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A Ubiquitous Mobile Edutainment Application for Learning Science through Play

Isabelle Astic and Coline Aunis, Cnam/Musée des arts et métiers; Areti Damala and Eric Gressier-Soudan, Cnam/CEDRIC, France

Abstract

This paper advances the state of the art in games design of serious pervasive games. We analyze the game design of the two serious pervasive games built during the "PLUG, Play Ubiquitous Games and play more" project. We compare their desired objectives to the really completed ones. We then conclude with a section on what serious pervasive game design should be.

Keywords: pervasive games, serious games, game design, magic circle, flow theory, edutainment, learning

Introduction

In recent years, the unprecedented world-wide spread of the use of mobile devices and applications in our everyday life (Harper, 2003) has made possible the introduction of light-weight and fully-fledged mobile multimedia museum guidance systems as a new museum interpretation medium, thus redefining the notion of interactivity itself. One of the many consequences of this trend is the appearance of mobile, multimedia and interactive edutainment applications for learning through play within the context of a cultural visit (Damala, 2009). These applications can be considered as alternatives to "conventional" mobiles, handheld or PDA-escorted guided multimedia visits.

Among these applications, games are particularly appreciated as they favour non-traditional attitudes towards artifacts and involve the visitors physically, intellectually and emotionally. But, to the authors' knowledge, few pervasive games exist in a museum context. For McGonigal, (2003), pervasive games are "mixed reality games that use mobile, ubiquitous and embedded digital technologies to create virtual playing fields in everyday spaces". She pointed out the main feature of such games: the existence of two universes, one real and one virtual, that are interrelated. The virtual space therefore expands reality through 3 dimensions: spatial, temporal and social (Montola & al., 2010), with ubiquitous technologies and architectures creating the necessary connection points. Ubiquitous games are qualified as a subcategory of pervasive games. Thus, in pervasive games, as in ubiquitous games, the frontiers between virtuality and reality vanish. Then, what could we conclude about the game design of serious pervasive games?

This paper advances the state of the art in serious pervasive game design. First we look at already-existing mobile edutainment applications in museums. Then we present the two pervasive games designed and implemented during the "PLUG, Play ubiquitous and play more" (PLUG) project. We examine them under the perspective of the **Magic Circle** and **Flow** game design theories, before reaching our conclusions.

1. Edutainment in museums

Games and other play-like approaches have for a long time now been introduced in the museum environment to familiarize - most often - families and young visitors with museum collections, exhibitions and objects. Hands-on activities, workshops, and paper and pencil quests are only some of the expressions of already well-established museum interpretation policies.

Within this context, the introduction of edutainment applications as an addition or alternative to mobile multimedia tours can be considered as a natural evolution inscribed in the general context of shaping effective and captivating mobile multimedia tours. Mobile museum edutainment applications are often inspired by already well-known types of museum games and activities such as treasure hunts, observation games or mystery-detective games, most of the time traditionally proposed in a paper-and-pencil format.

This phenomenon can be also related to the use of a relatively new term, the neologism "edutainment", a concatenation of the

words "education" and "entertainment", used to describe the convergence of entertainment activities, such as video games, and educational purposes, by using the former as a primary vehicle for passing on or delivering - more or less explicitly- educational messages (Addis, 2005).

Though the introduction of interactive games delivered to mobile platforms can still be considered quite marginal as an interpretation policy and activity, several paradigms of mobile games allow the establishment of a taxonomy scheme for this particular type of edutainment application. As briefly sketched out in an earlier paper (Damala, 2009b), mobile games for the museum setting can be either solitary (Belotti & al., 2004) or team games (Thom-Santelli & al., 2006). Teams may consist of individuals (Broadbent & Marti, 1997) or groups of two or more players (Hall & al., 2001). In collaborative games, different teams or team members have the possibility of communicating among themselves while communication can be synchronous - as is more often the case - or asynchronous (Belotti & al., 2004). Games can also be delivered to one or multiple platforms, including stationary work-stations, video projectors or even head-mounted displays (Van Dijk & al., 2009). Mobile museum games take place by default in an indoor environment. However, games may also include other outside- the-museum learning environments, including classrooms, as proposed by the Zydeco project (Kuhn & al., 2010) which also provides an example of a game taking place at an informal learning environment (represented by the museum exhibition) and a formal learning environment (a school course taking place in a classroom).

