On Using Games to Enhance the Learning Experience in Egypt

Shaimaa Lazem, Kamal Bassuony, Mostafa Gaber, Karim Youssef, and Mohammed Morsy Farag

Abstract—**The presented research is based in a rural community of a developing country with major socio-economical challenges; Egypt. We discuss how educational technologies, games in particular, could motivate the students cope with some of the stresses in their learning environment such as the lack of appropriate teacher feedback due to the crowdedness in the classroom. Educational games could additionally help the teachers better organize their limited time. We propose a model for integrating educational games in the learning environment inside and outside the school. Furthermore, we present a prototype for an affordable multi-player interactive floor that allows for various gaming scenarios.**

Index Terms— **Game Technologies, Interactive Floors, Cooperative Play, Technology-Enhanced Learning**

I. Introduction

Rural communities in Egypt are the least receiving of adequate services. Students face various stresses such as the lack of qualified teachers, and the lack of parental support due to illiteracy. Moreover, the crowdedness in the classrooms prohibits the students from receiving appropriate attention and feedback from their teachers. Students hence resort to private tutoring [1], [2].

It is worth mentioning that despite the economic challenges, there are significant efforts to supply every school with a computer lab, and an Internet connection, sometimes with the help of foreign aids and technology giants such as Intel.

This research is based in Borg El-Arab, a rural community located in the North West of Egypt. The children in Borg El-Arab have access to some sort of technology. Many of them have personal computers or access to Internet cafes at moderate prices. Recently, a cloud infrastructure has been set up in a national research center, the City of Scientific Research and Technological Applications, located in Borg EL-Arab. Therefore, planning for an educational reform in Borg El-Arab that benefits from large-scale digital solutions is an attainable target.

The focus of the presented work is primary school students, hoping that the enhanced learning environment will discourage the students from dropping out of school.

Educational games could come in a variety of genres and difficulty levels, and could be designed to emphasize either the understanding or the practice of various skills [3].

Often educational games track and record the students' performances, which allow the teachers who have access to this data to provide their attention to the students who need it the most (*e.g.,* low-achievers). It additionally means that the good students could advance their skills by playing the games with minimal supervision. Moreover, games could create a good basis for a dialogue between the illiterate parents and their children about the children's performance in the school.

We present a model for integrating educational games in the schools. We further propose a prototype for an affordable interactive technology that could be appropriated for various gaming experiences. A further discussion about the games supported by the prototype is presented.

II. A Model for Integrating Educational Games in the Schools

We argue that educational games should be integrated with the curriculum, and personalized for one-to-one use outside the classroom. Figure 1 demonstrates an example for a web platform that includes educational games, a communication and collaboration platform (e.g., social media), and an analytics engine. The students, their parents and the teachers could access the web platform.

The educational games provide educational games designed to support the curriculum. The students play individually or in groups. The games provide feedback to the students to help them reflect on their mistakes. Classic gamification techniques such as badges and leaderboards, could be used as extrinsic motivators that are recognized, but not enforced, by the school to encourage the use of the platform.

For every student, the games record some performance indicators such as the number of correct and wrong answers, and the time taken to solve a question. The logged data is analyzed by the analytics engine, and the results are shared in a comprehensible format with the parents and the teachers. The automated data recording and analysis reduce any possible intimidation for the students to enroll in private tutoring.

The web platform allows the students to communicate and share their play and study practices with their peers from the same school or other schools. They could start a study group, or explore material outside the curriculum.

We propose one example for re-designing a learning activity in math classrooms around educational games. A substantial

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part of the Egyptian math curriculum in the second and third primary grades is dedicated to memorizing multiplication facts. Using educational games, the teachers could focus in the classroom on the conceptual understanding of the multiplication process and its properties, while the students play multiplication games to help them with the memorization part. The teachers could plan their lessons around providing compelling examples for the multiplication facts, where the students struggle the most, or providing feedback about the students' performance in the game.

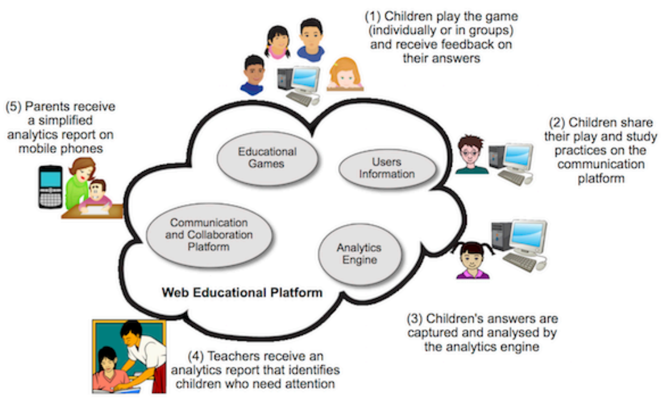

Figure 1: The proposed model for integrating educational games in the Egyptian schools.

Multi-player games offer opportunities for knowledge sharing among the students and their peers. An open technical challenge for developing countries is to provide an exciting multiplayer gaming experience using affordable technologies.

