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A Prototype on a Meta-model for Designing Instructional Pervasive Games

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Abstract—**Instructional pervasive game (IPG) is an innovative way in accomplishing m-learning. It has been introduced by various literatures in the past few years. An important critic of IPG is that most game strategy does not take into consideration the anthropological data pertaining to the specific context of use. In response to this issue, we proposed a prototype of a meta-model which puts together several partial perspectives of the IPG discussed in various literatures. Our meta-model emphasizes an urban cultural-rich task as the main goal of an IPG. Context requirement, pedagogy requirement, and design requirement form the main body of the meta-model. The elements of each requirement are also discussed in accordance with the related literatures. We also suggested a set of checklists based on our meta-model. Each set of the checklist depicts specific tasks to be accomplished. These checklists may be served as an initial reference for IPG designers. More rigid verification process for the meta-model is underway to validate the trustworthiness of the model.**

Keywords- mobile learning; instructional pervasive game; the GNS theory;

I. INTRODUCTION

As the continuing advancement of technology, especially the computer technology, the intensive discussions on the issues of "learn to use technology" and "learn with technology" have become more and more emergent in school education. In the past thirty years, the instructional implementation of computer technologies may roughly divide into several stages. The first stage was so-called "Computer-assisted Instruction (CAI)". It started around mid1980's, in this stage, stand-alone, self-paced, and well-programmed instructional materials were distributed with floppy disks or CD's. The second stage, namely "the web-based instruction", started around late 1990's, at the moment the World Wide Web was just booming. With the fast advancement of information technology after 2000, the educational implementation of computer technology went further that has broken the limitation of time and space, extends the classroom beyond its physical constrain, we have also been more and more familiar with the term "mobile learning (m-learning)" or "ubiquitous learning (u-learning)", this is the third stage. In compare with CAI and web-based instruction, ample research evidences have shown that m-learning or u-learning is especially helpful in facilitating learners constructing knowledge with regard to the situational information in social, cultural and physical contexts [1]. Mikic, Anido, Valero, and Picos [2] also believed that mobile learning has created a new learning environment that enables learners to learn anywhere and anytime.

With the help of advanced mobile devices and well-designed instructional strategies, m-learning is able to bring students out of classroom and interact with environment. We emphasize that well-designed instructional strategies are essential for a successful m-learning. However, many local studies on m-learning simply repeated the concerns of establishing a learning system, emphasizing the use of the mobile devices (such as PDA) with the established system, [3][4], they seemed to fall short of designing adequate strategies to carry out an effective instruction. These system-design type of studies may have caused the instructors, especially high school teachers, to be reluctant to adopt mobile technologies due to the lack of budget supports and applicable instructional strategies.

Fortunately, an innovative way in accomplishing m-learning- instructional pervasive game (IPG) has been introduced by various educational researchers in the past ten years[1]. Montola (2011) explained a pervasive gaming environment in "an extension of m-learning with an emphasis on the roles of an intelligent environment and of the context". With the aid of GPS, authors of this paper have previously initiated an experimental study which employed a typical pervasive-gaming activity "geocaching" in teaching high school students' geographical coordinates and map reading [5]. The results indicated that GPS-aided geocaching helped students learn map reading and the geographical coordinates in a more effective way. The results also showed that the GPS-aided geocaching group was generally acquired a better attitude toward using technology.

Such results is in coherent with some other related studies [6][7]. However, Gentes, Guyot-Mbodji, & Demeure [8] pointed out, most game strategy does not take into consideration the anthropological data pertaining to the specific context of use. They argued that the advancement of geolocalisation helped us to concentrate on the diversity of location-sensitive experiences rather than focusing uniquely on the geographical skills of players engaged in a treasure hunt of pursued by other players. They further indicated that maps and trajectories are one aspect of treasure hunts but companionship and discovery are at the core of the pleasure of pervasive game. We agree these comments and we continue our exploration of pervasive game with a shift of

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our direction. Our new interest is to place more cultural elements into the gameplay.

Furthermore, we reviewed some other valuable literature on designing IPG from various points of view. Each of the literature seems to only reveal a part of the whole picture of IPG. In this paper, nevertheless, we tried to synthesize a cultural-rich meta-model which is specifically appropriate for designing IPG. We also specified a set of checklists for practical purposes accordingly according to this meta-model..

II. REVIEW OF RELATED LITERATURE

A. Mobile Learning and Mobile Game

Laine, Sedano, Joy and Sutinen [1] defined m-learning as a form of informal learning where the learner traverses a physical context carrying a personal mobile device which provides learning materials and activities. Mikic, Anido, Valero and Picos [2] believed that mobile learning has created a new learning environment that enables learners, through action learning aids, teaching materials, teachers and other learners, to learn at anytime and anywhere. Learning content are location-sensitive as learners are free of moving. All learning paths and the contents are recorded accordingly. The advantage of employing mobile technology in learning is not the mobile technology itself, but the unique attributes of the mobile devices that provide an environment which allow apply the innovative learning theory and learning strategies [9]. Walther [10] recognized that a mobile game is a game that takes changing relative or absolute position/location into account in the game rules. This excludes games for which mobile devices merely provide a delivery channel where key features of mobility are not relevant to the game mechanics. Hence, one could distinguish between mobile interfaced games and mobile embedded games.