When the PLUG project was defined, only a few pervasive games taking place in a museum or cultural heritage context existed. REXplorer was one of them (Walz & al., 2006). So the PLUG project's purpose was to investigate this research domain. PLUG was a research project funded by the French National Research Agency (ANR). It was co-led by CEDRIC (the Centre for Study and Research in Computer Science and Communication) and the National Telecom Paris Tech University. It also attracted many other partners with different and complementary skills: the French National Industrial Arts and Crafts Museum (Musée des arts et métiers, MAM); research laboratories such as L3i La Rochelle University; as well as industrial partners like Orange; Tetraedge, a game-design company; and also a role-player outdoor games designer, Dune Aventure. This research project lasted two years, from 2008 to 2010, and had two major iterations. The project was presented to MAM visitors during the annual event organized in France by the Ministry of Higher Education and Research to promote science among the general public: the Fête de la science. The team launched two different and independent complete game versions: *Plug the secrets of the museum* (PSM) in 2008, and *Plug the Paris Overnight University* (PPOU) in 2009.

2. *PLUG, the Secrets of the Museum* (PSM)

The game PSM (http://www.dailymotion.com/playlist/. (http://www.dailymotion.com/playlist/x136hq_musee_des_arts_et_metiers_plug-les-secrets-du-musee/1#videoId=xalc8t) ..) is based on the concept of a Happy Families game. Virtual and animated cards are exchanged through RFID/NFC (Radio Frequency IDentification/Near Field Communications) technology. This pervasive game also delivers cultural contents, offering players a new form of visit.

The museum wanted to address the sparse public of kids and teenagers. The choice of a Happy-Families-based game design came naturally. The players had to collect cards for four families of museum objects. Using the NFC facility from the mobile phone, a Nokia NFC6131, the players collect virtual cards figuring real objects of the museum (cf Figure 1). The virtual cards, figured by RFID tags, are set on kiosks spread over the museum next to the real objects chosen for the game. RFID tags/cards are read by the phone as described in (Simatic, 2009b).

Fig 1: Four virtual cards on a mobile phone equipped with a RFID reader

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Fig 1: Four virtual cards on a mobile phone equipped with a RFID reader

The virtual universe of the pervasive game was peopled by animated objects owning their own personalities accorded to them by their inventor. When they are removed by the players from a kiosk and moved toward a phone and vice versa (Astic & Aunis, 2009), the players hear a text that provides the feelings and the emotions related to the inventor or to the object itself. So the NFC technology links the real and the virtual world. To match the requirements of a conventional game logic, the game play is quite competitive. This is achieved by limiting the game sessions to 55 minutes. This time limit is combined with a point management system: the winner is the team that gets the highest score.

The point system was carefully elaborated to match different playing strategies and players' skills. Great inventors being at the very heart of several of the museum exhibition domains, players were told and encouraged to cultivate all of their skills so as to develop their researcher potential. Scoring points was therefore also possible by showing one of the following skills. "Curiosity" is demonstrated through the acceptance of answering additional quizzes. (The answers can be found on object labels, other objects, or the object description embedded in the mobile phone.) "Accuracy" grants points when players restitute a virtual card back to the kiosk next to the corresponding real object, as in Figure 2. "Collaboration" is the act of accepting exchange of cards with other players as shown in Figure 3. Finally, a "Collection" bonus is granted when players manage to gather all four cards of one family (Astic & Aunis, 2009; Simatic & al., 2009).

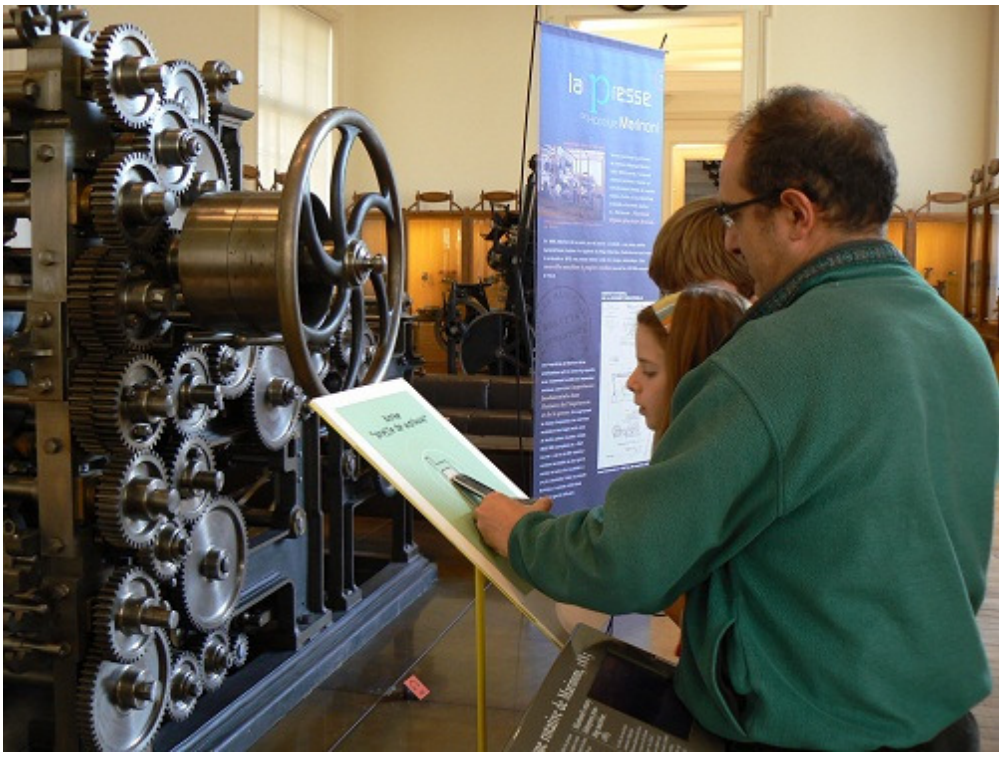

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Fig 2: exchange of virtual cards on a kiosk