In the following we propose an example for an affordable interactive floor that simultaneously identifies and tracks multiple students. We review the literature of interactive floors to position our contribution. The interactive floor implementation is then described.

III. RELATED WORK

Interactive floors could be designed using several technologies such as vision-based tracking, pressure sensors, wireless sensor networks (WSN), Radio Frequency Identification (RFID), and Light Emitting Diodes (LED). Examples from the literature are provided below.

iGame Floor [4] is an interactive floor that is covered by a glass projection surface ($3m \times 4m$). The glass surface consists of the carrying glass, a diffusion layer, and a hard protection surface glass. Four cameras are placed $3m$ under the floor, which capture pictures for the floor to detect the limb contact points and hence the movement of the person on the floor.

Luzardo *et al.* [5] introduced an interactive floor with a client-server system. The server processes the image stream from an overhead mounted camera and generates information about the location and shapes of users' blobs. The information is passed to the client, which creates the responsive graphics that are projected on the floor.

Z-tiles [6] were proposed as a modular design for pressure sensing floors. The floor is assembled into tiles. A Z-tile has 20 force sensitive resistors on its surface, designed with a mixture of silicon rubber and carbon granules. When a person stands on the tile, the tile senses the pressure of the person and detects her position but not her identity.

Scherhaufl *et al.* [7] proposed a passive ultra high frequency RFID tag localisation system using a multichannel reader. The RFID reader generates a continuous wave and the tag reflects the signal to the reader, which receives it on multiple channels. The phase of arrival indicates the length of the signal path, and hence the tag position.

Nadeem *et al.* [8] proposed a system for 3D positioning using white LEDs. LEDs are attached to the ceiling of the room as transmitters, one of them is considered the reference LED. LEDs transmit signals using frequency division multiplexing, meaning that each LED transmits at a different frequency. The receiver is a photodiode, which has a circuit contains a band pass filter, frequency down converter, and the positioning algorithm. Estimation of the position is done by solving simultaneous equations based on the phase difference. They did not tackle the case of multiple users.

Vision systems are often affected by environmental factors, such as ambient light and shadows, which may limit the flexibility in deploying the floor inside the school. Moreover, the precise tracking of multiple persons is possible only if every person limits her movement to a pre-defined area on the floor, which constrains the type of games being played on the floor.

On the other hand, pressure sensors are robust against environmental factors, but less accurate in distinguishing individuals of similar weight or footstep pattern.

Wireless communication technologies such as WSN, RFID, or LEDs are more capable of identifying the user since the sensor sends and/or receives identification data. We chose passive low frequency RFID tags because they are light-weight, low-cost, and portable as they do not require external power sources.

IV. AN AFFORDABLE MULTI-PLAYER INTERACTIVE FLOOR

The proposed interactive floor design allows simultaneous positioning and identification for multi-players. We describe the technical design, and propose examples for using the floor in multi-player games. General design principles for the games are discussed.

A. Technology Description

The multi-player interactive floor consists of N tiles as shown in Figure 2. The hardware system consists of one master circuit, and slave circuits (RFID detection circuits) embedded underneath each tile.

The students wear the RFID tag in their feet, the tag is read by the RFID detection circuit. The floor uses proximity-based identification, where the location of the RFID reader position is used to indicate the student's position.

The design supports up to N students moving concurrently on the floor as long as each student stands exactly on one tile.

The system returns the tag ID and the tile number on which the student is standing.

The master circuit is connected to the computer (PC) via a USB port and wirelessly to the *N* RFID detection circuits. It is responsible for managing the communication between the slave detection circuits and the PC.

The master circuit includes a low-cost wireless module nRF24L01, a USB to Universal Asynchronous Serial Receiver and Transmitter (UART) converter, and a low-cost micro-controller ATMEL ATmega8.

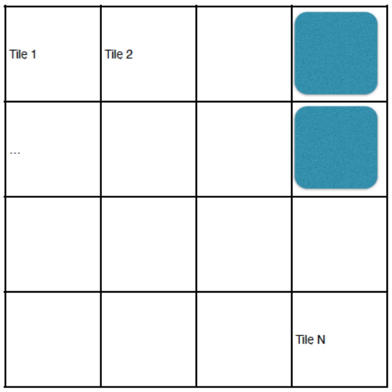

Figure 2: The RFID detection circuit, represented by the colored rectangle, are placed underneath each tile.

The nRF24L01 module has high speed communication air data rates up to 2*Mbps* with low power operation (*i.e.,* 11.3*mA* TX current and 13.5*mA* RX current), and its communication range is up to 60*m*. The communication protocol between nRFn24L01 and the PC is the Serial Peripheral Interface (SPI). Due to the unavailability of USB to SPI converters in our local stores, we used a USB to UART converter instead.

The ATMEL ATmega8 micro-controller, which has the two communications peripherals SPI and UART, is used to bridge the communication between the PC and the nRF24L01 wireless module. The nRF24L01 was configured using an open source firmware [9] .

