A Nested Design Approach for Mobile Learning Games

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ABSTRACT

Mobile Learning Games (MLGs) show great potential for increasing engagement, creativity and authentic learning. Yet, despite their great potential for education, the use of MLGs by teachers, remains limited. This is partly due to the fact that MLGs are often designed to match a specific learning context, and thus cannot be directly reusable for other contexts. Researchers have therefore designed various types of MLG authoring tools. However, a recent study we led shows that these authoring tools are ill-adapted to the teacher's needs and competencies. The teachers find them either too poor to create MLGs that fit their teaching requirements, or too complex and overwhelming to use. In this paper, we introduce JEM iNVENTOR, an authoring tool based on a nested design approach. It offers three conceptual levels adapted to the teacher's competencies, and allows them to progress in time.

CCS CONCEPTS

• Applied computing → Education → Interactive learning environments

KEYWORDS

location-based serious game, authoring tool, mobile learning

1 INTRODUCTION

1.1 Context

Recently, playful learning has been enriched with the mobile dimension, taking advantage of the widely spread mobile devices among learners [1, 2] and the attractiveness of mobile gaming in general (e.g. *Clash of Clans*, *Pokémon Go…*). The recent interest in Mobile Learning Games (MLGs) is also driven by the game industry [3] and government investments [4]. Several researchers have proven the effectiveness of MLGs in various domains of education [5, 6]. *Frequency1550* [7], for example, a MLG designed to learn about medieval Amsterdam, helped high-school students obtain higher scores on the knowledge test than the students with the regular lessons. Other MLGs have also proven their effectiveness for improving engagement (e.g. *TheMobileGame*, designed to introduce a university campus in Berlin to new comers [8]) and creativity (e.g. *skattjakt*, a MLG co-designed with students to promote physical activity while learning [9]).

The common advantage of these MLGs is their use of features typically available on mobile devices (e.g. geolocation, augmented reality, etc.). These mobility assets make MLGs pedagogically effective because learners are engaged in authentic, onsite learning, using role-play and solving complex real-world problems. Thereby, the challenges proposed by these MLGs are more realistic and engaging than classroom exercises.

However, the common inconvenient of these MLGs is the fact that they are limited to a specific learning context and location and therefore difficult to reuse. Moreover, designing and developing MLGs is very costly since it requires material and human resources including pedagogical experts, game designers, developers and graphic designers.

1.2 Previous Work

1.2.1 *Authoring Tool Analysis.* In previous work, we show that the use of MLGs in classrooms is currently limited because of the lack of tools to help teachers create their own MLGs [10]. In the same study, we list the existing authoring tools, which can create MLGs, and assess them with the help of teachers, in order to determine their limitations. This analysis allowed us to distinguish two categories of authoring tools: those who are simple to use but very poor in terms of functionalities and those who are powerful but too overwhelming. Indeed, the first category is composed of the authoring tools that offer rich low-level-item-based GUIs. Even though it is possible to create MLGs with these tools, the effort and expertise required to use them was overwhelming for teachers. The second category covers the authoring tools that include few or limited features, but which are relatively simple to use. The problem is that these authoring tools do not provide enough design features to create effective MLGs, such as those from the first category. However, if the authoring tools from the second category just provided more features, would this be the solution? According to HCI specialists, augmenting information density in general, implies augmenting perceptive and cognitive workload [11]. Therefore, we believe that augmenting authoring tools features would make them join the first category and so the usability problem would persist.

1.2.2 *Teacher Profiling.* In the same study, we led interviews with teachers who are used to organize educational field trips and interested in using MLGs. These interviews allowed us to divide teachers in two categories. The first one comprises teachers who do not have any game design experience but are quite interested in the topic and would like to create MLGs, if it does not take more than a few hours. In this paper, we will refer to this category as "*novice MLG designers*". The second category comprises teachers who have already designed or used MLGs and who are willing to put in quite a bit of effort and time in an authoring tool that would allow them to create the type of MLG they want. We will refer to those teachers as "*experienced MLG designers*". Therefore, in the next subsection, we present our approach for satisfying the needs of these two profiles and, more importantly, to help teachers who are *novice MLG designers* progressively become *experienced MLG designers*. Furthermore, even if we identified these two main user profiles, several intermediate profiles surely exist.

