Digital Learning Game Scenario
A pedagogical Pattern applied to Serious Game Design

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Abstract: The design of educational Serious Games (SG) remains a difficult operation which requires a tight weave between practices in instructional design and game design to be effective. Despite excellent works in the domain, the balance problem increases more significantly in the mobile learning system development such as Kids Smart Mobile School (KSMS) as a SG. KSMS is a school that aims to provide learning from K to 12 in Math and English as a Second Language to children without access to school in developing countries. This paper proposes a solution by designing a pedagogical pattern of a *Learning Game Scenario*, based on the educational Montessori approach mixed up with instructional engineering technique. This pattern is applicable to the various learning phases, making up the structure cognitive and pedagogical of KSMS. Moreover, this paper indicates how this pedagogical pattern makes easier the communication between members of an interdisciplinary team in different phases of design and development.

1 INTRODUCTION

Nowadays, there are still populations in the world in which children do not have access to school (primary and secondary). According to the EFA Global Monitoring Report 2012, an estimated 250 million children are not able to read, write or count well even after spending at least four years of schooling, (UNESCO. *Approved Programme and Budget 2014–2017 (37 C/5), objective 6- Improving learning, p.45)*.

So how can information and communication technologies (ICTs) help mitigate the impact of accessibility problems in education? The increasing penetration of technologies in developing countries could be seen as an opportunity to provide more access to education, in poor and rural areas. The development of mobile learning systems in form of Serious Games would appear as an alternative available to access face-to-face schooling for children in disadvantaged areas?

This paper proposes a pedagogical pattern as a support tool to SG design. It is dedicated to a learning game that merges both learning and game into a unique and same activity for the learner-player.

1.1 KSMS Research Program

Kids' Smart Mobile School (KSMS) is an interdisciplinary research program. Its aim is to create and develop a mobile learning system for mobile devices such as electronic tablets. KSMS is adapted to the individual self-learning, particularly for children in developing countries.

On the one hand, the overall goal of this program is to adapt the every subject's content offered from K to 12 in a standard state school curriculum onto a software/app. On the other hand, its targets to enhance the design practices and implementation of mobile learning systems based on SG's scenarios, and a smart and efficient human machine interaction management.

1.2 Originality of KSMS

The KSMS program's originality is that the system in its final form will represent a unique source of formal learning for the target population. KSMS will not be a complement to the formal educational system, such as school, classrooms, learning resources or teachers.

As highlighted by Ferreira, Gouin-Vallerand, and Hotte (2016), "*Unfortunately, most of current efforts in this area aimed to complement the daily school learning or focus only in a particular learning content, not offering strong solutions for providing children's education in lieu of availability of regular schooling*".

In contrast, KSMS aims to provide all its components in an integrated architecture of a mobile learning system. This can ensure learning efficiency and effectiveness for the target population, with limited access or no access to teachers or the schooling.

1.3 Three Specific Issues

In designing and developing KSMS as SG environment, we had to create a customized *Learning Game Scenario* that would integrate the learning and game in a same and unique activity. Moreover, we did it in order to face three specific issues that are 1.) how to amalgamate learning and game in a same process, 2.) how to compensate for lack of teachers, and 3.) how to provide a common language inside a multidisciplinary team, more specifically to enhance the collaboration between instructional designer and software developers.

The pedagogical pattern proposed in this paper is based on both the epistemological founding principles of the Montessori constructivism approach (1912) and with the skills' typology of Paquette (2002). Mainly, this pedagogical pattern has been used as a guide to the learning game activities design of KSMS prototype. Moreover, it facilitated exchanges within the interdisciplinary team during the learning game prototype development on the tablet. Section 2 raises the issue of SG design as digital learning environment as it stands today. Section 3 sets the principles of the ongoing research. Section 4 addresses the design of the *Learning Game Scenario*. Section 5 deals with the implementation of the pedagogical pattern called *Learning Game Scenario* to support the development of the first KSMS prototype as SG.

Finally, the conclusion puts into perspective the next steps of the research program and the educational pattern design, as a support to the educational SG design and development teams.

