EducaMovil: Mobile Educational Games Made Easy

Andreea Molnar[1]
National College of Ireland, Mayor Street, Dublin, Ireland
amolnar@student.ncirl.ie

Vanessa Frías-Martínez
Data Mining and User Modeling Group, Telefónica Research, Madrid, Spain
vanessa@tid.es

Abstract: The pervasiveness of cell phones among young people has made them an ideal platform to cater educational content informally (*anywhere, anytime)*. Although there are a large number of mobile learning tools, educational games provide an adequate compromise between educational content and games that makes the informal educational exploration more enjoyable and engaging. However, most educational games for cell phones are created by software developers as complex software packages which require software engineering knowledge to be modified or customized as needed. In this paper, we propose a system where games are created by game designers and educational contents by teachers, and both are brought together in a seamless manner. This novel approach facilitates the use of educational games without the need of programming skills and guarantees that teachers can easily create the educational contents that go into the mobile games.

Introduction

Mobile devices have become an integral part of people's lives and a pervasive platform that we carry around at almost all times. Unlike any other technology, cell phone penetration rates are also very high in emerging economies, leapfrogging landlines and broadband access (ITU 2010). This worldwide ubiquity has contributed to the advent of various mobile-based services in both emerging and emerged economies in areas like mobile education, mobile agriculture or mobile health.

Research in mobile education has mostly focused on providing educational content as a complement to formal schooling. The *learn anywhere-anytime* paradigm takes advantage of the mobile nature of cell phones and proposes the access to educational contents during downtimes *e.g.*, while commuting or waiting for public transport (Owaga 2010). There exists a large collection of mobile learning tools that propose the use of smartphones or high-end phones to deliver educational content that makes use of the student's environment (Daher 2010, Yin et al. 2007). Others propose mobile tools adapted to all types of cell phones, from feature phones to smartphones, mostly deploying SMS-based or Java solutions (BBC English n.d.). In this paper, we focus on game-based mobile learning tools that leverage educational contents with games making the learning process more engaging and enjoyable for the students (Malone 1980).

Although mobile educational games have struggled to prove that they can seriously contribute to the educational arena, recent research carried out in this area is starting to show signs of change. Banerjee *et al.* have shown that mobile educational games can significantly enhance the learning process when used to study math (Banerjee et al. 2007). Promising results have also been shown with usage of mobile educational games for improving children literacy (Kam et al. 2009, Tian et al. 2010). Furthermore, researchers have also developed meta-level reflections on learning strategies through mobile games (Facerw 2004). Even though mobile learning games are showing encouraging results, they suffer from an important drawback: the games are typically designed by educational technologists and software developers, and require extensive software engineering knowledge to be modified. Unfortunately, this model for game-based educational content creation does not scale since teachers wanting to create additional educational contents or wanting to localize the contents to other languages or cultural traditions have to pay educational companies and software developers to do it. Game technologists should design the games, but we believe that teachers should be able to easily design, change and re-factor the educational contents that go into the games as needed.

[1] Work done while the author was an intern at Telefónica Research, Madrid

There exist many educational tools and social networks devoted to helping teachers create educational contents and sharing them with students and other teachers (Educared n.d., Descartes n.d., RedDOLAC n.d., Teachbook n.d.). However, the contents created in these forums are typically web 2.0; non-game based, and prepared to be accessed mostly through computers. In this paper, we present **EducaMovil**, a PC and cell phone-based system where teachers can create and modify educational contents for mobile educational games; and students can download the mobile educational games on their cell phones and play as they wish. The integration of the educational contents into the games is done by EducaMovil in a seamless manner and requires no teacher intervention. EducaMovil has a plug&play architecture where games and educational contents can be easily mixed and matched as needed. Teachers can create new educational contents or modify existing ones and EducaMovil will repackage game and contents and leave everything ready to be downloaded at any time by the students. Additionally, the separation between the game and the educational contents allows to better evaluate the educational progress of the students. The only requirement for the students who wish to use the games is to have access to a cell phone that supports Java applications. Although EducaMovil mostly focuses on low-feature cell phones that are common in emerging economies and among young teenagers, the system we propose can work for any type of platform. The rest of the paper is organized as follows: next we present a literature review in the areas of mobiles for education and mobile games. After that we will describe the architecture of EducaMovil and its PC and cell phone components. We will also describe the pilot deployment and evaluation and we will finish with conclusions and future work.

