Extending a Game Authoring Tool for Ubiquitous Education

Eugenio J. Marchiori, Javier Torrente, Ángel del Blanco, Iván Martínez-Ortiz, Baltasar Fernández-Manjón
Department of Software Engineering and Artificial Intelligence, Complutense University, Madrid
{emarchiori, jtorrente, angel.dba, imartinez, balta}@fdi.ucm.es

Abstract

Educational game authoring tools allow for the creation of educational games for personal computers and web-browsers reducing costs and development cycles. However, gaming has changed in the last few years, with a significant increase of games developed for mobile devices. We propose an extension of existing educational game authoring tools that allows for a seamless adaptation of current games to mobile platforms and to take advantage of the new features provide by mobile devices (e.g. GPS, compass) at the same time. Additionally, mobile educational games allow for ubiquitous learning by providing highly interactive and engaging contents with educational value in different situations. We have exemplified our approach extending the <e-Adventure> educational game platform and using Android™ as the target platform. We present the identified challenges and the proposed solutions to explore the ubiquitous educational gaming possibilities.

1. Introduction

Nowadays educational gaming is gaining acceptance, but new approaches that simplify mobile game development and deployment are needed to promote a more general adoption. Traditional educational desktop video games (a.k.a. serious games) have been mostly displaced by educational games embedded in web-browsers. Web enabled games helped to overcome some of the issues related to the delivery of the games and their interoperability while hindering other features such as the use of powerful game engines [1]. Thus, educators can take advantage of the already established web-based learning infrastructure available in their organizations [2] or even use new applications such as social networks [3]. Moreover, the broad availability of web-browsers and their limited hardware requirements allows a wider access to educational games.

Mobile games are also on the rise. For instance, according to the 2009 Entertainment Software Association 37% of Americans reported to play games on wireless devices, up from 20% in 2002 [4]. This means that educational games should also consider these new channels of content delivery to reach the new generations of mobile users. This enables a new shift in educational games that take advantage of the new possibilities offered by the mobile technologies.

However, developing mobile games poses new and different challenges compared to desktop or web-based game development. Many mobile platforms with potential for gaming have appeared in the last years, but each platform introduces particular user interfaces, interaction paradigms and specific development tools. Platform-specific knowledge is needed to develop mobile games, increasing the technical skills required to create and deploy educational games. Besides, the costs are increased further as usually different game versions must be developed for each target mobile device or family of devices. These new technical requirements not only increment the development costs but also limit the possibilities for educators to create their own educational contents or at least participate in the development process. We propose to address these problems by extending pre-existing game authoring tools, adding the features needed to create mobile educational games.

Our approach is exemplified with the <e-Adventure> educational game development platform [5]. The platform has been extended to create games for *Android* devices, reusing a solid development model designed for desktop applications for mobile devices [6]. The <e-Adventure> game editor has been specifically tailored for educators and allows developers or instructors to adapt preexisting educational games to mobile devices or to create new ones with a reduction in both costs and complexity.

This paper is organized as follows: In section 2 we present the background technologies and related work in educational and mobile gaming. In section 3 we identify the challenges posed by the translation of desktop games to mobile platforms. In section 4 we discuss the advantages and limitations of mobile educational games. In section 5 we present our approach to mobile educational games. Finally, in section 6 we provide the conclusions and future lines of work.

2. Background and related work

To contextualize our approach current mobile software platforms are presented in this section. Then a general description of the mobile games and it use in m-learning (application of mobile devices in education) are discussed. Finally, other general and mobile-specific game development tools are also studied, considering the types of games that can be created and the educational features included.

2.1. Mobile software platforms

Our approach is based on the *Android OS*™. This is a smart-phone OS developed by *Google*™ as an open-source alternative to other systems such as the *iPhone OS*™, *Symbian*™ or *Windows Mobile*™. Our choice is based on the potential for growth of the platform and the open-approach to development allowed by the tools available. Besides, current *Android*™ based hardware uses the latest technologies, making it possible to place it at the disposal of educational game developers.

The *iPhone*™ platform provides a complete set of tools for development and a big installed base. However, the closeness of this platform and legal problems (the developer agreement only allows development using Mac systems) present problems for our approach.

Symbian^2™ and *Symbian^3*™ have taken an open-source approach and have the backing of *Nokia*™ (the world largest handset producer). The latest versions of these platforms provide developer tools up to the standards of any other platform. However, these platforms are mainly used in low-powered and low-features devices, limiting the advanced features that can be included in the games.

