Pervasiveness in Real-World Educational Games: A Case of Lego Mindstorms and M.I.T App Inventor

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Abstract. Without a doubt, children consider mobile phones to be something more than just a means of communication. It is, actually, an extension of themselves and an integral part of their lives. The unique relationship that they have developed with these devices, which has been reinforced with the launching of smartphones, could not be left unnoticed by the educational community as every successful educational activity does not exist without the motivation of students via a climate of enthusiasm and the constant providing of incentives. Games, digital or otherwise, at school fall under the same category. Their blending and the children's response to them are particularly interesting and, thus have triggered off the creation of a game, presented within the context of this paper. This game, designed for smartphones with android O.S, was developed through the M.I.T. App Inventor programming environment, which interacts with Lego Mindstorms robotic constructions.

Keywords: smartphones, educational robotics, digital games, M.I.T. App Inventor, digital game-based learning, educational programming environment.

1 Introduction

According to contemporary educational theories, the main goal of the educator today should be to establish a teamwork-research environment within which students, through appropriate activities, would be able to shape the new knowledge themselves. This is a procedure in which the educator acts as a facilitator and incorporates a series of processes such as searching and scanning the given information via multiple sources, evaluating the newly-acquired knowledge, experimenting, discovering, problem-solving and giving feedback. Dewey [1], for that matter, advocates that children's education should be based on their innate instincts for questioning, building, expression and communication. Experiential education plays a crucial role to the effectiveness of the above theories as far as the meaning and the practice of a methodology towards problem-solving are concerned as well as towards the existence of suitable motivation for their involvement in the educational activities.

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Educational robotics and programming, not just as a school subject but as a theoretical method, are prerequisites for the realization of the first factor as it is evident through the widespread use of the programmed robotic kit of Lego Mindstorms NXT[1] in education, as well as of other educational programming applications, most popular of which are M.I.T. Scratch[2], Alice[3] and logo-environments, such as StarLogo[4].

On the other hand, key to the success of the second factor is the use of the children's special interests and activities. Taking into account that they are the "natives" of today's digital world [2], and considering the pertinent research [3][4] that testify for the intense drawing of the youth generally towards smartphones and especially towards mobile gaming, it is made clear why the educational community for the last few years has been focused on integrating digital games (Digital Game Based Learning) and mobile phones devices (Mobile Learning) into the educational process. Since the benefits for education that derive from the use of the above technologies are substantiated, it is interestingly challenging to search for methods and processes that would allow for their combining use under a united platform within the learning process. M.I.T. App Inventor[5] has made it possible for the development of the game which is presented in this paper, whose objective is to examine whether and to what extent the combination of Educational Robotics – Digital Games – Smartphones could add on to the enthusiasm, the motivation and the active participation of children in the learning process.

According to the above, the structure of the paper is as follows: In section 2, background information is presented concerning the tools and the methodology used for the development of the game. In section 3, the game is presented along with a discussion upon the results of its application in the Gravia Secondary School. Finally, in section 4, the authors of the paper conclude their research and propose further areas for improvement.

2 Tools and Methods

2.1 M.I.T. App Inventor

M.I.T. App Inventor is a new visual programming internet environment which allows for the creation of applications for smartphones with android operational system. This was presented by Google in 2010, and as of January 2012 M.I.T. has been in charge of its support and development. The commands are given through predetermined coloured tiles, which are connected just like the pieces of a puzzle to form command blocks activated upon realization of an event (event driven programming) (Fig.1).

