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Design and Development of a Serious Mobile Game "MathAventure"

Loubna EL AZIZI[1]

Department of Mathematics. Laboratory: Algebra and Operator Theory,

Faculty of Sciences, University Abdelmalek Essaadi, Tetouan, Morocco[1]

Abstract: In this paper we propose a method to motivate students to acquire and consolidate mental calculation skill by using a serious mobile game. We have developed a serious game *MathAdventure* for Grade 6 students. This game, we can use it on several platforms, Android, IOS or Windows.... It's like Super Mario game where players can try to pick the right answer to arithmetic questions with increasing difficulty. The prototype development process combines instructional system design with the game's development approach. The developed prototype has been successfully tested using the functionality test which has been used to control the stability, game mechanics and integrity of the game elements.

Keywords: Serious game; Mobile phone; Math; Video game; Motivation; Student

I. INTRODUCTION

The majority of kids spend a lot of time playing video games on mobile phones, so the new way to learn from this generation is a cognitive style characterized by fast learning and multitasking based on crawling and discovery. The inductive approach is privileged, because they are confronted with problem situations that require to formulate hypotheses, to try strategies, to revise them by adapting them during the game, then to apply them in a constructivist approach. In addition, peer learning plays an important role in this situation. So we can say that mobile phones have become a common gadget in society. Playing video games on mobile devices has become a trend because it can be played anywhere, anytime. This type of technology has properties such as portability, connectivity and social interactivity that make it a preferred platform for learning. As a result, the use of mobile devices can be extended to mobile learning, where the learning environment is not limited in the classroom. By combining the playful factor of video games, the flexibility of mobile learning and the benefits of games, serious mobile games have been developed.

Mobile phones are increasingly becoming part of the daily culture of almost every generation. But some mobile applications are intended for learning (J. M. Randel, B. A. Morris, C. D. Wetzel, and B. V. Whitehill, 1992). The younger generation normally used mobile phones as a platform for playing video games (Prensky 2003). Research in this area has revealed that about 6 million people download games on their mobile phones each month (F. Ke, 2008). So we decided to use the playful video culture of the learners in our project. One of our goals is to develop a serious mobile game for elementary students to improve their mental calculation skills. The important thing is to learn and have fun at the same time, students can learn faster and more effectively. The use of handheld devices has made the application easy to access, anytime, anywhere. Attractive features are also important for attracting video game players.

The growth of mobile phones and the potential of video games have led to the idea of designing a serious game *MathAventure* for elementary students. *MathAventure* is designed for the portability and flexibility of mobile phones.

In the next part, we will talk about the design phase of our serious game *MathAventure*.

II. MATHAVENTURE DESIGN

Play is a way to get students to soak up something. They can use various visual and sound effects to make learners more excited and willing to study something they do not want in general. Games can also have an interface and system that encourages students to play more and more, encouraging students to do their best to be better in the game.

More recently, the use of serious games has been treated as a challenge in the classroom. Some researchers have recommended their use and there is even a method based on the use of video games: Learning Based on Digital Games (DGBL).