Windows Mobile™ provides both the tools and the hardware that would fit out needs. However, *Windows Mobile*™ is a closed environment, and current versions (6.5) are being phased out. The next generation of this platform, *Windows Phone 7*™, has not been deployed in any devices yet, limiting its current potential, as the educational games cannot be "field-tested".

All the platforms in their latest versions share some common features such as "application markets" (first introduced by *Apple*™ for the *iPhone*™) and support for touch-screens. The "application market" solution to content distribution has allowed the exponential growth of mobile applications (including games) and must be considered in any educational game development as possible distribution medium. However, all these markets require fees to include software and filter the content using criteria that are not fully clear to the public. As a result it is a requirement to provide both additional support and alternative distribution models.

2.2. Mobile games and m-learning

The use of mobile devices is very diverse and opens a wide range of possibilities in the educational field, originating a trend known as m-learning [7]. The approaches used range from the introduction of "in-field" reference tools to augmented reality simulations. "In-field" reference tools allow students to improve their skills in real scenarios and use background materials whenever they are needed. For instance, mobile devices are being used in medical education to improve on-site students' clinical skills [8]. Other experiences describe the application of mobile devices in places where informal learning usually takes place, such as museums or environmental areas [9, 10]. Moreover, mobile devices can be used in disfavored locations and wherever there is no access to computers [11].

Besides, mobile devices can support more authentic and meaningful learning experiences as they include special characteristics that are not present in computers. For instance, mobile devices can be used to develop location-based and augmented reality applications where the students get deeply immersed [12-14]. Therefore mobile devices can be used to promote situated learning [15] and trigger students' pre-existing knowledge of the real environment [16].

At the same time, as Dieterle [17] has identified mobile devices and Wireless Handheld Devices (WHD) can be means to achieve ubiquitous learning, supporting "neomillennial" learning styles by combining collaboration, authenticity, role-playing, mobility and self-directed learning. Nonetheless barriers to achieve a more general implementation have been identified, such as different teachers' concerns about the effects of these new technologies in the learning outcomes of students and the establishment of effective instructional designs [17].

2.3. Mobile game development platforms

There are different game development platforms that support mobile games specifically or as an additional feature. Such platforms include *Unity*[1], *GameSalad*[2], *AdventureMaker*[3] and *Corona*[4]. All these tools allow for the creation of games for *iPhone*™ and other mobile devices (Table 1).

Some tools limit the types of games that can be developed but require virtually no technical skills, such as *Game Salad* and *AdventureMaker*. These tools have been designed with a focus on game/user interaction and the elements that compound the game. Their aim is the creation of recreational games and they include no

[1] http://unity3d.com/
[2] http://gamesalad.com/
[3] http://www.adventuremaker.com/
[4] http://anscamobile.com/corona/

specific educational features. *Game Salad* is designed to create 2D arcade games while *AdventureMaker* allows for the creation of *point-and-click* games, virtual tours and interactive presentations.

Other tools are tailored for professional development and include sophisticated features, such as device specific restrictions (e.g. battery consumption) and hardware (e.g. GPS and accelerometers). Such tools include *Unity* and *Corona*. *Unity* is a powerful professional tool, widely used to develop 2D and 3D games. Although it was originally developed for 3D PC games, later versions include mobile game creation as well. *Corona* is a specific game and application development tool for mobile devices, allowing the creation of games with high performance by using hardware accelerated graphics and a small footprint (particularly relevant in some mobile devices). *Unity* and *Corona* include optimized physics engines, renderers and devices simulators. Both tools present high performance scripting that is pre-compiled (e.g. Lua in *Corona*) to add complex behaviors.

Table 1: Relationship between game development tools and the mobile devices where the games developed with them can run.

Developing tool	Mobile Devices
Unity	iPhone, iPod Touch, iPad
Game Salad	iPhone, iPod Touch, iPad
AdventureMaker	iPhone, iPod Touch, PSP
Corona	iPhone, iPod Touch, iPad, Android

None of the studied platforms include specific out-of-the-box educational features (e.g. mechanisms to send a report on student's performance to the instructor). Nevertheless, *AdventureMaker* is intended to be used for educational proposes as well. Besides, none of these platforms is open source and only *AdventureMaker* is freeware. All these platforms require that the games developed must be distributed through the application market of the target platform (that could not be suitable for some educational settings).

3. The challenges of mobile platforms

Developing games for mobile platforms presents different challenges compared to the development of games for PCs. The hardware available in most mobile platforms is not only limited (e.g. less memory and processing power) but in many instances fundamentally different (e.g. touch-screens versus keyboard and mouse). Games originally developed for desktop environments require both technical solutions and design or adaptation solutions to run on mobile devices. Both issues are described in section 3.1 and 3.2 respectively.

