another apps that contains educational content, can be used further for student learning media, mainly 2nd grade of primary school who learn mathematics.

Keywords: educational, game; mathematics; primary student

## 1. Introduction

Numerous games are developed today and they are easily accessible for people, from children to adult. The easiest way to get is by Google Play Store, Apple Store or other application stores. However, games containing educational content are still lacking. Therefore, it will be better if the educational content included in a game, not just for fun but also for interactive learning. Furthermore, it will also be useful for better education in the future.

Several years ago, research on the development of educational computer game was doubted and questioned by many people (Bi et al., 2012). However, as time passes, people gradually realize that educational game can be used as an alternative learning tool. Furthermore, according to a study (Lekka et al, 2017), the impact of learning and interactive educational software has also been augmenting, for example in learning statistics. Even, study about how to develop a game for preschoolers was also done to identify user interface, particularly the character, emotion and reward (Sudarmilah et al, 2016).

Educational games are the games aimed for educational purposes that allow players to learn a subject instead of merely for entertainment purposes. Generally, educational games provide a specific theme of education, for example mathematics. Some researches on educational game related to these topics are Math-City (Polycarpou et al, 2010), Vidyanusa (Qonita et al, 2015), MathBharata (Mangowal et al, 2017), and many more.

Having insight of mathematics knowledge is essential at all grades of school, from kindergartens or even preschool. As we know, developing mathematical thinking is important and has significant objective for later development in life (Lekka et al, 2017). However, some students perceive that Mathematics is difficult subject (Stodolsky et al, 1991), even further they avoid this lesson. One of the problems is caused by learning media that are used, apart from teaching method by teacher. Therefore, learning tools as alternative media need to be created or developed to support students.

Digital computer game is one of learning media that can be used for helping students in learning mathematics. This is highly possible because learning materials can be embedded in the game, so that players unconsciously learn. This media can also improve efficiency of teaching and learning performance (Bi et al, 2012). Previous studies showed that the usage of game for learning media have a high interest for students (Ibrahim and Jaafar, 2009).

## 2. Literature Review
## 2.1. Educational Game Benefits

According to some researches, based on the cognitive approach of learning, educational games could be beneficial for students, such as:

a. Educational games enable the transfer of knowledge or skills learned and practiced by playing it since the games provide further overlearning after once mastered. Therefore, the students are able to focus on new learning information that are provided in the games.
b. By integrating learning and game experience, educational game will be able to individually build intrinsic motivation that is provided by the virtual world environment of games.
c. Educational games encourage players to accomplish mission by trial and error, so that they can learn to be decision maker in these challenges. The players also receive immediate feedback on their actions and decisions.
d. Players are able to predict the game result and determine or distinguish pattern of tasks that are provided by the educational games.
e. By playing the game, players can also improve their abilities by its game levels and measure their capabilities with the scores they obtain.

## 2.2. Mobile Game-Based Learning Development

Mobile game-based learning or commonly referred as mobile game for learning is a learning method that utilizes mobile devices (smartphone, tablet or iPad) through the installed game. Players may play games anywhere that enable them to train learning materials or other learning outcomes as often as possible. To develop mobile game-based learning applications, the key steps to be considered consist of phases, components, activities and deliverables (Giannakos, 2013).
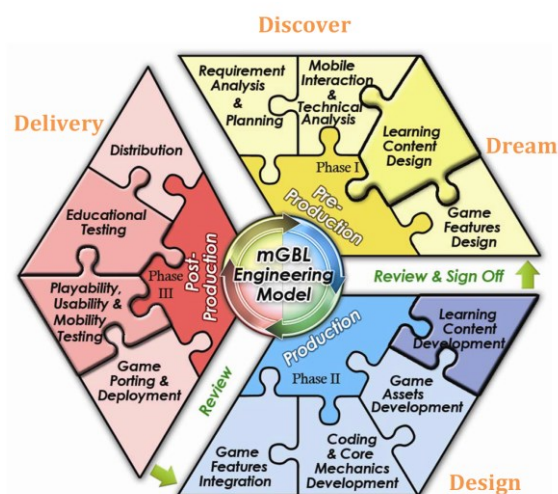


Figure 1. Mobile game-based learning engineering model (Giannakos, 2013).