One instance of instructional system combining mobile learning and mobile game was designed by Schwabe and Goth [11]. Their instruction used college students as learners. Students were divided into groups to play the game. They obtained information from the website regarding the mission and geographical coordinates of the locations. They then used GPS to complete a task and uploaded the result back to the workstation before they could get the location information of the next mission. The winner was who completed the task first.

B. Pervasive Gaming

According to Walther [10], pervasive gaming (PG) implies the construction and enacting of augmented and/or embedded game worlds that reside on the threshold between tangible and immaterial space, which may further include adaptronics, embedded software, and information systems in order to facilitate a 'natural' environment for gameplay that ensures the explicitness of computational procedures in a post-screen setting. Another important notation of PG has been made by Montola [12]. He argued that PG is a game ''expand the magic circle of play socially, spatially or temporally". He further explained that magic circle of play is a social and cultural contract that separates ordinary life from play, communicating a way of understanding events that happen within the circle. Pervasive games differ from the usual games in that they brake the lines of the magic circle. Unlike traditional video and computer games, they are not played on a virtual environment, and they tend to involve outsiders. Pervasive games often blur the boundary of game and real life.

It is not able to construct a pervasive game without some constructional frameworks and guidelines. Walther [10] gave a constructional framework that he called "four axes of PG". He illustrated the four axes as follows: 1) Distribution, refers to the network which can widely distribute the gaming information; 2) Mobility, refers to computing mobility; 3) persistence, refers to total availability all the time; and 4) transmediality, refers to a media circle that multi-link the world of virtual social networks. Upon such a constructional framework, he further depicted three key units of PG: 1) Game rules: all PG's must be rule-based; 2) Game entities: abstract class of an object that can be moved and drawn over a game map, it can further shape into three categories, game object, human agent, and physical object; 3) Game mechanics: an input-output engine that monitoring and modifying the physical and virtual linkage to ensure a fluent game flaw.

From educational point of view, Laine, Sedano, Joy and Sutinen [1], illustrated a "technology integration model" for game-based pervasive learning systems, stated that an IPG needs to meet the following requirement: 1) Pedagogical requirements, include user profile, interaction and collaboration, ownership, authenticity and relevance, finally, support and assessment; 2) Game design requirements, include Resources—financial and human, cultural issues, technical issues, environmental issues, social issues and temporal issues; and 3) Context requirements, include Context-awareness, dynamics, interaction, and content.

As stated earlier, Gentes, Guyot-Mbodji, & Demeure [8] raised an important issue that local culture recognition should be one of the key goals for PG, especially IPG's. They suggested that for a cultural-rich PG, three key features should be included, they are: 1) collaborative contents, the contents should be designed by people with qualified knowledge or actually living on the premises, therefore, scholars, neighbors, and respectable alike are all contributors of the content; 2) team exploration, the gameplay either relies on solitary errands or on collective sharing, strategies can be more "group oriented"; 3) Cultural narrative, unlike traditional computer games which always opening with a virtual scenario, PG's are based on urban-cultural representations. There is always a first narrative that sufficiently describes the culture of the city therefore game players are able to have a clear idea of the fashionable places, the living or working areas, and the cultural spots.

PG is relatively new term for most of the instructional gaming researchers and developers. The idea of PG started at the beginning of this century. Although there have been numerous mixed-reality game prototypes have been built and studied [12], a comprehensive model and guidelines for developing instructional PG are still on the way. After reviewing above valuable articles, we have been able to

integrate a rough picture of designing an instructional PG. The picture includes a developmental foundation model (four axes and three key units), a technology integration model which emphasized the equal importance of pedagogical requirement, context requirement, and game design requirement for PG, and finally, an urban-cultural model which depicted the key elements for culture recognition. However, for building an effective and immersive IPG, these articles fall short of paying attention on the players. They are the leading character of PG's.