3.1. Hardware challenges

The hardware constraints are mostly addressable by the use of different technical solutions, such as limiting the graphic complexity attained by rescaling images to lower resolutions. These technical solutions can be "hidden" in the implementation, either in the development platform or in the game engine. This allows game creators to be able to develop games that can target both kinds of platforms (i.e. mobile and PC platforms) using the same tools.

Such a challenge is presented by the support for video formats and *codecs*. Mobile platforms usually depend on hardware implementation of video *codecs* either because of power consumption or processing power. This problem must be solved during the authoring process, as once the video is included in an unsupported format the mobile platform will not be able to use it in any way. The authoring tool is aware of such limitations and includes mechanisms to encode videos using *codecs* and formats natively supported by the target mobile platform.

Other challenges have to be addressed in the engine implementation for the mobile platform. Even if the main memory is much more limited in mobile devices than on PCs, the use of solid state memory can mean that the system memory is faster than a Hark Disk Drive in a PC, resulting in different kinds of optimizations. These differences must be transparent both to the game developer (the solution must be part of the system) and to the game player (the technology must set as few limitations as possible to the games).

3.2. Design and adaptation challenges

The different input mechanisms and other features that are only available in mobile devices present new challenges. The solutions needed to address these differences will usually affect the development of the game, the use of the game or both. To reduce the impact on the game developer we chose, when possible, solutions that use the same or similar interaction patterns for the mobile implementation as the one needed for the PC version.

Such a challenge is presented by the reduced size of mobile screens. Even if screens are continually increasing in resolution, their size can make more difficult the perception of details in some games. This problem is especially significant when games are designed to be played in the screen of a PC (usually more than 13") but are being played in a mobile phone (usually less than 4"). *Point-and-click* adventure and simulation games where the player must sometimes manipulate small objects or find clues hidden in different scenes of the game are particularly affected by the size of the screen. To address these problems different methods can be used, such as showing parts of a scene (i.e. the game screen) at a time to increase the real size of the representation or using a "magnifying lens" inside the game.

Some challenges arise from the need of new means to distribute games in educational settings. The lack of standards or specifications in web-based learning tools that apply to mobile contexts [18] requires the development of custom or *ad hoc* solutions. The "application market" included in the different platforms are not well suited for this task because they are not designed to distribute content to specific users (usually applications are downloaded at users' request). Besides, the fees introduced and the review process that applications are subjected to does not fit most educational approaches.

4. Advantages of mobile educational games

As well as challenges, mobile educational games present advantages that must offered to game creators enabling them to use the full potential of mobile devices as tools for education. Some advantages, such as ubiquity, are tightly related to mobile games (section 4.1) but the use of other features of mobile devices need special tools (section 4.2).

4.1. The advantages of ubiquity in mobile games

The creation of ubiquitous games provides extra flexibility in the learning environment. One advantage of games over static contents, or contents with low interactivity, in this situation is the possibility to include in-game evaluation of the learning outcomes and student performance assessments. This way, making educational games mobile does not require additional mechanisms to follow the student progress, because most games have this as a part of their design.

Introducing mobility aspects in educational games allows for the seamless use of games in different contexts. For instance, if a game is played in a computer at school, the educational gaming experience ends when the student leaves school. On the contrary, if a game is played on a mobile device the player can continue with the same experience outside the school (e.g. in the public transport or at home). This seamless change of context can help to increase the time learners are exposed to educational games, and could thus increase the learning outcomes of such games.

Ubiquitous implementations of educational games can increase learning outcomes and knowledge retention for *point-and-click* simulations. As mobile games can be played anywhere, educational simulations can be played in the real environment of the simulated experience. For instance, a simulation of a laboratory procedure can be played in the same laboratory where the real procedure is performed, allowing the player to establish a relation between every simulated element and its real counter-part in the real world without leaving the game [19].

4.2. The unique advantages of mobiles as educational gaming platforms

Last-generation smart-phones usually include cameras, GPS chipsets and other advanced hardware components not generally available in PCs. To make full use of the potential of these features the game metaphor needs to be changed in the authoring tools and in the general perception of what constitutes an educational video game.

In addition, wireless connectivity allows new distribution models for educational games, where mobile games can be used in-class evaluation or in lab sessions as support material.

GPS locations can be used to force the player to perform certain steps in a game, or to play the whole game, in a predefined location. This way, learning can be reinforced, as the student is made aware of the real-world environment that is relevant to the game's lesson.

Accelerometers, not usually available in PCs, can be used to measure changes in position and movement. This provides a mechanism to implement health games where the player is motivated to perform different physical exercises such as jumping or running.

