Insights from EducaMovil: Involving Teachers in Creating Educational Content for Mobile Learning Games

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Abstract: The advent of feature phones in emerging economies makes them an ideal tool to be used for facilitating and complementing education performed in a formal environment (i.e. schools). However most of the proposed applications do not take into account the wishes of the teachers to customise the applications for student needs, or easiness to re-create and personalise the educational content. In this paper, we extend the state of the art by presenting the evaluation of *EducaMovil*, a platform aimed at easing the creation of educational games that allows teachers to customise or create entirely new

educational content by being agnostic of the underlying implementation of the games. Teachers have successfully been using *EducaMovil* to create educational content for mobile games that were later on used by the students both in formal (i.e. classroom) and informal environments (i.e. outside the classroom).

Introduction

Mobile phone penetration and network coverage continue to increase. Recent surveys show that mobile phones penetration rates are 96% globally (ITU, 2013), and it is expected that 100% network coverage will be achieved by 2015 (ITU, 2012). Unlike any other technology, mobile phone penetration rates are high both in developed and emerging economies (ITU 2013).

As it is often the case in emerging economies in special, or in low-income schools in general, the school has a low budget and scarce educational resources leading to a challenging environment that often has an impact on student motivation and their performance. On the other side, the high ownership of mobile phones among students has made them a cost effective solution to complement formal schooling and to facilitate the delivery of educational content anytime-anywhere. Having access to educational content anytime-anywhere, facilitates learning for students that do not have that much time for home studying and hence they learn in unpredictable situations such as the time used while commuting (Ogawa, 2010), waiting for public transport (Ogawa, 2010), waiting while in line at the grocery store (McElvaney & Berge, 2009), waiting at the doctor's office (McElvaney & Berge, 2009), etc. This is especially important in emerging

economies where children often travel long distances to get to school and might benefit from the access to educational content in their downtime.

To a large extent, research on mobile learning has focused on using smartphones or high-end phones to facilitate the delivery of educational content (Daher 2010, Fernández-López *et al*. 2013, Molnar & Muntean 2012) and very few studies have addressed feature phones that are the most present devices among students in emerging economies (Trucano, 2011). Some work has been done to adapt educational content to all types of mobile phones (from feature phones and smartphones), mostly by deploying SMS or Java based solutions (BBC English n.d.). The research presented in this paper, focuses on feature phones, as they are the most used mobile device among low income students, but in our case the educational content is delivered through games, as they are known to be motivating for students (Malone 1980).

Recent research carried out on mobile educational games is starting to show positive results for the usage of these in educational arena. Banerjee *et al.* (2007) have looked at the usage of mobile educational games for teaching math. The results of their study have shown that the usage of games delivered on mobile devices has significantly increased the students' knowledge (Banerjee *et al*. 2007). Another arena where educational games have been used is for improving literacy (Kumar *et al*. 2011, Edge *et al*. 2012). Edge *et al.* show positive results in helping learners to improve the Mandarin Chinese skills. Even though mobile learning games are showing encouraging results, most of the games are typically designed by educational technologists and software developers, and require extensive software engineering knowledge to be modified, leading to little or no involvement by the teachers. Once the game is developed, the teacher typically cannot

personalise the content to the classroom needs, or cover new educational content. Covering new educational content typically implies involving the educational technologists and software developers that leads to an increased cost. Unfortunately, this model for game-based educational content creation does not scale since teachers wanting to adjust existing educational content or to create additional educational content depend on software developers to have it integrated in the game.

Several educational tools and social networks exist helping teachers create educational content typically for web 2.0 non-game based platforms that are most of the time accessed through a computer (Educared n.d., Descartes n.d., RedDOLAC n.d.). Recent works, such as *MobileMath* (Kalloo *et al*. 2010) allow teachers to create educational content for mobile learning application, and tools such as *EducaMovil* (Molnar & Frias-Martinez 2011) and *English Literacy Tool* (Alismail *et al*., 2010) allow teaches to create and automatically compile and integrate in the game, the desired educational content. This allows teachers to customise the content for their specific needs. For these reasons, our research focuses on the evaluation of *EducaMovil* - a game-based mobile learning tool that allows teachers to create or customise educational content in an easy and cost effective manner. The evaluation takes place with teachers from a low-income school in Lima, Peru.