Research Background

There exists a wide range of mobile learning applications to deliver educational content. Daher e*t al.* (2010) examined how middle school students used mobile devices outside the classroom. Students were provided with the mobile application *Fit2Go* (a graphic tool that allows drawing linear and quadratic functions) to perform activities related to real world phenomena (Daher 2010). The authors conclude that the use of mobile phones while carrying out real world activities can enrich students' knowledge. JAPELAS2 (Japanese Polite-Expression Learning Assisting Systems) is a mobile educational tool that suggests to the learner the Japanese polite expression that can be used based on the learner's context (Yin et al. 2007). The authors gave to each learner a PDA equipped with IR (infrared), RFID (Radio Frequency Identification), GPS and wireless LAN (Local Area Network). Learners were required to introduce their personal information when they used the system for the first time. Based on this information, whenever the learner encountered someone, the system suggested the appropriate "level of politeness" based on three variables: hyponymy (e.g. age or position), social distance (e.g. family or colleagues), and formality of the situation (e.g. meeting).

Game-based mobile educational learning applications have been created for different curricular areas such as: language learning (Kam et al. 2009, Tian et al. 2010) or mathematics learning among others (Kalloo et al. 2010, Butgereit et al. 2010, Ketamo 2003). Kam et al. explored the use of mobile learning games to improve English literacy among Indian children (Kam et al. 2009). The results of their pilot study showed that mobile phones have the potential to improve English literacy. However, the results were uneven among the participants: the students that had a higher English level at the beginning of the pilot benefited more from the use of the mobile learning application. In order to solve this discrepancy, the authors proposed as a solution the creation of adaptive mobile learning games that offer personalized contents depending on the students' knowledge. Similar research was presented in Tian et al. (2010), who studied how culturally inspired mobile learning games could help to improve Chinese literacy. The paper analyzes different traditional Chinese games, and uses them as a motivation to design cell phone games that follow similar rules. The authors show that culturally inspired games have more potential than western games to attract the interest of children-students in China (Tian et al. 2010). These approaches differ from our proposal in the fact that the games are created by game designers and thus teachers can not easily create or modify them in order to explore new concepts.

In the area of mathematics skills, a couple of interesting projects are MobileMath (Kalloo et al. 2010) and DrMath (Butgereit et al. 2010). Although none of them rely solely on games for delivering educational content, the games are an important part of their educational models. MobileMath is an architecture that provides games, lessons, tutorials, examples, and quizzes as separate entities for students to practice concepts in algebra. This work is different from our approach since teachers can create educational content that is not delivered within a game: students can choose to either play a game (created by game technologists) or explore different lessons. On the other hand, DrMath is a communication framework that allows children to consult a tutor, participate in competitions, or to play single or multiple user text adventure games in the area of arithmetic.

Different educational social networks have been created with the aim of sharing content over the web 2.0. EducaRed is a platform that facilitates the use of web 2.0 at computer labs in schools (Educared). The platform addresses teachers, students, parents, and schools, and provides a large array of tools to create and access educational contents over the web. Other tools like MobileStudy or Descartes are web-based tools that allow teachers to create educational contents over the web (MobileStudy, Descartes). These contents can later be accessed by students as *html* snippets or applets over the web. Although all these platforms and tools have proved successful, none of them can be delivered on feature to medium-range phones and none of them allow educational content delivery through a game approach.