Most modern mobile devices also include cameras that can be used in games to introduce information. For instance, 2D barcodes can be used as a complement or alternative to GPS localization, forcing the user to read a tag left in a specific place to unlock new features in a game. This use is particularly relevant in doors, where GPS localization does not always perform as expected. The camera can also be used in educational settings if the player is asked to perform a real-world task, capture the results with the camera and the photo included in the report sent to the educator for later evaluation.

5. From educational games to ubiquitous educational games

The main goal of our approach is the seamless transition for game creators from PC educational game development to mobile game development. Besides, easing and improving the development process, our approach allows for the evaluation of the benefits of ubiquitous learning from the player's perspective, as it will reduce the complexity to introduce mobile educational games in new environments. This approach is a continuation of the previous work made in <m-Adventure> [20] which takes advantage of the main ideas of cost reduction and ease of use introduced by <e-Adventure> to make games currently available in this platform usable in some mobile phones.

5.1. The <e-Adventure> authoring tool

The <e-Adventure> authoring tool has been in continuous development for the last few years by the <e-UCM> research group at that Complutense University at Madrid. This platform allows for the creation of *point-and-click* adventure and simulation games and produces games that can run in PCs or inside web-browsers.

<e-Adventure> support several educational features such as evaluation of student performance and adaptation of game contents to specific student needs. Besides, games created with <e-Adventure> can be automatically deployed in web-based learning environments compatible with e-Learning standards.

This authoring tool was developed to reduce development costs for educational games. The <e-Adventure> game editor is tailored for educators, reducing complexity and including different features that ease the inclusion of educational features out of the box.

<e-Adventure> is developed in *Java* (the same programming language used by *Andorid* OS apps) and games created with this platform can be run in PC with the *Java* platform or any web-browser that supports *Java* applets.

The games created with <e-Adventure> belong to the *point-and-click* adventure or simulation genre. These games are composed of scenes (i.e. game screens) where the action takes place, and the player interacts with the different objects in the game using a mouse.

Our previous work in ubiquitous education and m-learning resulted in the <m-Adventure> platform, which allows <e-Adventure> games to run in mobile phones that support J2ME. However, J2ME poses technical restrictions that make specific mobile features unusable across different implementations, such as audio and video support that require device-specific application interfaces. This problem resulted in the limited application and portability of the previous model, a problem that we expect the present solution will overcome.

5.2. Extending <e-Adventure> for *Android* platforms

The use of two open-source technologies (<e-Adventure> and *Android*) means that we have full access to the framework where we are developing our solution and can take full advantage of all available technologies. Besides, this allows for a low cost solution and easy testing of different hypothesis to validate our approach.

The current implementation of the <e-Adventure> system in the *Android* platform allows for the running of games originally developed for the desktop platform (Figure 1). The interaction is automatically adapted for touch-screen devices and the graphic resources are preprocessed in the mobile devices themselves for two reasons: to allow the reuse of existing games without further changes and to adapt to the differences among mobile devices (e.g. screen resolutions, processor power and graphic chipsets).