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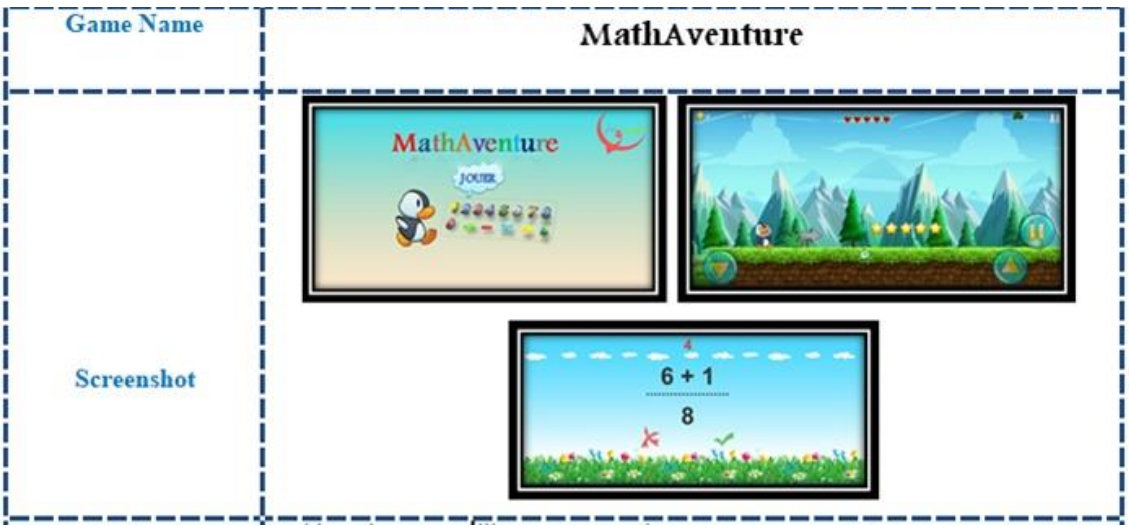
This approach relies on the use of electronic games for learning purposes (Evans, 2008); Similarly, Prensky (2001) defined it as the marriage between video games and learning. DGBL provides learners with learning based on virtual experiences; and even though they may not be as authentic as the real ones, they might be considered the closest mirror of reality. In fact, some classical authors such as Plato and Aristotle have argued that the best possible learning comes from experience: learning by doing (Power, 1991, Cohen, 2007). The main advantage of this method is that it can increase students' motivation to continue playing and hence to learn (Dondlinger, 2007). According to Gros (2009), encouraging the motivation of learners should encourage them to redouble their efforts to carry out their tasks and promote their entertainment during the hours of play. Taşçı (2016) said that the application of this approach based on the use of video games has already been implemented in other fields such as psychology, sociology, history or the military, as well as in the learning of mathematics. Moreover, it seems that the DGBL approach is based on constructivist knowledge (Duch, Groh and Allen, 2001), in which learning is active since the learner is a player rather than a passive audience and it is treated with problem solving that is continually encountered in the game scenario (McFarlane, Sparrowhawk and Heald, 2002). In addition, concerning cognitive development theory, it is also based on experiential learning since the player is required to take actions in different game environments (Squire, 2005).

The design of our serious game *MathAventure* involves the design of the structure, the mobile interface and the technical strategy of the game. It comprises four main segments: theories of learning, the approach of mobile learning, the approach to game development and the Learning Environment.

Constructivism was chosen as the theory of learning. Constructivist learning theory is about developing autonomous learners who can access a wide range of cognitive structures and transfer learning to other contexts they have not yet encountered, it requires learners to they build their own understanding by trying to put into practice what they have learned in real life.

For the mobile learning approach, our serious game uses activity-based themes for informal learning. This approach is to support learning outside of a dedicated learning environment and to adapt it to the application that complements the formal learning environment.
Research in this area has confirmed that learning theories in the mobile environment must take into account learning outside the classroom and move from local learning to mobile learning, allowing learning at the learner's usual and preferred place. For our serious game to be motivating we chose the Malone Model for the development approach. The serious motivating game features according to Malone are: Challenge, curiosity, control and fantasy. The criteria guide the development of serious game to make it interesting and applicable to any situation.
MathAventure has adopted all the features to develop a real serious gaming experience for learners.

Our serious game is a solo game, is based on the game of Super Mario and is aimed at primary students. It is called "*MathAventure*": as the name shows it is an adventure in which the learner moves in three worlds: Each world contains quiz fabulous theme of nature: Summer, winter, spring, autumn, day, night, Sahara ... ex. It is a world of fun for learners. In each world the learner must acquire an arithmetic skill. It is a serious game where there is no violence.



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Game Rules	- This serious game like a Super Mario game. -The engaging serious math game that sharpens students' arithmetic knowledge. -A game in which students can perform additions, subtractions, multiplications and divisions. -It is a non-violent, mathematical adventure game inspired by the beauty of landscapes. There is no enemy to fight, and no harm is done to nature during the game. -A Serious math game that encourages kids to practice and improve their arithmetic skills, while leading the Penguin on an adventure through an exciting platform game of jumps and races. -An awesome game for kids to keep playing and learning. This is the ideal way to avoid regression in math. -Very good adventure gameplay with jumps and runs. - Excellent resource for students and teachers. - Great way to engage students and improve their learning performance in mental calculation. -45 levels of exciting adventure on 2D platform -The Penguin encounters ten arithmetical questions when there is a collision with enemies or obstacles, to allow the learner player to progress and collect stars hidden around 15 beautiful worlds. -We can use it in windows and Android platforms. -Recommended for children aged 6 and over.