Developing a good game is essential to ensure the players to be more motivated to keep playing in order to achieve the goals. Figure 1 depicts mobile game-based learning engineering model which is divided into two layers. The first inside layer consists of pre-production, production and post-production which is called general phases, while the second outside layer consists of components that includ each phase.

## 2.3. Educational Game Design Model

According to Ibrahim and Jaafar (2009), as depicted in Figure 2, to develop educational game, one should combine three main factors, they are: game design, pedagogy and learning content modelling. The game design factor consists of usability, multimodal, and fun that should be noticed, as stated by Prensky (2003) that an effective educational game design must provide a balance between fun and educational value. Meanwhile, under the pedagogical factor, which refers to Bloom Taxonomy, containing learning outcomes, motivation theory, self-learning, and problem solving. The last factor, learning content modelling, relates to learning outcomes to achieve appropriate learning goals that are adjusted to the syllabus.
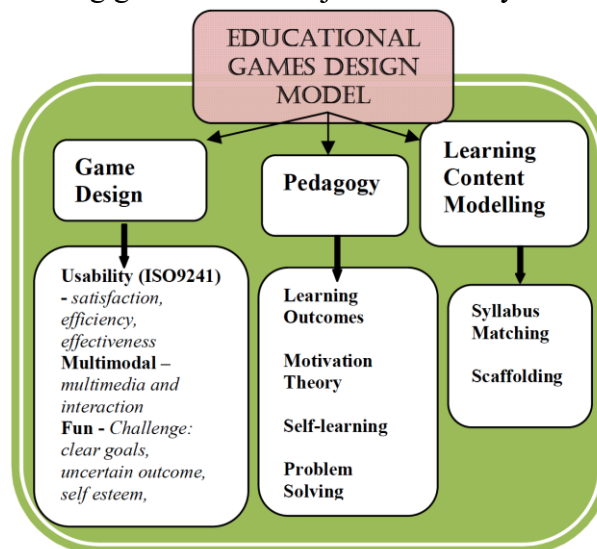


Figure 2. Educational game design model (Ibrahim and Jaafar, 2009)

It can be seen from the main factors that in developing educational game involves some people from various backgrounds such as computer programmers, subject matter expertise, learning theorist, game designers as well as instructional designers (Ibrahim and Jaafar, 2009). This is due to many considerations from various perspectives to achieve the best result.

## 3. The Game Concept and Its Technology
## 3.1. Game Design Concept

Referring to the mobile game-based learning engineering model [10], the first phase to develop the game is pre-production. Before developing, the game concept and flow diagram are defined as depicted in Figure 3 in general. The game has some scenes that enable players to do actions and make decision.
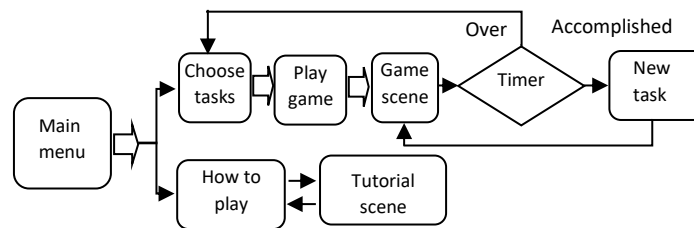
Figure 3. Game concept and flow diagram of game

When the game application launched, main menu scene will be opened after loading scene finished. The players may choose tasks or see the tutorial first to understand how to play the game. The tasks consist of four topic options; they are addition, subtraction, multiplication, and division. All the tasks are automatically generated by the game system and will always different set of questions in every single task. The task is limited by timer, if the task is finished before the end of timer, the score will be given. On the other hand, if it does not finish then the game will be restarted and goes back to choosing task scene menu.

## 3.2. Technological Support

In order to reach many users, the game is developed in cross-platform that can be installed on iOS and Android operating system. Cocos2d-x game framework is chosen since the game engine is open source and enable to support multi-platform game development, it means that with a single code, the game can be deployed to mobile, desktop, web, and console platform. The game engine uses C++ programming language to scratch the code behind the scene of game. Besides that, it is also support JavaScript and Lua binding included. To compile the codes, it can be done by using Xcode, Microsoft Visual Studio, Android Studio or other compilers that support it. This game engine can also be used to build games, apps and other cross platform GUI (Graphical User Interface) based on interactive programs (official website Cocos2D-x, 2017).