EducaMovil: Architecture

EducaMovil is a system that has two main components: (1) a PC tool for educational content creation in mathematics and (2) a mobile game-based educational application for Java-enabled cell phones. On the PC, teachers can create the educational content snippets that will be shown in the games. On the cell phone, the mobile game-based application consists of an open-source cell phone game where points and lives are won after correctly answering a specific educational content snippet. This architecture allows teachers to strictly focus on educational content creation, and uses open-source games created by game developers to provide the engaging component surrounding the educational snippets. Next, we explain each component in detail.

I. PC Tool

The PC tool allows teachers to create the educational snippets with mathematical contents that will be shown in the mobile game. Figure 1 shows a screenshot of the tool where we observe that teachers can create various types of educational snippets (left hand side) and see in real time how they would look on the students' cell phones (right hand side).

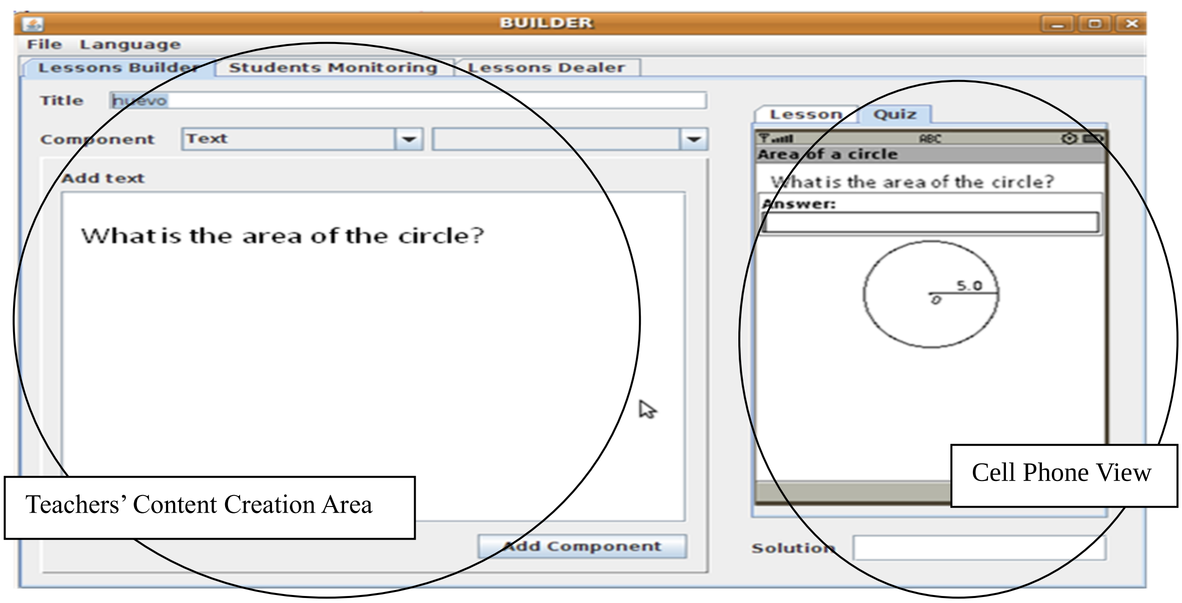
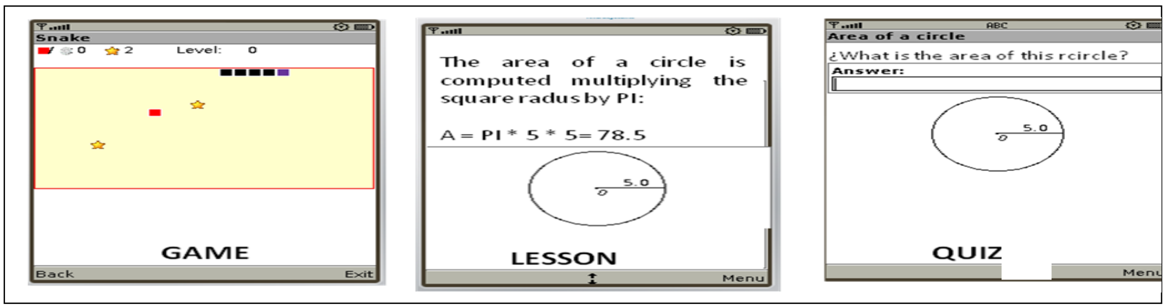


Figure 1. PC tool to create educational content snippets that will be shown in order to pass from one level to another in the mobile game. On the left hand side teachers can create lessons and quizzes and on the right hand side they can see how it will look on the student's cell phone.