Table1. *Elements of MathAventure*

The *MathAdventure* design is simple and clean or there is no violence. Playing games that are violent can have a negative impact on children's behavior. Any form of contact with violence in video games can lead to desensitization to violence, making children more likely to engage in violence themselves. (C. Anderson, N. Carnagey, M. Flanagan, A. Benjamin, 1. Eubanks, and J. Valentine, 2004).

In the next part, we'll talk about *MathAventure*'s development process.

III. MATHAVENTURE DEVELOPMENT

MathAventure is a serious platform game; it's like Super Mario game. Game development includes the development of graphics, game levels and animation.

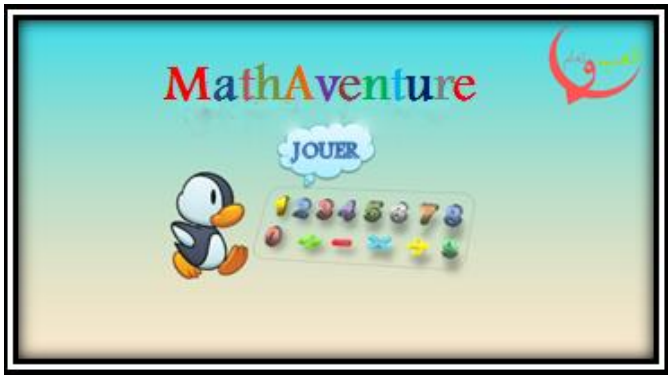

Fig. 1. *Main Menu of MathAventure*

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All are designed and assembled. The prototype was developed using the Charp programming language and the Unity game engine. Unity is a game engine that allows the user to create 2D and 3D games. The games created with Unity can also be deployed easily on several platforms: Android, IOS, windows,... The development focused on the creation of game worlds, game levels and also random generators of necessary equations to the application. The first game screen contains the game name and the play button for the player to start. Fig. 1.

The second screen illustrated in Fig. 2, which will be the screen of Worlds. In the game we have three worlds, each world contains 15 levels. The learner cannot choose the world 2 without passing all the levels of the 1. After the collision of Penguin with the enemies or the obstacles another screen opens Fig. 3 in which the learner must answer ten questions of arithmetic to repeat the level and continue the game. In the calculation screen the learner must choose the correct answer by clicking True or False.