The rest of the paper is organized as follows. Next we present a literature review on mobile educational games aimed at developing countries. After that we will describe the architecture of *EducaMovil*. We will continue with the set-up of the evaluation, followed by student demographics and mobile phones and game usage data, we continue by providing a brief overview of the teaching effectiveness of the games, followed by the

teachers' feedback on *EducaMovil*. We will finish with a summary of the presented work and conclusions.

Research Background

Game-based mobile learning applications have been seen as an enjoyable way to teach. Teaching language learning (Edge *et al.* 2012, Kumar *et al.* 2011) or mathematics (Kalloo & Mohan 2012, Butgereit *et al.* 2010, Nygren *et al.* 2012) are among the areas covered by existing game-based mobile learning applications. Kumar *et al.* (2011) worked on cell phone mobile learning games to improve English word reading among children in rural areas of India. They have successfully used two games that children were playing after school showing the potential of improving their English vocabulary. Similar research was presented in Edge *et al.* (2012) showing positive results of mobile educational game usage for improve the Mandarin Chinese skills.

In the area of mathematics, some projects such as *MobileMath* (Kalloo & Mohan 2012) and *DrMath* (Butgereit *et al*. 2010) have included games as part of their educational models. Although successful, none of the above tools allowed teachers to change or create content for their educational games (for *MobileMath* teachers can create content for other applications but not for games). There exist other game-based mobile learning tools, like *EducaMovil* (Molnar & Frias-Martinez 2011) or *English Literacy Tool* (Alismail *et al*., 2010) that are not confined to a certain curricular subject, providing a more general framework. These tools allow teachers to create educational content for different subjects and automatically embed educational content into games and in the same time maintaining the cost low as they do not require large budgets or engineering knowledge. Given that sustainability and low cost are critical variables for low-income

schools, we focus our research on *EducaMovil* evaluation from a teacher perspective at a low-resource school in Lima, Peru.

The evaluation of the game-based mobile educational learning applications have been mostly focused on student perception of mobile learning (Ally 2013), and the educational impact and usability of the tools (Edge *et al*. 2012, Kumar *et al.* 2011, Frias-Martinez *et al.* 2012a, Frias-Martinez *et al.* 2012b, Frias-Martinez & Virseda 2011, Nygren *et al.*, 2012). When the evaluation is done from a teacher perspective, it is aimed at assessing teacher attitude towards using the proposed application (Nygren *et al.,* 2012), but not on how easy it is for them to create and customise educational content for the proposed games. This research will cover also this aspect by involving teachers in content development.

EducaMovil: Architecture

In this section, we present a description of EducaMovil, by providing a brief overview of the platform. EducaMovil is a system that has two main components: (1) a PC tool for educational content creation and (2) a mobile game-based educational application for Java-enabled cell phones. On the PC, teachers can create the educational snippets that will be used in the games. On the cell phone, the mobile game-based application consists of open source cell phones games, where points and lives are won after correctly answering a question pertaining to a certain educational content snippet. The platform is designed so that it allows teachers to be agnostic of the game design and focus strictly on educational content creation. The open-source games are created by the game developers and allow an engaging element surrounding the learning content. Next, we explain each component in detail.

PC Tool

The PC tool (see Figure 1) is designed for teachers, to create and/or modify the educational content of a mobile game. The teachers can also see in real time how the content would look on cell phones. Educational content consists of a lesson and a quiz. The lesson typically contains an image and/or an explanation about a specific concept. A lesson is always followed by a quiz. The quiz can be a simple- or multiple-choice test question. The quizzes are used to evaluate students learning gains. For that purpose, their answers to the quiz questions are compared against the correct quiz answers provided by the teachers while creating the lessons.

Additionally, the PC tool allows teachers to offer a hint or to add an explanation. The hint is provided to the student when s/he pressed the help button during a quiz. The explanation is shown to the student once he runs out of chances to answer the quiz. Additionally, the teacher has to assign for each of the educational snippets its educational grade (1^{st} to 12^{th} grades) and a complexity level (five levels from *very easy* to *very difficult*).

Figure 1 provides a screen shot of the tool as being used by the teachers. It shows a lesson about how to compute the area of a circle, provides the answer to the quiz, hints for the situation in which the student asks for help, and an explanation on how to reach the correct answer, given the student fails to do so.