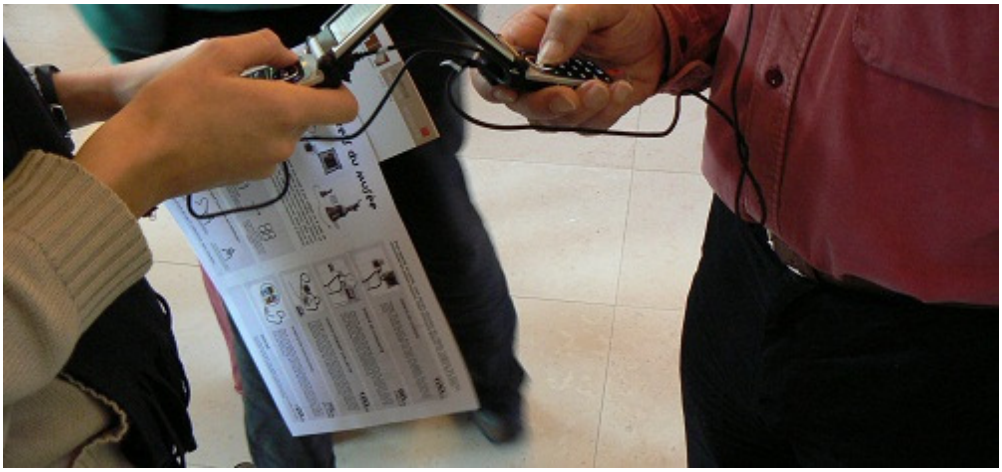

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Fig 3: exchange of virtual cards between players

However, the team of MAM advocated enriching the game play with more educational features than just quizzes. First, virtual objects were augmented; more exactly, they were personalized. Also, each family of objects gathers artifacts chosen in a very specific way. They were issued from distinct collections of the museum and independently of their notoriety. Each family was defined by a theme chosen from an educational perspective. The family "ghost hunters" pays homage to the great inventors who marked the history of science and technologies and whose objects are presented in the Museum. The family "tamers of elements" gathers objects that correspond to Aristote's theory stating that everything on Earth is composed from the 4 elements: water, earth, fire and air. The family "wonders creators" brings together objects made foremost for fun and entertainment. The family "accelerators of time" is directly related to the industrial revolution whose inventions have induced radical change in the fields of communication, transportation, energy and textiles.

The last game design specification was to inform players of well-known museum visiting rules: "do not run anywhere at any time" and "take care of other visitors".

As previously said, this serious pervasive game was improved during the two days of the French annual Fête de la Science 2008 where 160 visitors discovered the museum by playing PSM. At the end of the project, 750 players had been involved in testing PSM. As partner of the project, the Telecom Sud-Paris and Telecom ParisTech worked on the sociological aspects of PLUG (Gentès & al., 2009). They studied the level of involvement of players and analyzed the dimensions of edutainment within PSM. Questionnaires were provided to all players after their game sessions, seeking their assessment: level of involvement, level of learning, their retention of gained knowledge, their path in the museum, their feelings about PSM, their general feelings towards games in museums. Semi-structured interviews lasting one hour were also conducted with 40 players to gain additional insight as to their appreciation of the game, both as museum visitors and game players.

It appeared that PSM performed very well with family audiences. Parents and children on the same team worked collaboratively, one person focused on the gaming devices with another one working on the musuem objects and the collection, and vice versa. Also, players particularly appreciated the strong collaboration that could be developed between different teams. Game strategies they deployed were interesting to study and analyze. For example, children gave false directions in the museum so that competitors lost time, while adults were wiser and more conscientious. Overall, the players were unanimous in appreciation of the game in the museum: it provided a very interesting way to discover the museum, its spaces and works, but also resulted in a certain frustration which made visitors want to return to go further in discovery and learning. The reason seems to be that the time constraints were too tight to get time to read the explanatory texts for each object (zoom) and play quizzes. But the pressure helped to fully immerse players in the game, and so involve them. Sometimes witnesses saw unusual scenes in a museum: people running in the halls from one object to another ! So, PSM has been a great teaser for the museum as the following example suggests. An entire family that played at PLUG during the morning session was still there at 6 pm when the museum closed. The game made them want to continue the museum visit, and they finally stayed until closing.