2 STATE OF ART

Previous studies had stated that "*in the past 10 years, the field of learning games has grown dramatically*" (Groff, Clark-Midura, Owen, Rosenheck, and Beall, 2015), that "*serious Games (SGs) are gaining ever more interest as an instructional tool*" (Arnab et al., 2015) and that "*Educational games are being backed up in the Technology-Enhanced Learning domain as strategies that can lead to worthy learning outcomes*." (Melero and Hernández-Leo, 2014).

The literature makes amply state of design work (Moreno-Ger et al., 2008), good stories examples (Prensky, 2001), and prototypes related to SG design applied to learning or Learning Games (Marsifi-Schottman, 2012). Nevertheless, their design is always a difficult and poorly controlled operation.

2.1 Serious Game, a digital application

Crookal (2010) specifies that he prefers "*the term computerized simulation/game for training or learning because it includes explicitly the three main elements* [*games, advanced video graphics, research*]*, and also because a learning game is indeed serious, almost by definition, and so does not in itself really need the epithet*.". In the education domain, SG connects an useful component from educational domain or training (Serious), with fun components (Game) from a video game or computer simulation.

2.1.1 A French point of view

In the francophone community, the Alvarez's thesis (2007), marks the beginning of the digital learning environment design as SG, in other words, designing a gaming environment for the purpose of learning. So, Alvarez (2007) defines SG as a computing application whose initial intention is to combine with consistency, both serious aspects (Serious) including, but not limited to, non-exclusive, teaching, learning, communication, information, etc., with fun springs from the video game (Game).

Marne (2011) considers SG like computer-based environments for human learning that are based on a knowledge domain simulation to teach with which the player-learner can interact playfully using a metaphor.

As for George et al. (2013), the learning games are digital learning environments that incorporate effective scenarios based on metacognitive strategies. Finally, Marsifi-Schottman (2012) affirms that in order that a LG be really at the service of the learning, its educational activities and game scenario must be carefully woven together in order that the learner feel an intrinsic motivation to learn.

2.2 Designing a SG, an elusive issue

The George et al. (2013)'s states that the core of the problem is still lies today in the integration of educational content into the game or the game in the pedagogical scenario. This solicits transdisciplinary collaboration between, minimally, educational designers and game designers.

Alvarez (2007) writes that his problem is, in particular, to understand how this relationship between a pedagogical scenario and a video game operates.

More exactly, the challenge was the successful amalgamation of play and learning. The most appropriate scenario to design a SG must provide all the necessary conditions for knowledge real construction, without the game taking over by its visual tricks and dynamism or, conversely, that too much academic educational aspects make the game boring, demotivating the learner-player.

2.2.1 Motivation to learn

Marne (2011) adds that the balance between motivation and learning in the design of these serious games is based on the synergy of fun and educational expertise. According to (Abdessettar, Hotte, Gardoni, and Abdulrazak, 2016), Marshall, H. (1987) defines motivation to learn as "*the meaningfulness, value, and benefits of academic tasks to the learner regardless of whether or not they are intrinsically interesting*."

In order to reach this balance, Marne (2014) proposes a generic model of a fun-pedagogic process for the serious games by steps called MoPPLiq. On the other hand, Abdessettar et al. (2016) suggest, "*to integrate persuasive design and persuasive technologies in a framework of three layers that among others in the Learning Content & Scenarios layer*."

3 FOUNDATIONS OF THE MODEL

KSMS proposes to create and develop a mobile learning system using tablets to provide learning from K 1 to 12 in math and ESL to children who are deprived. This mobile learning system consists of a server and a 7 inches' tablet, supported by a second-generation network, called 2G. The server is dedicated to account administration, monitoring of interactions, and data collection. The tablet hosts the serious game and collects some of the information. The system belongs to the partner that handles the link between the tablet and the server.