The educational snippets contain two different components: lessons and quizzes (see Figure 2). Lessons are interactive exploratory units that allow students to read about specific math concepts and to explore them freely without answering any questions. Lessons are based on previous research that shows that the use of dynamic and interactive mathematics software enhances better the students learning capabilities (Jones 2000, Roschelle et al. 2000). The PC tool offers teachers the possibility of creating exploratory lessons in four different mathematical areas: arithmetic, geometry, algebra and logic. Within each area, the teacher can select among a group of functions or exercise types to be shown on the screen *e.g.*, a circle or a truth table, and add his/her own explanation. On the other hand, quizzes are questions (simple or multiple choice) that the students are required to answer. Upon creation, each educational snippet is composed of one lesson and one quiz. Additionally, the teacher is required to assign to the educational content being created its educational grade (1st to 12th grades) and a complexity level (five levels from *very easy* to *very difficult*). Figure 2b shows an example of an educational snippet that appears after the student has eaten an item in the snake game (see Figure 2a). The snippet contains an explanation on how to compute the area of a circle (text box) and in the canvas the student can enlarge or shrink the circle (using the keys on the cell phone) to observe how the value of the area computed changes. Once the student feels confident with the concept explained, he/she can jump to the quiz (Figure 2c) and try to answer it correctly.



(a) (b) (c)

Figure 2. Educational content shown after item is eaten. It contains an exploratory lesson and a related quiz.

II. Mobile Phone Educational Application

The mobile phone application that students run on their cell phones consists of two elements: the game and the educational snippets created by the teachers (Section III will explain how the game and the contents are downloaded onto the cell phone). Although in this paper we present a modified version of the Snake game, any other open-source game for cell phones can be used by EducaMovil. Our modifications to the game are always the same: to simply add a module that handles the interactions between the game and the educational snippets. This module consists of three components: *Game Model*, *Adaptation Model* and *User Model.*

Game Model

The game model is responsible for the interaction between the open-source game and the educational snippets created by the teachers. The game model is fired every time an event in the game allows players to win points (or lives) and introduces the educational snippets as the units that need to be solved before winning the points. In this paper, we present an open source version of the Snake game, however the philosophy would be the same for any other game based on events and levels. The snake game consists of a snake that needs to eat the items that appear on the screen until it can pass to the next level. The snake game has four different types of items: red squares, diamonds, ladders and stars. We have modified the game such that whenever diamonds or stars are eaten, the student is shown an educational snippet. The educational snippet contains an explanatory lesson and a quiz. As explained before, the content of the lesson is interactive (for example, for the geometry lessons, students can modify the geometric shapes and see how these modifications affect the perimeter/area of the shape). These are performed with the aim of making the concepts they learn less abstract and more interactive. After the student finishes exploring the lesson, s/he will be prompted with a quiz, which is based on the lesson content. If the learner provides a correct answer to the quiz, s/he receives an award based on the item eaten: it might diminish the length of the snake, increase the score of the game, or give a new life. The game finishes either when the student runs out of lives, when the snake dies (by colliding against the wall) or when all the questions have been correctly answered.

Adaptation Model

The adaptation model determines the specific educational content that is going to be shown to the student. Recall that each educational snippet is labelled with a grade and a complexity level. The adaptation model selects the grade and complexity level of the educational snippet that is going to be shown to the student next, based on the students' past learning evolution. Although the learning evolution of a student can be modelled taking into account multiple variables, we use the same strategy as Ketamo (Ketamo 2003) where the average time the learner needs to answer a quiz and the number of accumulated errors the learner has made over time determines whether the student gets an educational snippet that is more or less difficult than the previous one. In that manner, students that invest long times to answer the quizzes and make a lot of mistakes will be offered easier quizzes and students that seem to answer correctly in short times will get increasingly difficult quizzes (see Figure 3). EducaMovil's architecture is plug-n-play, meaning that the adaptation model can be easily changed by another one to model learning evolution differently.