Following these results, the museum immediately wanted to foster the educational aspect of the game (Damala & al., 2010). The goal now was to balance gaming with learning. The key issue was game design. We needed to find a new approach to deliver more education and less play.

3. *PLUG, Paris Overnight University* (PPOU)

To achieve that goal, we decided to reexamine some competition aspects of the game play. We expected that this might have an impact on the educational dimension. Then, the time limit in the game session and the points system disapeared. So players were allowed to take their time while discovering and learning in the museum context. The elimination of the points system diminished contestant attitudes inappropriate to exploration. Finally, after a large debate inside the consortium, we decided to

build a completely new game.

The concept that led the new game design was for a pervasive infiltration game. This game uses new features as bio-feedback sensors, RFIDs as player locators, game monitoring and real time game design adaptations. RFID tagging allows tracing the players and following their progression into the game. Sensors are used to include players' heart rates and stress in the game play. This feature helps staff to know if players run inside the museum: running does not seem to be ideal for concentration and learning!

PPOU intends to address a new kind of public and new kinds of events. It targets social events for groups. This public ranges from teenagers and engineers to fine art specialists, aged from 15 to 45.

The narration built for PPOU results from fruitful brainstorming between Dune Aventure, TetraEdge, and the museum. PPOU immersed players as undercover agents to investigate unexpected activities happening at night inside the museum when it is closed. They are supposed to become part of the mysterious Paris Overnight University (PO University). PO University studies and brings museum artifacts to life to provide new inventions and innovations. At the end of the game, a viva, in front of the PO University board, announces whether or not they succeeded in being admitted as students of the PO university. Their infiltration ends here, but they need to give feedback to the police officer that recruited them at the beginning of the game. They can reveal the real nature of PO University, or they can keep the PO University secret.

This scenario provides a framework where the virtual world and the real world share the same place, the same time, the same social space. Connections between the two worlds are implemented through the RFID tags, the bio-feedback sensors, and the smart phones. Players are immersed in a pervasive world. The line between the real and the virtual worlds is blurred by the game design.

Learning became the core of the new game design. Then we decided to focus the game's content on this main purpose. We wanted to make visitors understand how an innovation is the result of several previous related or non-related discoveries, innovations and/or technologies. We emphasized also that social and historical contexts of the targeted objects were key to better understanding of why and when an invention occurs. Then, we underlined the importance of existing links between innovations to lighten the process of invention. These considerations led to including the treasure hunt pattern inside PPOU. We decided that players have to discover a first artefact, then four others that are the previous innovations that led to it. We built the game design in a way that players had to understand the relationships between artefacts to achieve their quest. The quest is split into subquests as shown in Figure 4. The treasure hunt ends when players pass their admittance examination. The players have to provide feed back about what they really learned at that time.

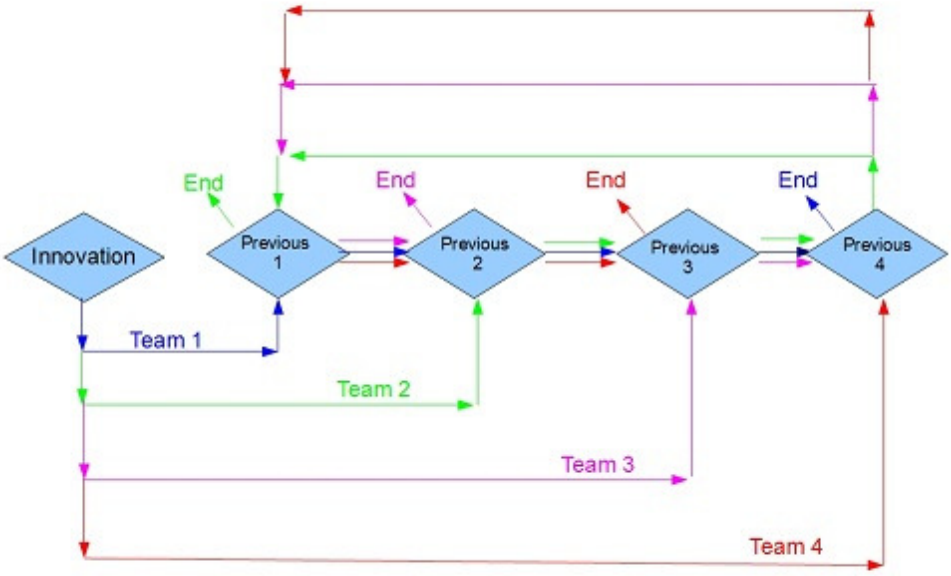

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Fig 4: Game's main structure

Each subquest begins with the search for an artifact. As a consequence, before starting a subquest, players must find the

dedicated hall of the museum. This defines the localisation phase. The next phase is dedicated to the targeted object comprehension as depicted in Figure 5. The localisation phase is validated using RFID tags set in the halls and near the exhibits. Rich multimedia clues (images, text, audio or videos), like the one shown in Figure 6, help players to discover the corresponding museum exhibition hall and each artifact. The comprehension phase includes one or several interactive games (puzzle games, quizzes, or text to be completed) as shown in Figure 7. It involves players' knowledge, artifact inspection, and search of resources embedded into the mobile, available around the object, or at the museum documentation center.