3.1 Instructional scenario

The instructional scenario adapted to a game became the sensitive point of the SG design applied to learning. The scenario is a learning flow process that guides the learner in his knowledge-building process throughout his training. The consideration of individual self-learning situations guided the instructional scenarios design of KSMS as a school without teachers, and the metacognitive strategies including those of self-observation, self-assessment and, in particular, the debriefing defined as "*the processing of game experience to turn it into learning*" (Crookal, 2010).

Taking into account the literature review recommendations, including those of Klopfer, Osterweil, and Salen (2009), in KSMS "*we focused in both aspects, learning and gaming, from the beginning of the design process. The result of this strategy was learning to design gaming scenarios and game mechanics that include both gaming and learning aspects*" (Ferreira et al., 2016). According to (Bouvier et al., 2013), "*Learning games are digital learning environments that involve efficient year scenario based on metacognitive strategies*." On the other hand, Arnab et al. (2015) draw attention to the fact that "*despite the digital games' potential in terms of interactivity, immersion and engagement, more work is still required to understand how to better design, administrate and evaluate digital games across different learning contexts and targets*."

In recent years, various initiatives lead to the conclusion that "*The amalgamation of mobile learning is mini terminal and learning games is promising to solve the lack of access to education of children who are deprived populations*" (Bouvier et al. 2013). Furthermore, the literature review proposes learning system models that serve as levers to deliver customized learning experiences (Eggers and MacMillan, 2015) by exploiting technologies.

The AltSchool is one example. It has been implemented experimentally since 2013, in order "*to rethink how education can serve families in the modern era*" (Max Ventilla, Linked In). The AltSchool model finds its foundations in the Montesseri constructivist approach (1912). It provides pedagogical organisation centred on individual self-learning and group cooperative

approach (Ultanir, 2012). The individual self-learning encouraged the track of students' activities, aiming to send back to them personalized learning scenarios.

3.2 Montessori's constructivism

Any approach in education presupposes an epistemology, that is to say a set of theoretical principles that justifies it. In *Montessori and Constructivism*, David Elkind (2003) states that: "*Montessori education encompasses all three epistemologies that it has survived and continued to grow as a pedagogical influence*." These epistemologies are empiricism, nativism and constructivism.

In the education domain, they match reciprocally with behaviourism, Socratic method, and constructivism. Concerning the behaviourist approach, the learner explores his/her natural environment to learn. In the Socratic educational method, one is handled the concepts and objects to deduce learning, and in constructivist approach the learner implements knowledge through a personal construction. Depending on its activity "*Every child has a bit of the mime, the logician, and the architect in himself or herself. Indeed, these three models might be described as the three basic modes of learning: imitation, reason, and construction*" (Elkind, 2003).

3.3 Paquette's typology of skills

Concerning the Paquette's typology (2002), it suggests four main classes of skills related to the information cognitive processing: to receive, to recreate or reproduce, to create or to produce and, finally, to self-manage. The first three ones are in keeping with roles of learner-player suggested by Montessori approach. We added the fourth class, to self-regulate, to the first three in order to introduce a debriefing process to the *Learning Game Scenario* model. It is the self-management class of Paquette's skills typology (2002). This fourth iteration is a kind of tool to guide the learner-player into a metacognitive reflection about his/her own learning process. Eventually, in KSMS scenario, an activity of a learning-game process includes four steps: to explore, to manipulate, to operate, and to self-regulate. Each step definition is a combination of the educational approach of Montessori (1912) and Paquette's skills typology (2002).

The first approach belongs to the epistemological principles in education and, more particularly, to a kind of constructivism relatively eclectic (Elkind, 2003). The second one belongs to the learning systems engineering, particularly, online learning systems. It finally finds its foundation in a cognitivism hypothesis of the information process at the human being based on the computer theory. Both align themselves with constructivism as an instructional approach centered on the learner, more specifically, on his/her capacity to learn by him or herself.

4 METHODOLOGICAL DRAFT

On the one hand, all good scholar instructional engineers know the Paquette's work about the knowledge and competencies modeling (2002) integrating typologies of skills. The outcome of this work is a graphic language to conceive and learn that we have used to represent *Learning Game Scenario.*

On the other hand, all good scholar learning system engineers know how it is crucial to adopt tools in order to enhance communication at an interdisciplinary team, particularly, in order to favour exchange between instructional designers and IT developers.