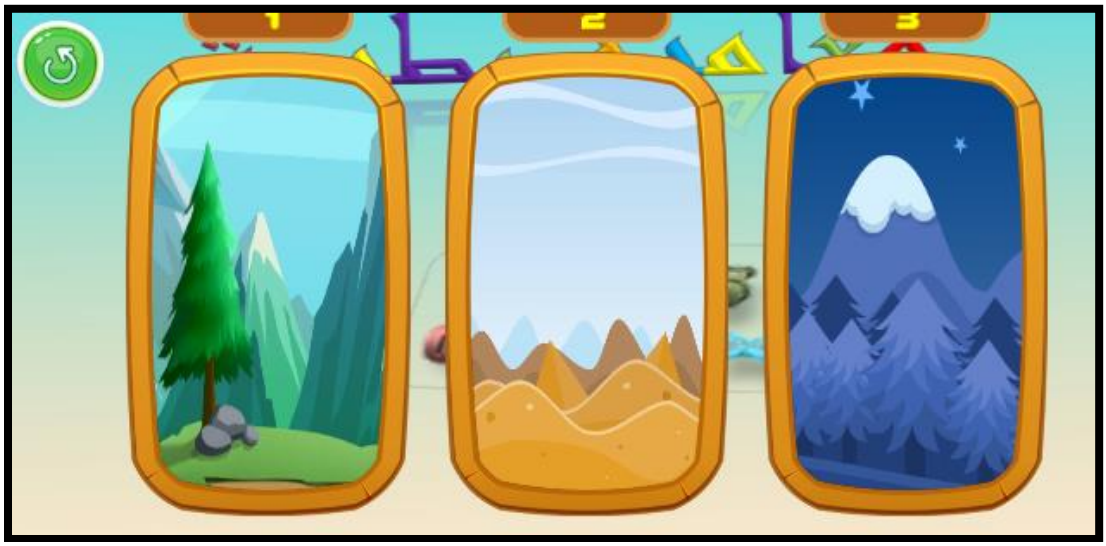

Fig. 2. *The worlds of MathAdventure*

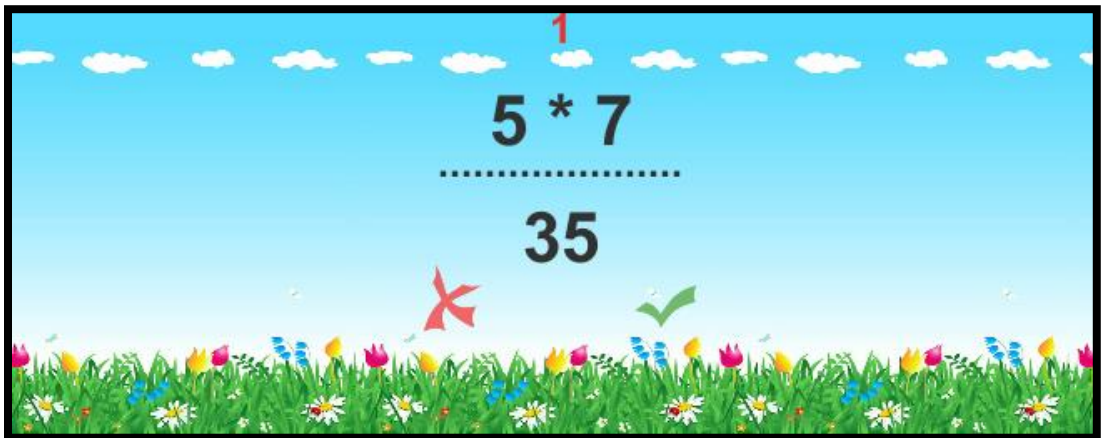

Fig. 3. The calculation screen

After developing our serious *MathAdventure* game, we did the prototype test to check their functionality.

IV. MATHAVENTURE TEST

The prototype of the game is tested to ensure that it is developed according to the specifications of the previous design phase. A functionality test has been performed for this purpose. Functional tests will verify the functions available in the prototype. We will check if the prototype works well. The functional areas tested are stability, integrity of game resources and game mechanics.

A. Stability

The stability of the prototype has been tested on several mobile phones. The game was first tested on Android platform using SAMSUNG GALAXY S6, SAMSUNG GALAXY J5 and SAMSUNG GALAXY A5. The prototype did not show any problems of stability on the emulator environment.

To test the serious game stability on IOS platform. We used the IPhone 6 and IPhone 7 mobile phones. The game freezes as soon as the tester tries to launch the game. After some modifications on the game, we repeated the test. However, the expectations are good because the result of the second test is not identical to that of the first test, the serious game runs correctly.

B. Integrity of game resources

The game's resources are the texture interface, the appearance of the character. This test looks for any errors in the integration of the game elements. Each texture applied in the game is examined to ensure that it is correct and works as expected. The testers did not observe any texture corruption or instability. They were satisfied with the integration of serious game resources.

C. Game mechanics

This test is used to identify possible errors in the game mechanics. The game mechanics to be tested is the generation of random numbers, the generator of equations and the movement of the character. The generator component of random equations, which is the crucial part of game mechanics, has been modified to avoid giving illegal arguments or equations. The prevention measure was put in place to prevent the generator from generating zero-equation division, negative numbers and extremely high numbers for the equations. The equations are randomly distributed in the *MathAventure*. The random cast is working properly and the character's movement is fluid. Overall, the tester is satisfied with the accuracy of the game mechanics.

V. CONCLUSION AND FUTURE WORK

Serious games were primarily designed for use on a computer. But in recent years, we have seen a shift in the way people consume content and learn from it. Mobile devices are booming and increasingly challenging other platforms. Smartphones look like previous computers and, even now, the performance of ordinary computers. People are now developing serious games for mobile devices based on mobile operating systems, such as Android, iOS, and Windows. In an increasingly digital world, it is natural to have access to these products from different platforms and at any time. Using smartphones, for purposes other than entertainment, seems an interesting direction to exploit the small size of these devices and their contextualization facilities, as well as the availability of the user anywhere to devote it to a more useful activity like learning.

Mobile learning is becoming a key element in the development of serious games, where the accessibility and convenience offered by mobile devices can be a significant advantage over computers and static equipment. In addition, m-Learning can be context-independent, using the user's availability to learn in any location or context, taking into account the location of the user. Given all these facts and the demonstrated effectiveness of serious games in learning and teaching processes, we believe that this is an opportunity for Moroccan development to invest in the serious game for mobile and mobile learning solutions.

We designed and developed five serious games for elementary school students to acquire and improve their mental calculation skills. Several researches in this field have shown that serious games have several impacts on student learning. So the last step of our project is to test our five serious games with students to determine the educational impact of this type of games.

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