## 3.3. Similar Apps

Besides through reference studies, similar mobile educational game apps are also analyzed to compare and to define application features that will be developed. It is important because we can study and modify the former apps to create new and better apps and according to the learning outcomes. The similar games that are used for references are "Math Games 1st", "Kids Numbers", "Kids Math", "Numbers and Math", and "Math for Kids. The game comparisons can be seen on the table 1.

Table 1. Comparisons of similar game apps

| Name of Games | Math Games 1st | Kids Number | Math Game for Kids | Math for Kids |
|---|---|---|---|---|
| Developer | Yuyu Science | Orkun2u Studios | DaDo | 2bros – game for kids |
| Screen orientation | Landscape | Landscape | Landscape | Landscape |
| Main Menus | Too many useless menus | Menu differences are not clear | Three menus and sub menus | Simple menus |

| Name of Games | Math Games 1st | Kids Number | Math Game for Kids | Math for Kids |
|---|---|---|---|---|
| Developer | Yuyu Science | Orkun2u Studios | DaDo | 2bros – game for kids |
| Difficulty level System | None | Many levels unlocked | 0-10, 0-20, 0-50, 0-100 | Easy, medium, hard |
| Live System | Three chances | Three chances | There is no penalty | Three chances |
| Gameplay system or game topics | Equation, Comparison, True/ false, Memory game, number pattern, sort ascending | Number recognition | Addition, subtraction, and its mix. Each topics has limitation number | Addition, subtraction, multiplication, and division |
| Requirement | Have to get some score to play other topics | Unlocked previous level to continue, have to buy to unlock all levels | None | Unlocked previous level to continue |
| How to play | Touch to answer | Touch to answer | Drag and drop system | Touch to answer |

Generally, all the games are good for educational purposes, but the games contain many advertisements that it will be harmful if the players do the wrong touch while playing, even for the children who play the games.

## 4. Result and Discussions

The research on this educational game development is done through approach method as previous studies and also by comparing similar game apps. Based on the concept depicted in Figure 3, the game contains three main scenes, namely menu, task options, and game scene. Main menu will appear after the game is launched as presented in Figure 4 (a), which is run on Xcode simulator.

Figure 4. Prototype: (a) Main menu and (b) Task options.

Player has to press play button to go to task options scene. Player may choose what task they want to play, such as addition, subtraction multiplication, and division represented by buttons. The plus button refers to addition task, minus button is subtraction task, multiply button is multiplication, and divide button is division. Game scene will be launched when one of that buttons is pressed. For example, addition task will be opened, as depicted in Figure 5 (a), when plus button is pressed, which is the question generated by system. The player has to choose the right answer attached above on the balloon. If the answer is right, reward score will be given as depicted Figure 5 (b), and vice versa.
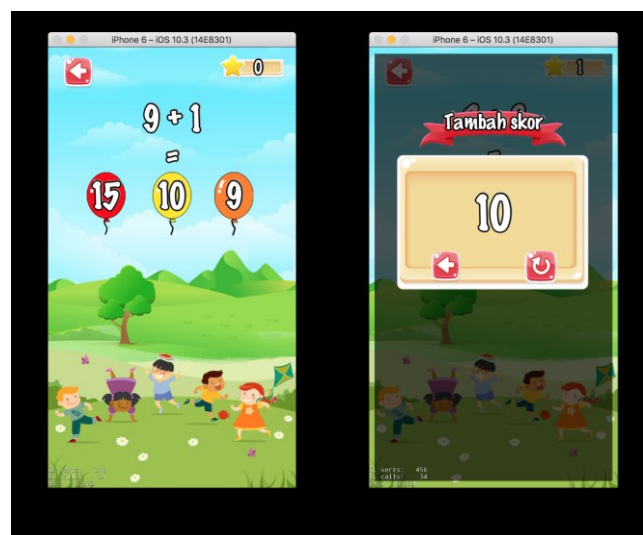


Figure 5. Game scene: (a) Task to do and (b) Rewards score.

In this game scene, the learning outcome can be embedded based on Bloom taxonomy. For example, the students know how to define number and arithmetic operation, then understand how to use them. After that, students can explain why the result of that operation is generated.

The task can be repeated in many times because the game tolerates any mistakes. Therefore, the students will really understand what tasks they have done.