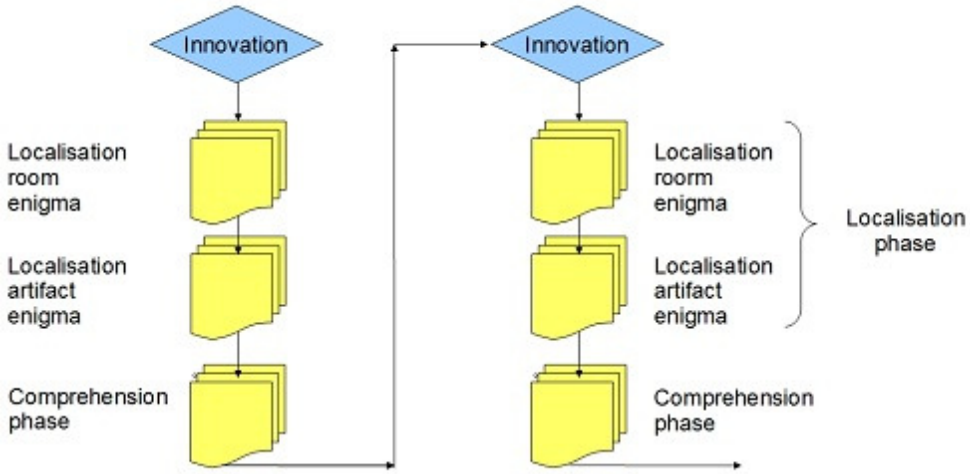

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Fig 5: Artefact subquest process

The game design of PPOU considers the different profiles of the expected players to avoid boredom or discouragement, and thus fully reaches its educative purpose. So clues were defined into 3 levels of difficulty to adjust the game play to players' knowledge and ability. Every team starts the game at the most difficult level. Every team is monitored by the game master: he adapts the game play to players dynamically (Champagnat & al., 2005). He seamlessly lowers the level to an easier one, depending on the players response time, the time spent since the last question, the number of mistakes, their heart beats and their stress. All these data assert players' ability, or not, to achieve the proposed challenges. Therefore, these measurements provide a gauge of anxiety or boredom that can result from a game's design not fitting the players' skills. However, the next subquest always starts with a higher difficulty level than the one achieved, to maintain interest in the game, and also to favour problem solving and collaboration between players of the same team.

This specific monitoring needed new technology. The resulting infrastructure is more complex than the one for PSM. Due to the inability of the NFC Nokia mobile phone to display rich multimedia contents, we chose iPhones to display clues and puzzle games. A sensor network is used to convey sensors' measurements, while mobile phones communicate through 3G networks. All meaningful data converges to the ubiquitous GAming Services Platform (uGASP) which in turn send them to the monitoring service and the game master. The full architecture is described in Gressier-Soudan & al., 2011.

To further involve players in the game, we added two competitive rules. They were defined as two PO University specific traditions: a joust and a hacking. A joust is a mime opposing two teams. In a hacking, a player wearing sensors tries to follow the heart rate of another team's player. 'Win a challenge' gives an additional clue to the team, facilitating its current subquest. The game master decides when teams face each other, depending on their progress in the game. The game master arbitrates the competition too - introduced as the Dean of the University to maintain players' interest in the narrative.

The *viva* was a good way to assess if PPOU learning objectives were achieved. Interviews and questionnaire completed this final scene. They focused on game acceptance, players' feelings about the game itself, or the way it reached its purpose. Four test sessions were organized; 45 persons participated, aged from 9 to 60.

Concerning the cognitive impact, feedback was very encouraging. All players affirmed that they attentively looked at the selected artifacts but also at those around, to compare them or find information that could help: 80 % of players could explain

the relationships between objects during the *viva.* The Director of the PU University board helped the others to discover it. The dynamic adaptative process contributed to this result. Most of players did not have scientific knowledge. During the introductory scene, some of them even reported their fear of being unable to solve puzzles. Finally, all of them seemed to be very excited by playing the game. The adaptation mechanism was also appreciated as the players did not feel devaluated, and despite the difficulties of certain proposed activities, they were delighted to play.