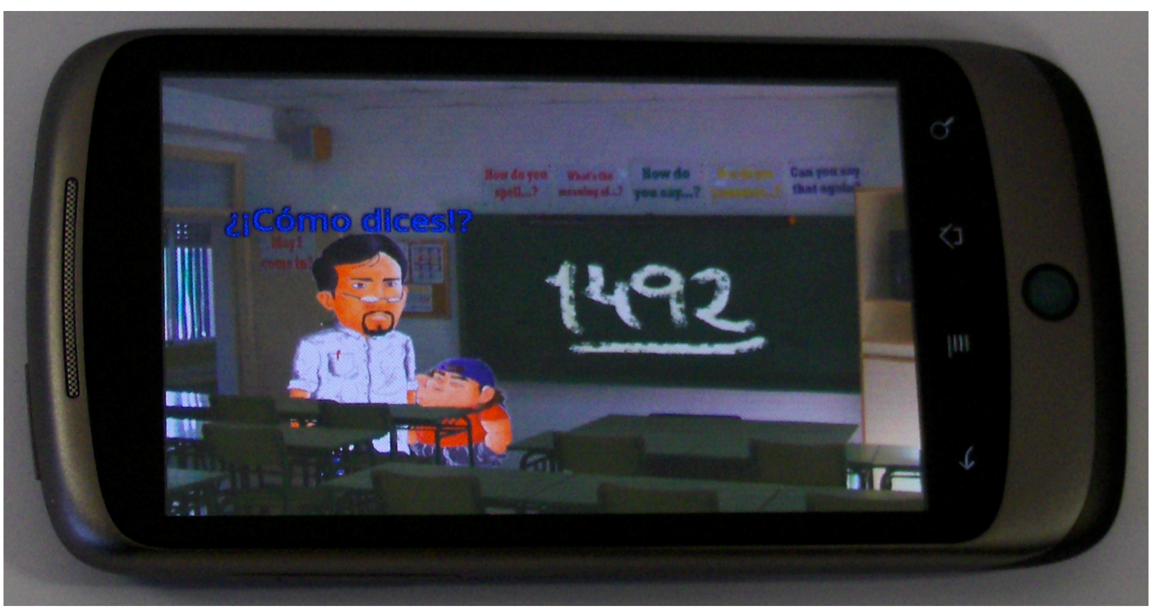

Figure 1. A game originally developed for the PC running in the current version of the *Android* <e-Adventure> engine in a *Nexus One* phone. This shows a conversation taking place between the player character (right) and his in-game teacher, a non-player character (left).

Figure 2. User playing with a *point-and-click* simulation game in a *Nexus One* phone. The "magnifying glass" is showing the details of the scene where the user's finger is pressed. The caption over the "magnifying glass" shows the name of the object under the finger ("Teléfono").

However, this approach based on the use of games originally developed for other platforms does not, by itself, take advantage of some of the unique characteristics of mobile phones. To take advantage of these features, the authoring tool has been extended to introduce new in-game interaction metaphors related to mobility. Player interaction with games can now be based on the player location in the real world (i.e. by using the GPS coordinates) or the proximity of the player to a real world object (i.e. by the use of the camera and 2D barcodes placed on objects).

5.3. Addressing the challenges

Different challenges require different solutions. The current implementation has shown that most hardware challenges can be addressed by the game engine optimization or by the authoring tool extension to perform adaptation of the game contents during the exportation or compilation process.

The optimizations are mostly targeted at reducing the required memory for games execution. Such optimizations are done taking advantage of two facts: that games are installed in the mobile platform (in contrast with browser games, that run directly on a web-browser) and the higher speed of the system memory based on solid state technologies in contrast with HDD drives used in PCs.

The use of the mouse is replaced by the touch-screen input. In *point-and-click* games the two mouse buttons are used, so this behavior is emulated in the new interface. To perform a left click, the user taps the screen. To perform a right click, the user must leave the finger pressed on the screen for a short time.

To make details visible in the usually small screens of mobile devices, we include a "magnifying glass" metaphor (Figure 2). When the user presses the screen, the magnifying glass appears providing a detailed view of a part of the game space. As the user moves along the screen the "magnifying glass" follows the movement of the finger. When an object is placed under the user's finger, its name is displayed in the screen (emulating the mouse-over effect). If the player raises the finger from the screen when an object is under it the behavior of the right-click in the PC version of the game will be emulated.

Modern point-and-click games use contextual menus, accessible using the right click, to display the actions available for an object in the game. Contextual menus are replaced with modal menus in mobile games, because they allow information to be displayed better in a small screen by using all the available space.

5.4. Taking advantage of the mobile platforms

The use of GPS coordinates and 2D or matrix barcodes makes the games part of the world where they are being played. These characteristics can be used for different objectives, such as modification of the in-game behavior depending on the position or the deploying of different games depending on the location of the player.

The first use can result in the creation of “Treasure Hunt” game types, where the player finds clues in the game that take him/her to different places in the real world. These games, in an educational context, can be used to provide additional information to that found in the real world.

The second use can result in games being delivered to potential learners when they are close to the matter of interest being taught by the game. For instance, a 2D barcode can be placed near a painting to load a game related to its subject or creator, allowing a student to further improve his/her knowledge. This feature makes it possible for games to be used where audio-recordings are now used to impart contextual knowledge, such as museums or historic sites.

6. Conclusions and future work

The path to achieve ubiquitous educational gaming is still not clear. Our work is a first step to make use of most currently available features of mobile devices with a reduced cost to the developer. Our approach is based on the extension of the <e-Adventure> platform, a platform of proven educational potential. However, our approach is focused on the game creator perspective while the effects on learners’ educational outcomes and engagement of ubiquitous educational gaming require further study.

The current version of the <e-Adventure> platform for the *Android* OS shows that the technical and design challenges faced by educational gaming in mobile devices can be tacked by the combination of different solutions. This platform can now be used to evaluate the benefits for learners of ubiquitous educational games.

We are currently working on different improvements to the implementation, both to extend its capabilities and to increase its integration with the learning experience. We expect to keep working on different game examples to test the educational outcomes of such games in real world environments.

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