[1] http://mindstorms.lego.com/en-us/Default.aspx
[2] http://scratch.mit.edu
[3] http://www.alice.org
[4] http://education.mit.edu/starlogo
[5] http://appinventor.mit.edu

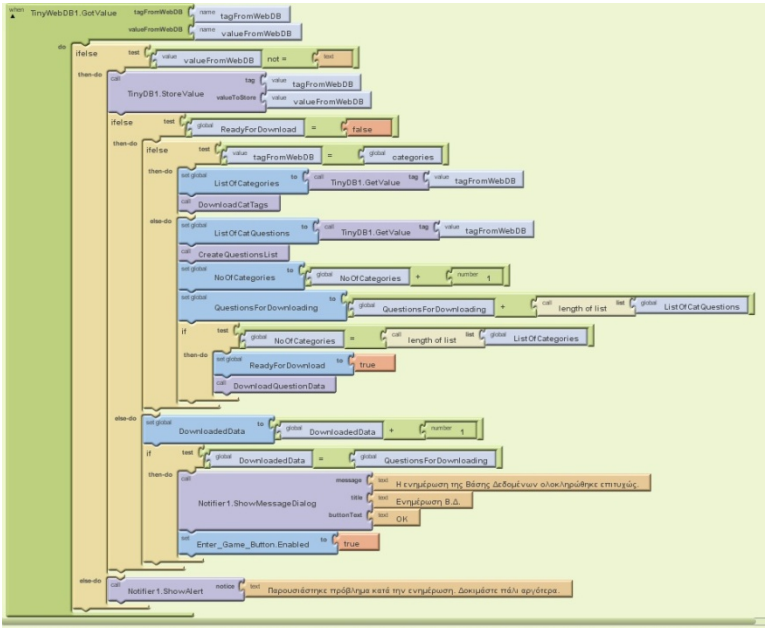

Fig. 1. App Inventor's Programming Environment

Thus, the chances for syntactic errors to occur are minimized as, like with the puzzle, the tiles have special incisions and projections that prevent the connection of tiles "non-syntactically connected". The development of the application's interface is a simple procedure which involves the placing of set components through drag n'drop on the screen of a virtual smartphone. It involves a wide range of possibilities like creating and processing local and remote Databases, using Bluetooth technology, supporting multiple screens and managing Lego Mindstorms robotic structures. Since it is still in beta edition, it is currently undergoing improvements and additions of new functions. The trial and error of the programs can be done either by connecting the mobile phone to the computer, or by using the installed emulator. The applications formed can run in all smartphones with an android system and can be intershared through Google Play.

This is an innovative tool, as its development environment allows for the formation of complex and demanding applications even by people with minimum experience and knowledge in programming in an easy, fast and, most importantly, entertaining way.

2.2 Lego Mindstorms NXT

Lego's educational robots have been around since 1998 and within a few years have succeeded in being a reference point for education. They involve a group of sensors, Lego bricks, motors, service mechanisms and other components which form constructions programmed through a microprocessor called NXT (Fig. 2).

Fig. 2. NXT Microprocessor, sensors and mechanisms

The newly-built robots can, by using the correct programming tools, execute a set of actions and can react to stimuli received by their sensors. Lego Mindstorms are used as an educational tool to solve problems, being at the same time a pleasant and interesting occupation for the children. The children built their own constructions putting into practice their special skills, knowledge and abilities via a process of building, experimenting, giving feedback and trouble-shooting. Their distinct feature, which bears an added value, is that the students see them as more of a game, than as an educational tool, as the majority has already "played" with them since it is one of the first toys the children come in contact with since their early childhood (block constructions). The reasoning behind it is that the child should build the knowledge by themselves and that this is a very efficient educational process only when it comes directly through the game itself [5][6].

2.3 Methodology

The selection of the above tools is substantiated by the fact that they have been designed driven by the contemporary student-centered learning theories. App Inventor as well as Lego Mindstorms are based in the discipline of "constructivism" as developed by Jean Piaget [7] and as it was redefined by the philosophy of "constuctionism" by Seymour Papert[8][9]. The authors have developed the game according to the above theories setting the following objectives: a) forming the "new knowledge" to be more efficient through the children's involvement in constructing objects and/or entities that bear personal meaning, b)forming the correct learning environment which provides authentic activities engaging in solving open-problems in the real world, encouraging, therefore, the expression and personal involvement in the learning procedure, as well as supporting social interaction, and c) the problem to be solved should trigger the learning. In order for the children's interest to be sustained and for the atmosphere to be challenging children should incorporate their own experiences and desires in the class. So, the authors have developed the game presented in the following section based not only on the above methodology but also on the given appeal that the youths have towards smartphones and specifically towards mobile games.