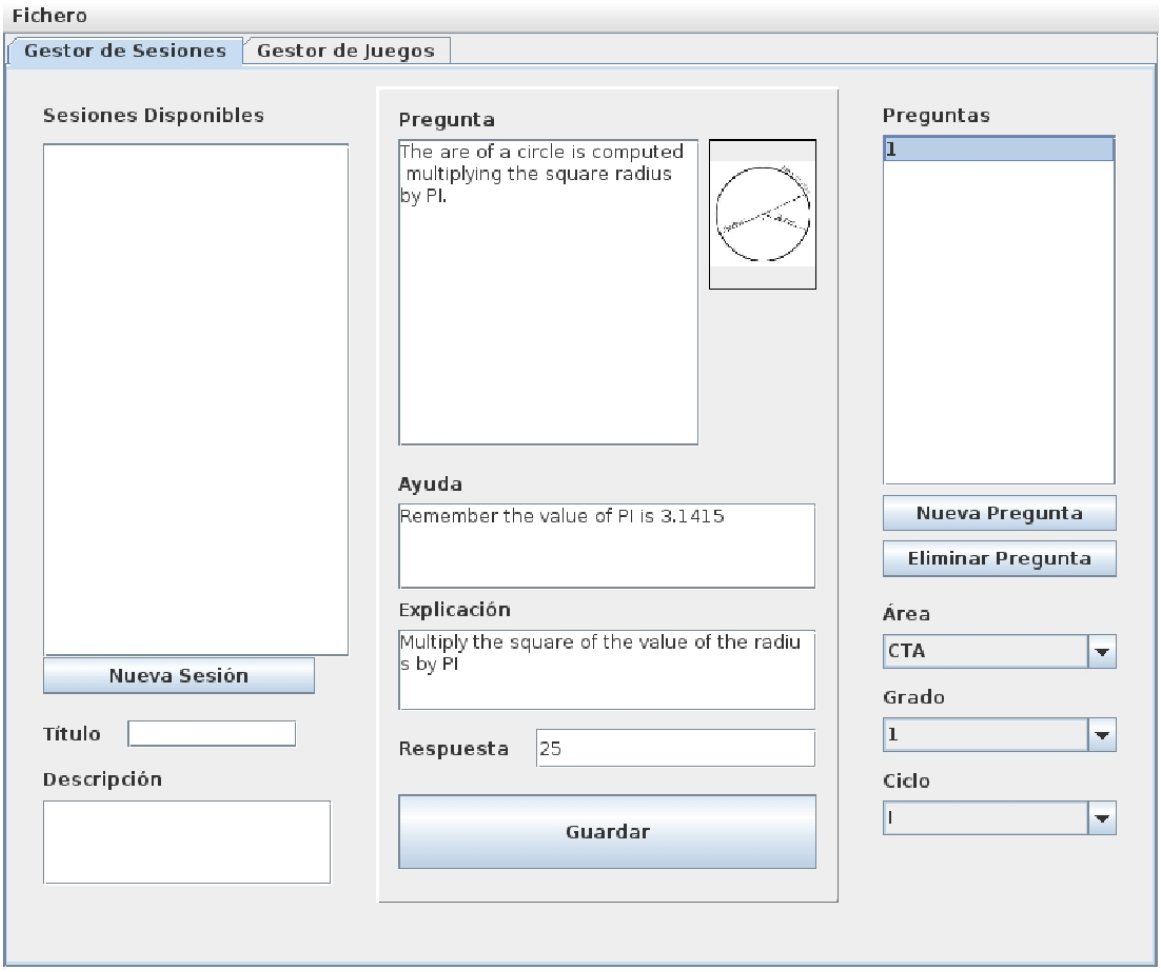
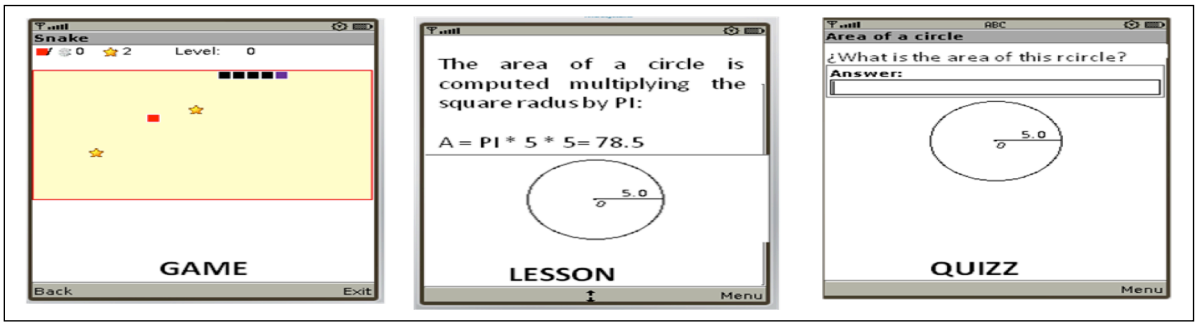


Figure 1. PC tool (Frias-Martinez *et al*., 2012a) to create educational content snippets that will be shown in order to pass from one level to another in the mobile game.