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Fig 6: a clue to locate the Communication exhibition hall

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Fig 7: a puzzle game to understand how the Machine of Vaucanson works

We worried about the numerous devices that players would handle. Surprisingly, this was never considered as detrimental. On the contrary, this forged and encouraged team spirit. Everyone instantaneously found a role: one searched and read the RFID tags, another found the artefact, everyone solved the puzzles. Thus, all appreciated this collaborative aspect. Indeed, most of them regretted that more collaboration was not allowed. Also, *joust* and *hacking* did not create the challenging spirit we hopedfor. But all players reported that they restarted the game when it slowed down. The second test confirmed it: no narrative universe existed for this session, and the game seemed long and linear. Indeed, characters, the scenario, and subdued lighting during the final scene produced a serious atmosphere, but also a lot of fun. Players really enjoyed and, at the end, generally did not betray the PO University and its board so the police officer was never enabled to catch them.

This time the game design was more balanced. Immersion was a key to success. But it was not the most relevant characteristic to achieve the required balance of ability level against challenge. Adaptability was the real facility to lead to the correct tuning of learning vs play.

4. Games theory and PLUG game design

The two serious pervasive games of the PLUG project were initially designed without relying on any game design theory. To our knowledge, the European IPERG project (IPERG, 2008) is the first one that formalized theory and design for pervasive games (Montola & al., 2010). This work extends the **Magic Circle** introduced by Huizinga (1949). The Magic Circle defines a limit between the game world and everyday life. The player is able to experience the game design and is immersed in the game world within the Magic Circle. Within this limited space, he feels safe because the rules of the games do not invade the real world, and vice versa. Montola et al., through different experiments, extend the theory of the Magic Circle to pervasive games. But its formal limit no longer exists when reality and virtuality encounter each other. In pervasive games, real life events bring their own effects in the game world. But Montola et al. prove that the Magic Circle still holds. Pervasive games blur their previous limit, but the Magic Circle becomes a metaphorical frontier and stays valid. In addition, pervasive games introduce three types of expansion to it: temporal, spatial and social. Temporal expansion defines game sessions as possibly unlimited actions without explicit start or stop. Spatial expansion reflects the impact of the real world on pervasive games: the real world is considered as a 'playground'. Social expansion takes into account non players that share the playground with players ruled by the game universe.

The theory of **flow** has been introduced by the psychologist M. Csikszentmihalyi (Csikszentmihalyi, 1990). It addresses the issue of focusing and attention during an activity and examines the issue of immersion. Csikszentmihalyi defined the components of what he also called the "optimal experience": clear goals, concentration, a loss of feeling of self-consciousness, distorted sense of time, direct and immediate feedback of the current activity, balancing of ability level against challenge, a sense of personal control, an intrinsically rewarding activity, lack of awareness of bodily needs and strong involvement in the proposed activity. This theory may be applied to video games (Chen, 2006), but also to educational activities. It completely matches the requirements of serious games to succeed. As far as we know, no effort of correlation of the Flow Theory with pervasive games has been ever attempted, even if Montola & al. (2010) advocate that the Flow Theory doesn't well suit pervasive games' needs.

If we compare PSM and PPOU game designs to these theories, we see that each one refers to one theory. The game design and the game play of PSM finally join the Magic Circle. Indeed, the player evolves in a closed universe with well-defined rules involving players and competitors, a defined playground, objectives, challenges and constraints. A well-defined mission is assigned to the player: to collect a family of cards. The player has an ultimate goal: to win by scoring more points than all other players during the same game session. The player's mission and objective are subject to certain constraints, particularly the time limit that forces him to be fast and strategic. Thus, each player involved is immersed in a competitive environment within an unexpected playground: the museum and its collections. So PSM is closer to the Magic Circle theory because of the importance of rules and constraints in the game.

PPOU game design can instead be related to several components of Mihaly Csikszentmihalyi's Flow theory. Indeed, the game's

main thread, consisting of finding a link between one innovation and four previous ones, gives a clear goal to players. Every action they undertake has immediate feedback: a message displayed on the mobile phone when the answer is false, the next subquest available if it is true. The interconnection of the game's world with the real world increases players' involvement in the game, and also, into their quests. But this involvement is always under control to maintain the game's pleasure and to offer a smooth effortless environment. The dynamic adaptative engine allows tuning each subquest difficulty level to be just hard enough to stimulate players but not so hard as to discourage them. It helps to modulate the game's pace too to allow time to concentrate on the mission. Immersion through the narrative universe and adaptatibility favour the loss of time consciousness, as time still does not seem linear, but disrupted. Hence, immersion and adaptation to players' ability are the main reasons why PPOU is closer to the Flow Theory.