1.3 Hypothesis

1.3.1 *An Authoring Tool with several conceptual levels.* In order to create a powerful yet simple authoring tool, suited for both *novice* and *experienced MLG designers*, we studied previous research on TEL authoring tool complexity [12–14] and found two theories that could potentially answer our problem: differentiating interfaces and hidden complexity [13–15]. Consequently, our authoring tool will contain different interfaces in order to match different user profiles. Hence, as we have at least two teacher profiles, our authoring tool will propose at least two different interfaces with adapted functionalities: the *novice mode*, for creating basic games very quickly and the *experienced mode* for creating complex custom games. Then, as these modes are quite different, we propose a transition mode that we detail in the next subsection.

1.3.2 *A Nested Design Approach*. Based on the exploratory interviews discussed above, after *novice MLG designers* have created a basic MLG and experimented it with students, they will most likely try to improve it by adding activities or changing the structure. Therefore, we intend to assist *novice MLG designers* so that they can progressively have access to more features as they gain experience. To allow such progression, we suggest an intermediary mode with more accessible features. This mode will keep the landmarks (i.e. interface organization, functionalities, vocabulary, game structure) that teachers will have acquired in the *novice mode* and introduce the complex functionalities of the *experienced mode*. The main idea is to progressively uncover the features, in order to help *novice MLG designers* gradually become *experienced* with a smooth learning curve.

In the next section, we introduce JEM iNVENTOR, an authoring tool based on a nested design approach, which reifies our hypothesis.

2 JEM iNVENTOR

2.1 Underlying Model

2.1.1 *Focus on Location-based Learning Games*. In a previous state of the art [16], we found that almost all of the most cited MLGs where actually Location-Based Learning Games (LBLGs). Back in 2006, Schlieder [17] already praised the great potential of "GeoGames" and the recent *Pokémon-Go*[1] seems to confirm this prediction.

We believe that providing *novice MLG designers* with a formalized MLG structure will help them. Indeed, designing learning games requires experience in game-design. Therefore, providing *beginners* with a common template should be quite helpful. Still, as this is quite a complex task, we decided to start by providing a basic template for LBLGs.

2.1.2 *Formalizing Location-based Learning Game Structure.* Following to our previous state of the art on MLGs, we have found that the analyzed LBLGs had a common recurrent structure. LBLGS are composed of a sequence of *game unit* that need to be done on a specific *Point Of Interest (POI)*. Each *game unit* is composed of a *clue* –indicating the point of interest POI to look for - a *learning content* - that is shown at the POI itself – and finally an *evaluation task* that can be given in several ways (answering questions, exchanging pedagogic information with team members, taking notes…). This structure is recurrent to most of the LBLGs that we came across, even out of the study. This structure was validated by our interviews with teachers, who affirmed that it fit their needs.

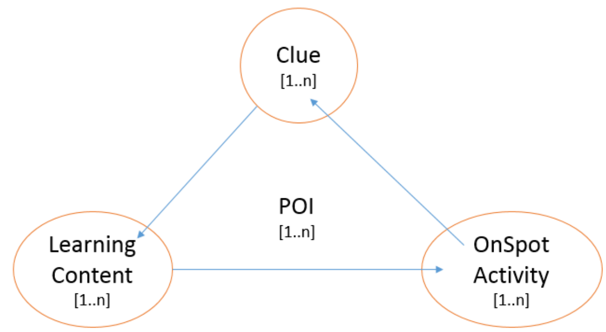

Figure 1: Simplified Schema of the proposed Location-based Learning Game structure

As shown in figure 1, this structure enab les teachers to directly transcribe their learning content and evaluation tasks on POIs. However, it does not take into account any game mechanic, and that is done on purpose, as we want *novices* to focus only on their pedagogic content. Indeed, pedagogic content is the teachers' field of expertise and therefore the easiest task to do. At this level, our system provides preconfigured game mechanics that the teachers do not have to handle themselves. The next subsection explains in details this purpose.

2.1.3 *The three Conceptual Levels.* As discussed in the introduction, we introduce our three conceptual levels. Each level is represented by a mode in JEM iNVENTOR:

- A "*standard mode*" providing a couple of object types that can be slightly adjusted (e.g. GPS coordinates of points of interest (POI), learning and questions content). This view will allow *novice MLG designers* to rapidly create a basic playful scenario with preconfigured game mechanics and scenarios (e.g. a linear game unit order, a standard way of counting scores).