4.1 MOT as modeling technique

In order to create, develop and represent the *Learning Game Scenario* as a pedagogical model, we have used a knowledge representation technique called *"Modeling using Object Types" (MOT)*. MOT enables to represent a large variety of situations and knowledge domains, transparent view of relationships between knowledge units, uncovering a domain's semantic (Paquette, 1996).

In addition, G-MOT is the editor of models by object types (MOT). Then, G-MOT is a modeling tool to support instructional design. It provides a graphical formalism that is able to ensure consistency of an educational system like KSMS. Modeling with G-MOT allows to represent, with graphics, knowledge and competencies and, then to link them to learning resources.

4.2 The formalism graphic MOT

The MOT graphic formalism allows the integrated processing of four knowledge types: facts, concepts, procedures and principles. Furthermore, it integrates

six types of links, subject to certain integrity constraints in order to ensure the pedagogical coherence of the system.

Three reasons justify our choice of this modeling technique. The first is that this technique makes it possible to represent, in the form of models and sub-models, learning processes as sequences of interrelated activities. The process includes procedures, concepts that are the inputs and outputs (products), and principles that regulate their execution. The second is that the MOT technique makes it possible to take into account the cooperation between participants in the possible definition of a collaborative learning system. The third reason is that a software tool support this technique. A graphic editor that provides a complete graphic formalism and all necessary functions to describe systematically all information exchanged between participants of an interactive mobile learning system.

4.3 The modeling process

We have designed the *Learning Game Scenario* in several phases based on Montessori approach, according to David Elkind (2013), and the Paquette typology of skill (2002). We believe that by matching the epistemological educational foundations with an instructional engineering approach we would reach our goal, to create a scenario merging learning and game into one only activity.

4.3.1 Start of the Learning Game Scenario

We have started the *Learning Game Scenario* model's design by the graphic translation of the Montessori approach, as described by Elkind (2003). This first draft allows representing a learning game activity in three steps: to explore, to manipulate and to operate and indicate the learner's role or positioning at each time.

4.3.2 A Learning Game Scenario enhanced

Then, in a second time, we have enhanced the model in including the Paquette's skills typology (2002) that describes the first three steps of an activity. This typology is based on four main classes of skills, more general and each of them corresponds with a phase of the information process cycle. The first phase is called *Reception.* During this phase, the learner pays attention to objects, notices the information in memory, that makes it possible to give a meaning to each stimulus and memorizes some of the information. The second phase is called *Reproduction*. The memory is managed in such a way as to select the relevant knowledge to prepare the possible reaction, by processes of instantiation, transposition and application. The third phase is called *Production and Creation*. They are the high level intellectual processes of analysis, reparation, and synthesis. The last one is called *Autogestion.* This process begins with assessing the situation that leads to self-control, influencing others, controlling a situation and adapting to event*s.*

To improve the *Learning Game Scenario'*s design, we have matched the first three classes of Paquette's skills typology (2002) with the high-level activity of Montessori approach. Furthermore, we have added competencies to each step as a principle introduced by "To be able to." That means that the learner-player must reach this competency in carrying out this step of the activity.

4.3.3 Debriefing

This learning game process seats the learner at the center of the game. The game gives a context to the knowledge in which the learner-player progresses. This instructional strategy puts the learner-player in a scalable situation: a mime who imitates, a logician who deduces, and an architect who builds his/her own project. At the end of the scalable process, the learner-player is invited to debrief through a challenge.

The fourth class of Paquette skills' typology (2002) can be considering as a debriefing one. Incorporated to the model as the learning game activity fourth step, it allows learners both to turn his/her game experience into learning (Crookal, 2010), through different steps of the activity, and at the end to progress from a level to another.

5 PEDAGOGICAL PATTERN

A part of the French researchers' works on computer-based environments for human learning (Jézéquel, 2006; Olavo et al. 2007; Marne 2014; Marne and Labat, 2012; Marnes et al., 2011) focuses on pedagogical design pattern studies.