5. Conclusion

Analyzing the results gained from both games, we found that PSM gave players a very intense gaming experience with a lot of fun. But we felt it missed the learning purposes of the project. Content about artefacts was set into the mobile device (quiz, zoom), but the way the game was played did not help users to go deeper to gain knowledge. The learning attitude was not fostered by the PSM game design. We found that the PSM game design suits the Magic Circle approach. Our very preliminary report indicates that the Magic Circle approach doesn't protect game designers of serious pervasive games against the risk of creating an application more entertaining than educational. Thus, they could miss the requirement of involving the players in a learning attitude.

PPOU is closer to the requirements of the Flow Theory. Flow Theory appears to help to balance learning against play. Defining challenges that a learner has a chance to complete and inducing strong involvement are features of the Flow Theory. They seem also important parts of successful educational activities. They were two features of PPOU game design, implemented through its narrative universe and its dynamic adaptability. It seems that they achieved their goal perfectly, as the game provided enlightenment as well as enjoyment for the players.

To promote visits in museums, 'gamification' of culture is an interesting approach. It leads to serious pervasive games in museums. Flow Theory seems to efficiently address serious pervasive games. But does the Magic Circle theory still hold in that case? Our experimentations advocate for a positive answer. A game inside a museum has to be contained in the strict frame of the well-defined social and spatiotemporal space of the institution that instantiates the magic circle. The right approach seems to be a combination of the Magic Circle and Flow theory that pervasiveness requires. Magic circle is used to provide gaming features, and Flow Theory helps to adjust challenges to users' ability, balancing learning against play. Further works will explore the combination of Magic Circle with the Flow Theory.

6. References

Addis, D. (2005). "New technologies and cultural consumption - edutainment is born!". *European Journal of Marketing, Vol. 39, Numbers 7-8*, 729-736.

Astic, I. & C. Aunis (2009). "PLUG : les secrets du musée - Recherche d'une médiation entre virtualité et réalité*". La Lettre de l'OCIM, N°125*, 5-11.

Belotti, F., R.Berta, A. De Gloria, M. Margarone (2004). "User Testing a hypermedia tour guide"*. Pervasive Computing Journal 1 (2)*, 33-41.

Broadbent, J. & P. Marti (1997). :Location Aware Mobile Interactive Guides: Usability Issues". *International Cultural Heritage Informatics Meeting ICHIM 1997*, 15-30. Archives and Museum Informatics Europe, Milano.

Champagnat, R., A. Prigent, and P. Estraillier (2005). "Scenario building based on formal methods and adaptative execution". *SAGA'2005. Int. Simulation and Gaming Association.* Atlanta. Also available at http://armelle.prigent.free.fr/publications /Prigent_ISAGA05.pdf (http://armelle.prigent.free.fr/publications/Prigent_ISAGA05.pdf) , consulted January 25, 2011.

Chen, J. (2006)**.** "Flow in games". Available at http://www.jenovachen.com/flowingames/thesis.htm (http://www.jenovachen.com /flowingames/thesis.htm) . Consulted December 30, 2010.

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience.* London: Harper Perennial.

Damala, A. (2009). *Interaction Design and Evaluation of Mobile Guides for the Museum Visit: A Case Study in Multimedia and Mobile Augmented Reality*. Unpublished PhD Thesis, Conservatoire National des Arts et Metiers (CNAM), Paris, France: Centre d'Etude et de Recherche en Informatique du CNAM. Also available at http://cedric.cnam.fr/PUBLIS/RC1830.pdf (http://cedric.cnam.fr/PUBLIS/RC1830.pdf) . Consulted January 28, 2011.

Damala, A. (2009b). "Edutainment Games for Mobile Multimedia Museum Guidance Systems: A Classification Approach" . In

Springer Verlag (Eds). *ICEC'09, International Conference in Entertainment Computing*, Paris, 307-308. Also available at http://cedric.cnam.fr/PUBLIS/RC1829.pdf (http://cedric.cnam.fr/PUBLIS/RC1829.pdf) . Consulted January 28, 2011.

Damala, A., I. Astic, C. Aunis (2010). "PLUG, Université Paris Nuit: A Design Reiteration of a Mobile Museum Edutainment Application". In Eurographics (Eds). *VAST'10, Virtual Reality, Archaeology and Cultural Heritage, The 8th EUROGRAPHICS Workshop on Graphics and Cultural Heritage, Short and Project Papers.* Paris. 91-94. Also available at http://cedric.cnam.fr /PUBLIS/RC1962.pdf (http://cedric.cnam.fr/PUBLIS/RC1962.pdf) . Consulted January 30, 2011.

Gentes A., C. Jutant A. Guyot and M. Simatic (2009). "Designing mobility: pervasiveness as the enchanting tool of mobility". *1st international ICST Workshop on Innovative Mobile User, Interactivity (IMUI 2009)*. San Diego. Also available at http://www-public.it-sudparis.eu/~simatic/ (http://www-public.it-sudparis.eu/~simatic/) **.** Consulted January 28, 2011.