- An "*intermediate mode*" allowing designers to go further in details, in order to better adjust their scenarios. This time, the teachers can configure the score mechanisms, the radius of POI, game unit triggers and dependencies.

- An "*expert mode*" allowing the *experienced MLG designers* to go even further in details. We aim to provide custom component creation at this level and visual programming features to create the logic between them.

The aim of creating three modes is to enable a transition between the basic preconfigured template that we propose in "*standard mode*" and the complex custom personalization functionalities offered in "*expert mode*". Even though, we decided to begin with three levels, this number is not definitive and surely can be adjusted according to intended users, especially if we generalize the use of this approach outside the MLG design field.

2.1.4 ***High-level Linking to Low-level Components Model.*** From a conceptual perspective, and as suggested by Murray [15], the authoring task requires the ability to conceptualize and structure concepts from a high level so that it makes sense to

[1] http://pokemongo.nianticlabs.com

users who are novice to the authoring tool. In previous work [16], we already proposed a high-level modeling language for designing MLGs based on POIs, Game Unit, Clues, Tasks... In order for JEM iNVENTOR to generate the executable applications on smartphones, each of these high-level components are mapped to one or several low-level components (e.g. buttons, text items, media players...) available on mobile IDE (e.g. Android Studio, Xcod, Silverlight ...)

Figure 2 shows a part of the class diagram including the main high-level components provided by JEM iNVENTOR. The arborescence starting from the LBLG entity, and going through Activity which is then divided into the formalized structure presented in the previous subsection.

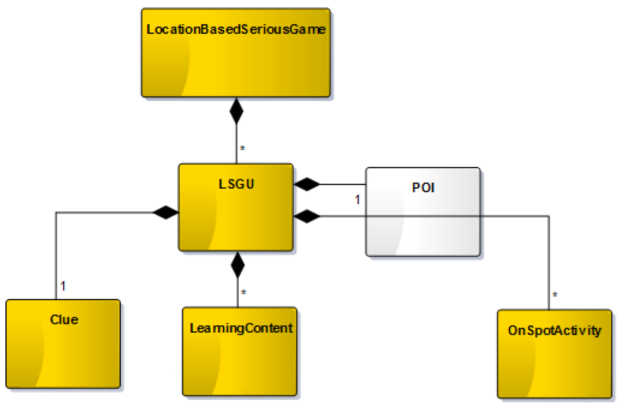

Figure 2: Part of the Location-based Learning Game Unit structure

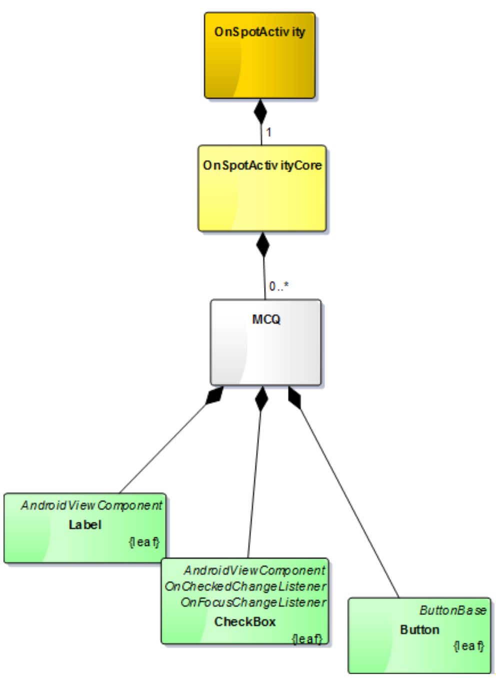

Figure 3: A Multiple Choice Question component on Android OS

Figure 3 details even more the composition of the high-level components provided with JEM iNVENTOR with the example of a multiple choice questionnaire, a pattern of evaluation task. In this example, components in green are Android classes for elementary mobile items. These classes represent the lowest-level items of our model and can vary depending on the mobile IDE (Android Studio, Xcode, Silverlight for Windows phone, etc.).

2.2 Reification

Following to our previous work on MLGs authoring tools [10], we decided to reuse an existing open-source authoring tool: App Inventor 2.