The prototype design is appropriate as educational game model as depicted in Figure 2. Related to its usability factor, the game background uses fun colors loved by students, and answer options by using balloon for a basic to put number choices. For multimodal factor, the game uses the combination of pictures and texts to construct the game. The game goal can be set up according to its learning outcome and learning competence. Therefore, student can unconsciously study by playing the game.

## 5. Conclusion

JarMat is a game that is designed for educational purposes with content for primary school students to study mathematics, which include addition, subtraction, multiplication, and division by doing tasks that are interactively provided by the game. The task is randomly generated by system which players can do it within a limited time. Reward will be given by giving score when they finish the task before the end of time limit. This research of game development is conducted through reference studies and similar educational games. The game is expected to provide another apps which contains educational content, which can be used further for student learning media, mainly 2nd grade of primary school who learn mathematics.

## References

Bi, T., Shi, Y., & Yang, W. (2012). Research on Development of Educational Games (pp. 2015–2018). Yichang, China. https://doi.org/10.1109/CECNet.2012.6202030

Ibrahim, R., & Jaafar, A. (2009). Educational Games ( EG ) Design Framework : Combination of Game Design , Pedagogy and Content Modeling (pp. 293–298).

Cartagena, A., Atienza, R., Tai, T., & Cruz, R. (2012). Experiences in developing mobile educational games. In *Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012* (p. H2C–6–H2C–8). IEEE. https://doi.org/10.1109/TALE.2012.6360337

Cocos2d-x. (2017). Retrieved June 21, 2017, from http://cocos2d-x.org/cocos2dx

Giannakos, M. N. (2013). Enjoy and learn with educational games: Examining factors affecting learning performance. *Computers & Education*, *68*, 429–439. https://doi.org/10.1016/j.compedu.2013.06.005

Lekka, A., Toki, E., Tsolakidis, C., & Pange, J. (2017). Literature review on educational games for learning statistics (pp. 844–847). Athens, Greece: IEEE. https://doi.org/10.1109/EDUCON.2017.7942945

Mangowal, R. G., Yuhana, U. L., Yuniarno, E. M., & Purnomo, M. H. (2017). MathBharata: A serious game for motivating disabled students to study mathematics. In *2017 IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH)* (pp. 1–6). IEEE. https://doi.org/10.1109/SeGAH.2017.7939277

Polycarpou, I., Krause, J., Rader, C., Kembel, C., Poupore, C., & Chiu, E. (2010). Math-City: An educational game for K-12 mathematics. *Procedia - Social and Behavioral Sciences*, *9*, 845–850. https://doi.org/10.1016/j.sbspro.2010.12.246

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment*, *1*(1), 21. https://doi.org/10.1145/950566.950596

Qonita, Q., Prihatmanto, A. S., & Wuryandari, A. I. (2015). Vidyanusa game utilization on arithmetic sequence and addition subtraction of integers to improve mathematics

learning outcomes of junior high school students (Case study in SMPN 31 Bandung). In *2015 4th International Conference on Interactive Digital Media (ICIDM)* (pp. 1–6). Bandung, Indonesia: IEEE. https://doi.org/10.1109/IDM.2015.7516322

Shiratuddin, N., & Zaibon, S. B. (2011). Designing user experience for mobile game-based learning. In *2011 International Conference on User Science and Engineering (i-USEr )* (pp. 89–94). IEEE. https://doi.org/10.1109/iUSEr.2011.6150543

Stodolsky, S. S., Salk, S., & Glaessner, B. (1991). Student Views About Learning Math and Social Studies. *American Educational Research Journal*, *28*(1), 89–116. https://doi.org/10.3102/00028312028001089

Sudarmilah, E., Susanto, A., Ferdiana, R., & Ramdhani, N. (2016). Developing a game for preschoolers: What character, emotion and reward will tend to hack preschoolers? In *Proceedings of 2015 International Conference on Data and Software Engineering, ICODSE 2015* (pp. 89–92). Yogyakarta, Indonesia: IEEE. https://doi.org/10.1109/ICODSE.2015.7436977

Sukirman. (2016). Digital Storytelling Interaktif dan Menggembirakan Menggunakan Augmented Reality, *2*(September), 55–60. Retrieved from https://www.researchgate.net/publication/317166496_Digital_Storytelling_Interaktif_dan_Menggembirakan_Menggunakan_Augmented_Reality