3 Results and Discussion

In an attempt to put theory into practice a digital game has been designed and developed for android smartphones using the above technological tools always considering the contemporary learning theories. The application was entitled "NXTriviaRacing", screens of which are shown in Fig. 3.

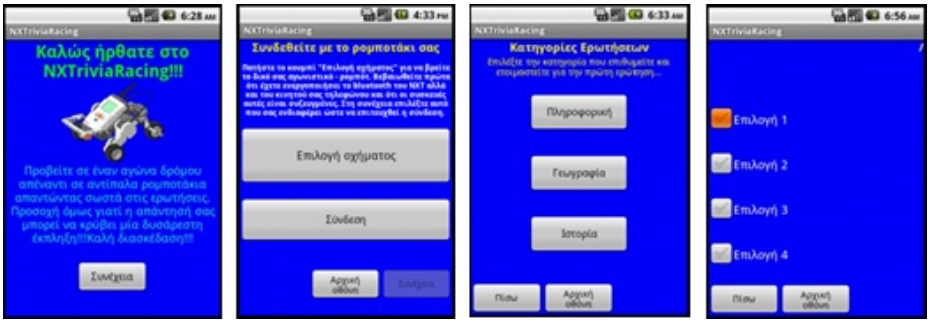

Fig. 3. NXTriviaRacing Application Screens

The title by itself states that it is a combination of quiz games (trivia) and racing along with the robotic constructions of Lego Mindstorms and NXT.

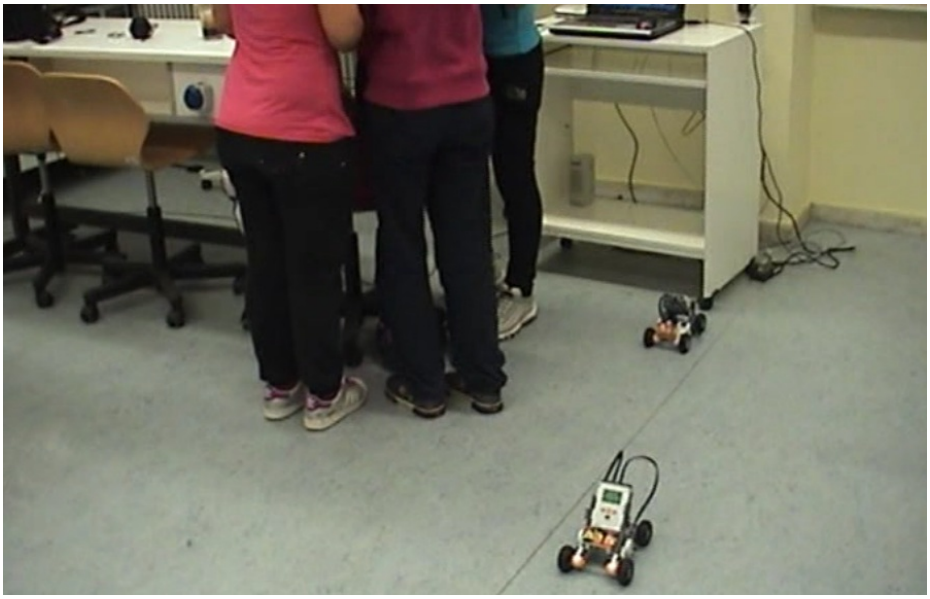

Fig. 4. Robotic vehicles in action. They were designed and constructed by the children.