The slave detection circuit consists of a passive RFID reader, a low-cost micro-controller ATMEL ATmega8, and a wireless module nRF24L01 that is similar to the one used in the master circuit. The circuit is responsible for reading the ID of the RFID tag or lack thereof and sending the readings wirelessly to the master circuit along with the number of the tile being read.

We use a RDM6300 module, which is an affordable low frequency passive RFID reader. RDM6300 reads the tag ID by sending an RF signal to the tag and receiving the reflected signal back from it using external loop antenna made of copper coil that operates at 125*KHz*. The dimensions of the antenna are 2.5*cm* × 3*cm*.

The system has two concurrent operations. The first operation is performed by the slave circuits periodically and independent from the PC. The RFID reader detects the tag ID (if present on the tile), and stores the ID along with the tile number (from 1 to *N*) in the slave micro-controller.

The second operation is performed by the master circuit to collect the data from all the slave micro-controllers, and forward it to the PC. For each tile, the PC sends the number of the tile to the master micro-controller, which forwards it to the corresponding slave micro-controller via the wireless modules. The slave micro-controller uploads the data back to the master circuit, which forwards it to the PC.

Figure 3 shows the analytical and empirical measurements for the total time taken by the PC to scan $1 \leq N \leq 12$ tiles (Tscan). Our analytical model provides a good estimate for the empirical results. A floor with 12 tiles, could be scanned in less than 100*msec* thus providing a real-time multi-player gaming experience.

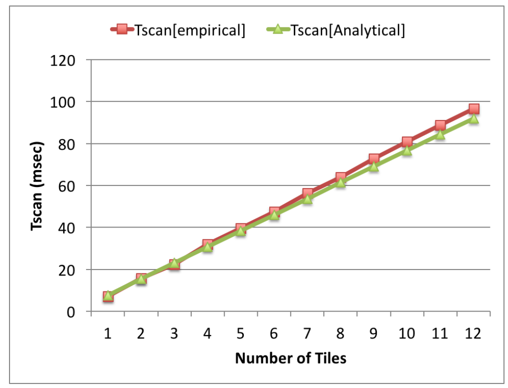

Figure 3: Empirical vs. analytical results of Tscan or the time needed for the computer to read the tag IDs from the floor (if present), for different number of tiles.

B. *Multi-player Interactive Floor: Gaming Scenarios*

We present several scenarios for multi-player games that could benefit from the proposed floor design. Students could interact with the game floor using several alternatives offering different user experiences. They could wear feet bands with RFID tags and move on the tiles. Alternatively, the RFID tags could be attached to some game tokens that students move on the tiles. Furthermore, since the tiles are not connected to each other, and connected wirelessly to the master circuit, the floor could be re-organized in different shapes to fit with a variety of game designs.

When students move on the floor, the game information is projected on the floor or the wall so that all the students could conveniently read it. Figure 4 shows an example for a simple game interface, that maps the floor tiles on the screen.

Games could be played without data projection by covering the floor with indicating labels, *e.g.* board games. The game information is displayed on a tablet held by a teacher/ or a facilitator who leads the game and provide the game instructions.

A suggested educational game is one that displays, on the screen, a question and multiple answers randomly distributed on a board analogous to the floor board. The students take turns to move on the floor and stand on the tiles corresponding to the right answer. For instance, the questions could be multiple choice arithmetic or spelling questions.

Games could be played by more than one team. A suggested example for a two-teams game is a word game, where each team is supposed to make moves on the board to construct a sentence or a word from a given set of words or letters distributed on the game board.

Another example would be an arithmetic game, where two teams compete to find the factors of a certain number from a set of random numbers distributed on the game board, the team who moves to the correct answers first wins.

Figure 4: The bottom right corner shows six tiles (with two flipped to show the circuits), above which the tags are present, the game board shows the tag numbers. The numbers could be replaced by the player names.

C. *Design Principles*

We propose some design principles for the educational games designed for the interactive floor.

Firstly, the games employ physical movement and thus require the students to coordinate their body movement and their thinking. Therefore, sufficient time should be allowed for the students to solve the game exercises. The physical play might be of particular importance in Egypt and other countries with similar economic challenges that lead to the reduction or elimination of the physical training activities.

Secondly, the game design adopts a form of retrieval practice [10], as a learning strategy that helps the students strategize their study practice based on what they do not master. Other learning strategies should be explored.

Thirdly, the content of the games is self-explanatory so it could be administrated by facilitators (inside the school), or illiterate parents (outside the school).

V. Conclusion

We proposed a model for integrating educational games in the classroom activities in the Egyptian schools. The merits of using the educational games will be fully achieved, when aligned with the curriculum, and the teachers' pedagogy in the classroom. Therefore, we argue that each school should have the flexibility of implementing the proposed model according to its available technological and human resources.

We presented a prototype for an interactive technology that support cooperative game scenarios beyond the desktop. We work on designing educational games for the proposed technology with the participation of teachers and students as major stakeholders.

The psychological and emotional implications for using educational games in an open shared space will be considered in the design process. Furthermore, a balance should be sought between competition as a classic derive in games and tolerance for failure to maintain safe, comfortable, and accepting learning environment.

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