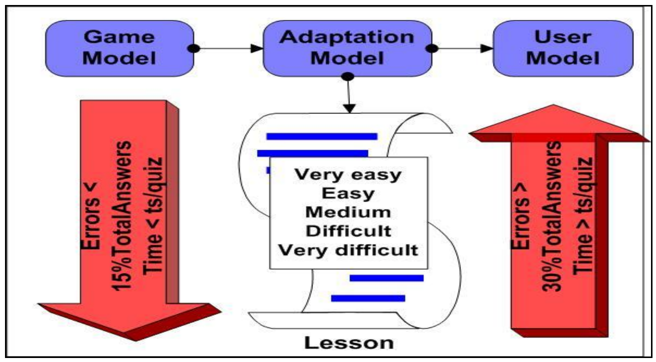


Figure 3. Sketch of the three models: the adaptation model determines the complexity of the next lesson based on the percentage of errors over total number of answers and on the average time spent to answer a quiz.

User Model

The user model stores the interactions of the learner with the educational units and the game. The model keeps counters about the lessons explored by the student, time invested on each lesson, the quizzes answered correctly or not, time invested to answer quizzes, and about the status of the game keeping the number of lives, score and length of the snake. This model is primarily used by the adaptation model to determine the complexity level of the lesson/quiz to be shown. Additionally, the user model can be downloaded to the PC tool. In fact, besides content creation the PC tool also allows teachers to monitor the progress that the students make exploring the educational contents on the cell phone. For that purpose, the PC tool contains a "Student Monitoring" tab (see top of Figure 1) that specifies for each student all the variables in the user model so that the teacher can explore the number of correctly answered quizzes or time spent playing the game and compute general class statistics that might help teachers understand areas that should be explained further.

III. Communication Model

There exist two types of communications at EducaMovil: (i) the game and lessons that are **downloaded** onto the cell phone, and (ii) the user model that is **uploaded** to the PC tool for student monitoring. The download process takes place once the educational contents have been created by the teacher on the PC tool. These contents can be bundled together with the game in a package in a seamless manner: the teacher simply needs to select the set of educational contents that wants to deliver with the game, and click on a button (tab "Lessons Dealer" in Figure 1). The package can then be downloaded by students onto their cell phones. EducaMovil allows for two different types of downloads: via Bluetooth or through a cable. Given that EducaMovil is offered as an after-class program, students can go to the computer lab after school and use their Bluetooth connection or a cable to download the game onto their cell phones. Additionally, students can also upload their user models using the same procedure: Bluetooth or cable when they visit the computer lab.

Evaluation and Future Work

We have proposed EducaMovil, a system that is aimed at helping teachers easily create educational content for mobile game-based educational learning tools. The system will be deployed soon at a public school in Lima, Peru. The benefits of the proposed approach will be examined through a pilot study. The aim of the pilot is to determine whether teachers are able to easily create meaningful educational content with such tool, as well as to evaluate the benefits of using mobile games as part of the students' learning curriculum. The pilot will be executed during a period of 6 months and the evaluation will be both qualitative, based on interviews to students and professors, as well as quantitative, based on the user models collected on the PC tool about the interactions of the students with the educational games. Future work will include an SMS-based communication feature that will allow students to communicate among themselves to ask for help when answering a specific quiz. Additionally, we will also add student rankings to promote competitive learning games.

Acknowledgements
This research work was also supported by IRCSET Embark Postgraduate Scholarship Scheme.

References

Banerjee, A., Cole, S., Duflo, E., & Linden, L. (2007). Remedying education: Evidence from two randomized experiments in India. *Quarterly Journal of Economics,* 122(3), 1235-1264.