5.1 What a Pattern is?

In fact, what does a pattern mean? Olavo et al. (2007) think patterns as micro-architectures, that are, "*structures larger than objects but not large enough to be system-level organizing principles*" (Coplien, 1996). As stated in Douglas et al. (1996) "*A pattern*

is a recurring solution to a standard problem." Conte et al. (2001) add that, in general, a pattern described a problem frequently encountered in a particular context as well as a general and consensual solution to the problem. Conforming to the Association for Computing Machinery, "*Not only do patterns teach useful techniques, they help people communicate better, and they help people reason about what they do and why*" (Douglas et al., 1996).

5.2 Pedagogical Pattern in SG

Marnes and Labat (2012) are more specifically interested in the implementation of design patterns in order to adapt pedagogical-playful paths in SG. They describe these kind of design patterns as serious games based on an intrinsic metaphor in which scriptwriting can be divided into activities. This division can take different forms such as a succession of levels, exercises, quests, case studies, etc.

5.3 The Usefulness of a Pattern

Design patterns are represented by a structured formalism. In our case, we have used the model editor G-MOT that is a modeling tool to support instructional design. G-MOT provides a graphical formalism that is able to ensure consistency of an educational system like KSMS. Modeling with MOT allows to graphically represent knowledge and competencies and, then to link them to learning resources.

As far as we are concerned, we have designed a pedagogical pattern, called *Learning Game Scenario*. This pattern is applicable throughout the development of the KSMS school's cognitive and pedagogical architecture, to which it gives coherence. Concerning the point of view of pedagogical design, this pattern makes it possible to ensure a progression in learning and to tie the activities closely to the universe of the game, precisely because of its level of abstraction. But what does it really mean from the game engineering point of view?

The use of the teaching pattern allowed to guide the teams in the conception of the KSMS's prototype in the form of a game. In this prototype we initiate a first activity, linking the learning of the numbers and their English nomenclature. Furthermore, we are currently working on the prototype evaluation with children to measure its usability and its usefulness in the overall design of the SG.

6 IN BRIEF

We have designed and implemented a Learning-Game Scenario to facilitate the mobile learning system (KSMS)'s development for children without access to school. According to Abdessettar et al. (2016), we have noticed that "*there is yet no research study that focus on technological learning system to compensate absence of school or teacher. Few existing studies focus on either complementing existing learning provided by standard schools, or on bringing new alternative learning (distant or hybrid) that always include teacher or tutor interaction with final learners*".

Our objective is that KSMS be fully automated and represent a unique source of learning tool for target population. KSMS learning environment is based on a Serious Games approach. To develop it, we have designed the Learning-Game Scenario adapted to the individual self-learning. We have believed that the Learning-Game Scenario's high-level representation, mixing up game and learning components into a same activity, would resolve an important problem of serious games' design in education. Furthermore, it would offer the basics of a shared language between the involved resources into the KSMS mobile application design and development.

Learning Game Scenario as a model based on an accessible language has made easier the cooperation inside the project interdisciplinary team, above all, between instructional designers and IT developers. The Learning-Game Scenario made easier the cooperation inside the project team. It facilitated the experts' commitment in education during the first prototype's production. In mixing up the Montessori approach with a skills typology, we established interesting links to explicit each iteration of the *Learning Game Scenario*.

So far, we have done a first evaluation of the learning environment prototype with children. The results demonstrated the value of the design strategy and highlighted aspects in the game design, pedagogical pattern, game instruction and tablet interaction that could be improved. These results have important implications for future research in this field, showing positive results of the design approach and providing recommendations for further research in this path (Ferreira et al, under review).

The Learning-Game Scenario as a pedagogical pattern would must allow a gradual learning and link the instructional activities tightly to the universe of the game. We will evaluate the pattern in designing a new learning activity based on the pattern and implemented on a mobile platform. So, we could complete measuring the utility and the usability of the Learning Game Pattern for the global design of a Serious Games as KSMS.

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