Figure 2 presents an example of a game (i.e. Snake) and how different educational components (i.e. lessons and quizzes) are displayed. Upon creation, each educational snippet is composed of one lesson and one quiz. First the student plays the game (see Figure 2a). After the snake has eaten an item, an educational snipped appears (see Figure 2b). The snippet contains an explanation on how to compute the area of a circle (text box). The educational content is interactive, the canvas allowing the student to 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 (see 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.

Mobile Phone Educational Application

A Java mobile phone application, that is an educational game, is given to the students. It consists of: the game and the educational snippets created by the teachers (integrated in the game). *EducaMovil* offers the possibility of integrating the educational contents into different open-source games for cell phones like Snake, Tetris or Rally. The games are altered to add a module that handles the management of the educational content, consisting of three components: *Game Model*, *Adaptation Model* and *User Model.*

Game Model

Game Model manages the interaction between the open-source game and the educational content created by the teachers. The game model is fired every time an event in the game allows players to win points or lives. At this point, the educational contents are presented and the students can explore the lesson. After the lesson, the quiz that is based on the

previously presented lesson needs to be solved correctly before winning the points. The game also allows the students to compare his score with the top 10 highest scores.

Adaptation Model

The role of the adaptation model is to decide which content is suitable to be presented to the student in each step of the game. The educational content is randomly selected from the pool of educational content created by the teachers which is then embedded into the game and downloaded to the cell phone. Each lesson and quiz is shown to the student up to three times, but never in a consecutive manner. If the student needs help, she can press the *help* button and the game will show a hint to help her answer the quiz. If the student does not successfully answer the quiz after three attempts, an explanation with the correct answer is shown. The lesson is eliminated from the pool of educational content either when the student provides a correct answer or after the explanation is provided.

User Model

The User Model stores the interactions of the student with the educational content and the game. The model keeps the lessons explored by the student, whether the quizzes were answered correctly or not, the time invested to answer quizzes, and whether the *help button* or the final *explanation* was instantiated. This model can be transferred to the PC tool via Bluetooth.

Pilot Set-Up

The pilot (Frias-Martinez *et al*., 2012a) took place at a public school in a low-income Peruvian urban area of Lima. The school, which offers both primary and secondary education, is part of the *Peru Educa* program ran by the Peruvian Ministry of Education

which focuses on providing educational tools and content to teachers and students through an online portal (PeruEduca, n.d.). For that purpose, the school has a very modest lab, *Innovation Lab*, with second-hand computers where teachers and students can access the Internet. The teachers said that most students are highly motivated when classes are held in the *Innovation Lab*. However, given the large number of students at the school, the computer lab can be used only once a month by each class. Additionally, computers are oftentimes infected by viruses and students have to share the PCs at a ratio of about five students per computer.

These issues highlighted the necessity to look for alternatives to the PCs that would be both engaging and attractive to students while being more affordable and sustainable (in terms of maintenance). Given the high penetration rates of cell phone ownership at the school (97%), we decided to explore the deployment of a mobile learning program. Teachers and students were involved from the initial stages of the project to understand the type of mobile activities that would better suit the curricular needs of the school. The teachers commented that they often test students with multiple-choice exams due to the characteristics of the Peruvian educational system.

In Peru, students willing to move from secondary school to a public or private university are required to pass a multiple-choice exam that covers all curricular areas. Thus, teachers put a lot of emphasis on multiple-choice tests, especially in secondary school, to prepare students for these highly competitive exams. The interviews with students revealed that they want to have tests on their cell phone to be able to practice for exams. More than 90% of the students reported that they used their cell phones mostly to call, send SMSs and to play games. These findings made us believe that *EducaMovil*

could be the most suitable tool since it provides game-based learning on mobile platforms and the possibility to test students with multiple-choice quizzes.