Gressier-Soudan, E., R. Pellerin.& M. Simatic (2011). "Using RFID/NFC for pervasive serious games: the PLUG experience". In CRC Press (Ed.) *Near Field Communications Handbook*, Syed A. Ahson**,** Mohammad Ilyas editors.

Hall, T., L. Ciolfi, L. Bannon, M, Fraser, S. Benford, J. Bowers, C. Greenhalgh, S. Hellström, S. Izadi, H. Schnädelbach & M. Flintham (2001). "The Visitor as Virtual Archaeologist: Explorations in Mixed Reality Technology to Enhance Educational and Social Interaction in the Museum". In David B. Arnold, Alan Chalmers, Dieter W. Fellner (Eds.*). Virtual reality, archeology, and cultural heritage 2001*, 91-96. New York.

Harper, R. **(**2003). "People versus Information: The Evolution of Mobile Technology". *Human-Computer Interaction with Mobile Devices and Services, Lecture Notes in Computer Science*, Volume 2795/2003, 1-14. Also available at http://www.itu.dk /~christie/mobilspeciale/litteratur/Harper, Richard People vs information the evolution of mob.pdf (http://www.itu.dk/~christie /mobilspeciale/litteratur/Harper, Richard People vs information the evolution of mob.pdf) , consulted January 25, 2011.

Heumer, G., F. Gommlich, A. Miller, B. Jung (2007). "Via Mineralia - a pervasive museum exploration game". 4th International Symposium on Pervasive Gaming Applications. PerGames. 159-160. Also available at http://vr.tu-freiberg.de/viamineralia /documents/ViaMineralia-Pergames2007.pdf (http://vr.tu-freiberg.de/viamineralia/documents/ViaMineralia-Pergames2007.pdf) . Consulted January 28, 2011.

Huizinga, J. (1949). Homo ludens: A study of the play-element in culture. London: Routledge.

IPerG (Integrated Project on Pervasive Gaming).(2008). http://iperg.sics.se/index.php (http://iperg.sics.se/index.php) , Consulted January 25, 2011.

Kuhn A., C. Cahill, C. Quintana, E. Soloway (2010). "Scaffolding science inquiry in museums with Zydeco". In ACM Press. CHI EA '10: 28th of the international conference extended abstracts on Human factors in computing systems. New York. 3373-3378.

Mc Gonigal, J. (2003). "A Real Little Game: The Performance of Belief in Pervasive Play". In Digital Games Research Association (DiGRA) Level Up, Utrecht: University of Utrecht, November. Also available at http://www.digra.org /dl/order_by_author?publication=Level (http://www.digra.org/dl/order_by_author?publication=Level) Up Conference Proceedings (http://www.digra.org/dl/order_by_author?publication=Level%20Up%20Conference%20Proceedings) , consulted January 12, 2011.

Montola, M., J. Stenros, A. Waern (2010). Pervasive Games Theory and Design, Experiences on the boundary Between Life and play. Morgan Kaufmann Publishers.

Simatic, M., I. Astic, C. Aunis, A. Gentes, A. Guyot-Mbodji, C. Jutant and E. Zaza (2009). "Plug: Secrets of the Museum: A pervasive game taking place in a museum". In Springer (Ed.), ICEC 2009, Eighth International Conference, Paris, 67-74. Also available at http://www-public.it-sudparis.eu/~simatic/ (http://www-public.it-sudparis.eu/~simatic/) , consulted January 28, 2011.

Simatic, M. (2009b). "RFID-based distributed memory for mobile applications". In Spinger (Ed.), MobiCASE '09 : The First Annual International Conference on Mobile Computing, Applications, and Services. San Diego, vol. 35, 185-202. Also available at http://www-public.it-sudparis.eu/~simatic/ (http://www-public.it-sudparis.eu/~simatic/) , consulted January 28, 2011.

Thom-Santelli, J., K. Boehner, G. Gay & H. Hembrooke (2006). "Beyond just the facts: transforming the museum learning experience". In ACM Press. CHI '06, Human Factors in Computing Systems. 3214-3222. New York.

Van Dijk, D. & al. (2009). "Out There: Connecting People, Places and Stories". In J. Trant and D. Bearman (eds). Museums and the Web 2009: Proceedings. Toronto: Archives & Museum Informatics. Also available at http://www.archimuse.com/mw2009 /papers/vandijk/vandijk.html (http://www.archimuse.com/mw2009/papers/vandijk/vandijk.html) . Consulted December 27, 2010.

Walz, S.P. et al. (2006). "Cell Spell-Casting: Designing a Locative and Gesture Recognition Multiplayer Smartphone Game for Tourists". Pergames 2006. Dublin. Also available at http://hci.rwth-aachen.de/materials/publications/walz2006a.pdf (http://hci.rwth-aachen.de/materials/publications/walz2006a.pdf) . Consulted January 28, 2011.

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