According to the scenario, the player is called to answer knowledge trivia. In this case and bearing in mind the educational feature of the game, the questions are grouped in three categories (informatics, geography, history) with questions formed based on the curriculum of the according subjects of the Secondary School Grade A. The application is connected via Bluetooth with a robotic vehicle built by the students (Fig. 4).

Every correct answer sets the vehicle to motion in X steps, and every wrong answer moves back the vehicle by half steps, taking, thus, part in a car race. In this way, no Wrong or Right labels are used as the player understands by the motion if they answered right or wrong using the pedagogical theories of incentives and rewarding of the students. The questions are stored in a remote Database where the administrator has access so as to be able to make changes, alterations and additions. One can download them via a special button in the application screen. Every team has their own vehicle with the winning team being the one whose vehicle is ahead upon completion of the questions. "NXTriviaRacing" game is, first and foremost, an attempt to demonstrate the advantages of App Inventor as a programming environment, as well as its extensive possibilities for the ambitious programmer-educator and/or the learner.

An alternative realization would require more complicated commercial tools and specialized knowledge which are neither appealing nor fun for the majority of children or even adults who would be keen to create their own applications. App Inventor's potential to connect with Lego Mindstorms robotic constructions and their inner communication via Bluetooth technology allows for educational robotics and digital games to incorporate their advantages into the learning process. At the same time, the interaction of the digital game with robotic constructions, which the children themselves make, presents some distinctive characteristics and advantages compared to other mobile games. Creating a simple game for smartphones would not intrigue, at least for a long time, the children, since they have familiarized themselves to a great extent with similar games, which in many cases are highly appealing both for their scenario and for their graphics. However, if the game interacts with robotic constructions that the children themselves have made, then this is an entire different thing altogether.

Through a gaming procedure children go from players to co-creators of the game they play, while the motivation and the interest is multiplied in the case of the students who design and program it, something which is actually possible. The element which labels it distinct is the fact that the application consists of two separate yet connected at the same time games that interact with each other and are realized in two different worlds (digital-physical). The answers to the digital game (trivial) have an effect on the game taking place in the real world (racing), the end of which gives the winner of the digital game.

The purpose of the digital game being incorporated in the real world is for the students and the educators to experience an unprecedented sensation as it is completely different form the games they have been accustomed to so far and which will, on the one hand, intrigue their interest and curiosity and, on the other hand, will understand in practice that the programme can have an effect both on the digital and

on the real world. To test the extent to which this is realizable in practice, in real classroom conditions, the opportunity was given to students of Grade A of Gravia Secondary School to play this game after they had built their own robotic vehicles. The results were more than satisfactory as there was great enthusiasm, eager participation, competition and determination to continue the game even through break time. Unfortunately and due to personalized information involving children's sensitive information, the respective video will not be available in social media channels.

The reactions spurred during the game indicated that the success of the game is mainly contingent to the fact that the children saw their answers to the game materialize into something totally different from what they had been used to. Even if they didn't win any points, they could still see the robotic vehicle that they had built themselves moving back and forth depending on their answers in a race where the winner is the one who would provide with the more correct answers. The success of this venture was more than evident in the agonizing faces of the children as they waited to see the "ramifications" of their answers.

4 Conclusions and Future Work

App Inventor and NXTriviaRacing were inspired by the indelible quest of the educator for ways to lead to the solution of the greatest "riddle" of all that today's educator is called upon to answer: provide the students with the correct "motivational tools" to actively participate in the learning process. App Inventor can give substantial answers, under specific circumstances, to their problem as it uses the most popular of all communicative devices amongst youths and other people, as well. Testing the game to students of Gravia Secondary School was a successful experiment and testifies that App Inventor's potential opens up new horizons as far as using games and robotics in the educational context. Notwithstanding, to get safest and conclusive results it is necessary to have field research using the above application anew, as such or modified by the students themselves during a school project and to further research the students thoughts and concerns via open-ended question polls.

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