BBC English. Retrieved from http://www.bbc.co.uk/worldservice/learningenglish/

Butgereit, L., Leonard, B., Le Roux, C, Rama, H., De Sousa, M., & Naidoo, L. (2010). Dr Math gets MUDDY: the "dirt" on how to attract teenagers to Mathematics and Science by using multi-user dungeon games over Mxit on cell phones, *IST Africa 2010*, Durban, South Africa, Retrieved from http://researchspace.csir.co.za/dspace/bitstream/10204/4085/1/Butgereit2_2010.pdf

Daher, W. (2010). Building mathematical knowledge in an authentic mobile phone environment. *Australasian Journal of Educational Technology*, 26(1), 85-104.

Descartes, (n.d.). Retrieved from http://recursostic.educacion.es/descartes/web/

Educared. (n.d.). Retrieved from http://www.educared.net/

Facerw, K., Joiner, R., Stanton, D., Reidz, J., Hullz, R., & Kirk, D. (2004). Savannah: Mobile gaming and learning? *Journal of Computer Assisted Learning*, 20, 399–409.

ITU ICT-Eye Free Statistics. (2010). Retrieved from http://www.itu.int/ITU-D/ict/statistics/

Jones, K. (2000). Providing a foundation for deductive reasoning: students' interpretations when using dynamic geometry software and their evolving mathematical explanations. *Educational Studies in Mathematics*, 44, 1-2.

Kalloo, V., Kinshuk, & Mohan, P. (2010). Personalized game Based Mobile Learning to Assist High School Students with Mathematics. Proceedings of *the 2010 10th IEEE international Conference on Advanced Learning Technologies* Washington, DC, 485-487.

Kam, M., Kumar, A., Jain, S., Mathur A., & Canny, J. (2009). Improving Literacy in Rural India: Cellphone Games in an After-School Program. Proceedings of *IEEE/ACM Conference on Information and Communication Technology and Development,* Doha, Qatar, 139-149.

Ketamo, H. (2003). An adaptive geometry game for handheld devices. *Educational Technology & Society*, 6(1), 83-95.

Malone T. (1980). What makes things fun to learn? A study of intrinsically motivating computer games. Proceedings of *3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems*, New York, NY, USA, 162-169.

MobileStudy. (n.d.). Retrieved from http://www.mobilestudy.org/home/

Ogawa, M.-B. (2010). Augmenting Large-enrollment Instruction with Mobile Learning. Proceedings of *15th Annual Technology, Colleges and Community Online Conference*, Retrieved from http://etec.hawaii.edu/proceedings/2010/Ogawa.pdf

RedDOLAC. (n.d.). Retrieved from http://www.reddolac.org/

Roschelle, J., DiGiano, C., Chung, M., Repenning, A., Tager, S., & Treinen, M. (2000). Reusability and interoperability of tools for mathematics learning: Lessons from the ESCOT project. Proceedings of *Intelligent Systems & Applications at University of Wollongong*, NSW Australia. ICSC Academic Press, Wetaskiwin, Canada, 664-669.

Tian, F., Lv, F., Wang, J., Wang, H., Luo, W., Kam, M., Setlur, V., Dai, G., & Canny, J. (2010). Let's Play Chinese Characters: Mobile Learning Approaches via Culturally Inspired Group Games. Proceedings of *28th International Conference on Human Factors in Computing Systems*. Atlanta, 1-4, 1603-1612

Traxler, J., & Leach, J. (2006). Innovative and sustainable mobile learning in Africa. Proceedings of *IEEE international workshop on wireless, mobile and ubiquitous technology in education,* Greece, 98-102.

Yin, C., Ogata, H., & Yano, Y. (2007). JAPELAS2: Japanese Polite Expressions Learning Assisting System in Ubiquitous Environments, Proceedings of *Supporting Learning Flow through Integrative Technologies*, T. Hirashima et al.(Eds.), ISO Press, 471-478.