2.1.1 ***MIT App Inventor 2*[2].** From a set of five deeply analyzed authoring tools for mobile applications, our choice was set on MIT App Inventor 2. Indeed, in a study performed in 2014 [18], Rouillard and his colleagues from Université de Lyon observed that App Inventor 2 enabled 116 students to develop 79 MLG prototypes in an average of 10 hours, of which 14 prototypes were considered prevalent to learn relevant information. In our MLGs authoring tools study [10], App Inventor 2 has been ranked as the most powerful authoring tool. Furthermore, as we intend to allow the configuration of low-level mobile components in the *expert mode*, App Inventor's bloc programming system seemed very advantageous. Indeed, blocs programming is henceforth taught in most of French middle-schools[3] and so, students would be able to further co-design MLGs made by their teachers on JEM iNVENTOR. Moreover, as App Inventor 2 is a widely used authoring tool around the world, we intend to keep the structure of projects made by JEM iNVENTOR in the current App Inventor format (.aia) so that interoperability between both editors could be possible. However, the main limitation with reusing MIT App Inventor 2 is the fact that the created MLGs will be executable only on Android devices. As this iteration of JEM iNVENTOR is considered as a first research prototype, we accept this limitation in order to benefit from the other advantages discussed above.

2.1.2 ***Current Prototype*.** JEM iNVENTOR includes the acronym JEM which means Mobile Learning Game in French. We kept the word "inventor" to refer to MIT App Inventor 2, the authoring tool that we choose to build on. Furthermore, if we are currently working on LBLGs, we chose JEM or MLG appellation because we plan to extend JEM iNVENTOR's assistance to every kind of MLG, as discussed in this paper's introduction. Actually, JEM iNVENTOR is a platform built on App Inventor 2 which offers a totally different interface with three conceptual levels. JEM iNVENTOR[4] (Figure 5) is currently deployed on Google Appengine service and source code is available on Github[5].

[2] http://appinventor.mit.edu/explore/
[3]http://cache.media.eduscol.education.fr/file/Algorithmique_et_programmation/67/9/RA16_C4_MATH_algorithmique_et_programmation_N.D_551679.pdf
[4] http://lium-jem-inventor.appspot.com/
[5] https://github.com/aouskaroui/jeminventor

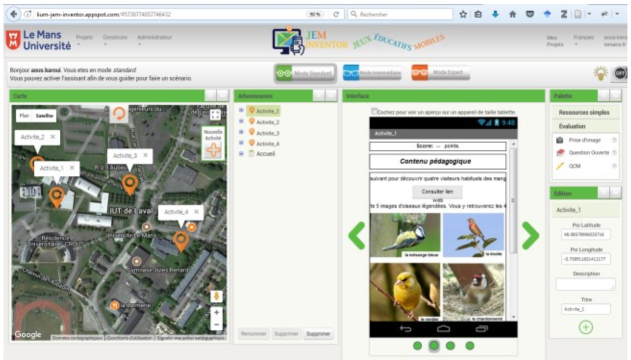

Figure 5: A screenshot of JEM iNVENTOR's Standard Mode

3 CONCLUSION AND FUTURE WORK

In this paper, we introduced JEM iNVENTOR, a MLG authoring tool based on a nested design approach which adapts to the needs of teachers weather they are novice, intermediate or experienced MLG designers.

In order to help novice MLG designers, JEM iNVENTOR offers a *standard mode* with simple functionalities and a template structure to create basic Location-Based Learning Games (LBLGs), one of the most promising subcategories of MLGs.

As the users gain experience, they can switch to the *intermediate* and the *expert mode* that offer all the functionalities needed to create complex custom MLGs. This nested design approach, that consists on gradually uncovering the tool's features, in intended to provide a smooth learning curve to help novice MLG designers become experts.

Finally, we presented JEM iNVENTOR's underlying model. This model consists in encapsulating low-level mobile components available on any mobile IDE (e.g. buttons, text elements…) within high-level components, which makes sense to end-users (e.g. clues, activities, points of interest…). This can be a first step to make a large number of teachers – without game design experience or computer skills – get involved into MLGs design.

More generally, as we took inspiration from TEL research work on authoring tool complexity [12–15], we believe that the nested design approach that we exposed could be useful not only for MLGs design, but also for other TEL systems in general.

JEM iNVENTOR is currently being evaluated with 22 teachers and more than 1000 students. We selected teachers with various profiles (from novice to expert MLG designers) and a large variety of fields of study (geology, natural science, history and even librarians). These experimentations will allow us to evaluate if JEM iNVENTOR allows them to create the types of MLGs they need for their courses. We will also be able to determine if the nested design model helped them to gain expertise and allowed them to design more complex and custom MLGs.

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