The academic year at the school is divided into three terms and classes run throughout the year covering different curricular objectives each term. At the end of each term, students take a final test heavily based on multiple-choice questions to evaluate their performance. A research pilot was deployed from September 2011 to December 2011. The teacher for the *Science and Technology* class volunteered to run the pilot with two first grade groups at the secondary level. During the last two weeks of August 2011, workshops were offered for the teachers to become acquainted with the PC tool and sessions were held with the students to learn how to use the mobile games. Although *EducaMovil* works on any Java-enabled feature phone, all students were provided with the same feature phone during the sessions to be able to focus exclusively on the study. A lab technician was available to help the teacher and the students' through the study.

Students Demographics and Cell Phone Usage

Students' questionnaires were used to gather demographic information, understanding the general cell phone usage behaviour of the students and getting feedback about *EducaMovil*. The results show that 97% of school students have access to a cell phone either owning them or a member of their family owns one.

Table 1 presents more details about student game usage on mobile phones. Most students prefer to play games on cell phones (83%) rather than on PCs. Playing games with friends are preferred (82%) over playing alone (18%), and did not find almost any difficulties in using the keyboard as part of the game (89%). Additionally, 58% stated that they download games to their cell phones (mostly from call centres).

Table 1. General questions

Game Use	*PC*: 17%	*Cell*:83%
Play Conditions	*Friends*: 82%	*Alone*: 18%
Keyboard Problems	*No*: 89%	*Yes*: 11%
Game Download	*Yes*: 58%	*No*: 42%

As for *EducaMovi*l, in general they liked the games (89%) and thought that they could help them learn (96%). Finally, when asking for help they prefer to talk to friends or no one (61% and 28%) instead of asking the teacher for help (11%).

Table 1. EducaMovil games questions

Like Game	*Yes*: 89%	*Little*: 11%	*No*: 0%
Learning	*Yes*: 96%	*Little*: 4%	*Not at all: 0%*
Help & Friends	*Friends*: 61%	*Teacher*: 11%	*No one*: 28%

Learning Effectiveness

Educational impact of *EducaMovil* in terms of learning gains effectiveness when used in the classroom or during school breaks was evaluated through a pilot study in Peru from September 2011 to December 2011 (Frias-Martinez *et al*., 2012a). This focused on: (a) analysing whether the use of *EducaMovil* has an impact on knowledge acquisition,

and if so, under what learning settings; (b) evaluating what type of students benefit most from using *EducaMovil*; (c) analysing the relationship between game performance and classroom performance so as to understand whether *EducaMovil* can be used as a proxy to measure a student's level of knowledge. The results showed that: (a) *EducaMovil* has an educational impact in both formal and informal environments. However, in informal environments a minimum interaction with the tool is required for the educational impact to be statistically significant. (b) Students that had an initial average knowledge benefitted the most from using the *EducaMovil*. Therefore, for obtaining significant educational impact it is important to check that the students have a minimum working knowledge. Additionally classroom deployments appear to produce higher learning gains than informal environments. (c) *EducaMovil* game points can be used as a proxy for student test grades in the classroom environment; in the break environment, it acts as a proxy only when attendance requirements are put into place. Thus, *EducaMovil* could be used as a complementary tool to homework so as to help them with student evaluation.

Teachers Feedback

Two teachers participated in the pilot evaluations and actively contributed towards the content. Moreover, we ran workshops with 20 other teachers at a school interested in learning how to use *EducaMovil*. Through the workshops, we found out that all of them are familiar with the use of computers (60% of them own one and the remaining 40% use the PCs at the lab at least twice a week to look for class materials). All of them felt that *EducaMovil* was easy to use and successfully created educational content during the workshop.

Summary and Conclusions

To sum up, we believe that given the widespread use and familiarity of students with cell phone games, and given the proactiveness of teachers at the school, *EducaMovil* could constitute a successful tool towards providing reinforcement education either in the classroom or in more informal settings as long as a minimum interaction time is guaranteed.

Our research extends the state of the art by presenting the evaluation of a game-based mobile learning tool aimed at easing teachers' creation of educational content. It has been shown that *EducaMovil* is an effective tool for improving users' knowledge about the subject taught. Moreover, it could be used as a complementary tool to paper based assessments.

We have presented the results of an evaluation performed to assess the usability and usefulness of the tool. This was done through a pilot study with two teachers involved in the active creation of the educational content that was used by the students both in the classroom and outside the classroom as an informal learning method. Moreover, workshops were run with 20 other teachers that also confirmed that *EducaMovil* was easy to use and successfully used the tool to create content during the workshops.

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