C. *The GNS Model*

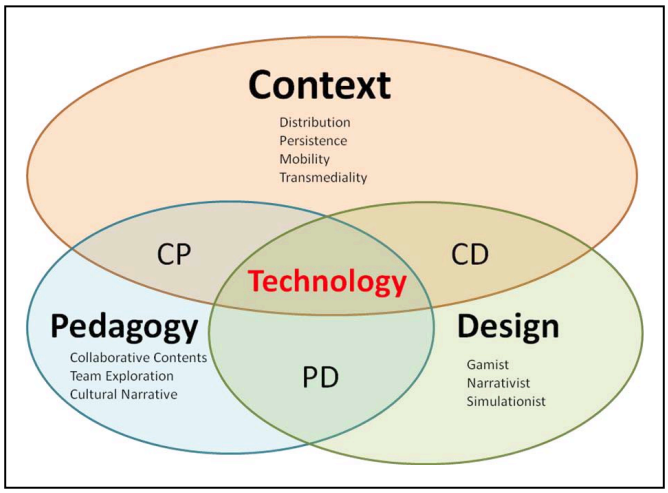
Several theoretical discussions on role-playing games have been found in literature, and some amorphous models or prototypes of role-playing games have been made in these few years. Among them, the "GNS Theory" originally developed by R. Edwards [13] seems to be useful for supporting our meta-model. GNS Theory holds that participants in role-playing games reinforce each other's behavior towards ends which can be divided into three categories: Gamist, Narrativist and Simulationist. Originally, GNS theory is concerned with players' social interactions, but it has been extrapolated to direct game design, both in and outside the world of role playing games. Among the three categories of GNS, Gamist refers to decisions based on satisfying clear predefined goal conditions in the face of adversity: in other words, on the desire to win; Narrativist relies on developing motives for the characters, putting them into situations where those motives come into mutual conflict, and making their decisions in the face of such stress the main driving force behind events; and Simulationist refers to a style of play where the main agenda is the recreation of, or inspiration by, the observed characteristics of a particular genre or set of source material. Detailed descriptions and practical examples of these three categories can be seen on a dedicated website for independent role-playing games: The forge (http://www.indie-rggs.com).

III. A PROTOTYPE OF THE META-MODEL FOR IPG DESIGN

A. *The Meta-model Proposed*

A meta-model is a model which integrates various aspects of related theoretical viewpoints. It is helpful in piecing up a whole picture of the interest. Synthesizing from above literature, our meta-model for IPG design purposed in this paper is composed of four sub-models: a developmental foundation model, a technology integration model, an urban-cultural model, and a roleplaying game model. The center of the meta-model is the technology, which embraced by three ovals of context requirement, design requirement, and pedagogy requirement. The three ovals are overlapped each other, means these three requirement are not mutually exclusive. The oval of "context" is larger than the other two, which represents the context variables affect more on the IPG. Inside these ovals are detailed foci of each requirement: the oval of "context" has four foci: distribution, mobility, persistence, and transmediality; the oval of "pedagogy" has three foci: collaborative contents, team exploration, and cultural narrative; and finally, the oval of "Design" also has three foci: gamist, narrativist, and Simulationist. The graph below illustrates the main relationship between these models.

Figure 1. The meta-model for IPG design.



Brief explanations of foci in each oval are described as follows:

1) Context Requirement

a) Distribution: Combination of embedded computing, dynamic networking, and information sharing so that game information can be distributed,

b) Mobility: Computing mobility, network mobility, and user mobility,

c) Persistence: Total availability of technologies all the time,

d) Transmediality: Adequate utilization of multimedia.

2) Pedagogy Requirement

a) Collaborative Contents: Sharing instructional content from various resources,

b) Team Exploration: Integrating the team power in problem solving,

c) Cultural Narrative: Building "advance organizer" in a mobile and multimedia format.

3) Design Requirement

a) Gamist: Designing challenge and adventure scenarios,

b) Narrativist: Designing conflict scenarios,

c) Simulationist: Designing seamless transitions between virtual and physical world.

Up to this point, we have not perform rigid quantitative and qualitative validations. Therefore each focus described in this paper has not yet exhausted. They can only be used as a reference for IPG designers.

B. *The designing guideline Proposed*

With this mega model, a structured guideline for IPG designers can be drawn. The guideline is consists of three sets of checklists: Context Requirement Checklist, Pedagogy Requirement Checklist, and Design Requirement Checklist. Detailed descriptions of each checklist are listed in the following tables:

TABLE I. THE CONTEXT REQUIREMENT CHECKLIST

Category	Description	Checklist
Distribution	Combination of embedded computing, dynamic networking, and information sharing so that game information can be distributed	1. In a gameplay environment, are there enough mobile devices available? 2. Where can I place my game server? 3. What system is compatible with different mobile operating systems? 4. Is it a well-structured database for data entry and retrieval?
Mobility	Computing mobility, network mobility, and user mobility	1. Are our mobile devices capable of executing designed game mission? 2. Are there sufficient wireless signal, such as wifi, 3G, Bluetooth… available? 3. Is the target place physically reachable by the game players?
Persistence	Total availability of technologies all the time	1. Are all technologies employed, including server and terminals in the gameplay, stable all the time? 2. Can wireless signals stably cover the game region?
Transmediality	Multimedia utilization	1. Are interface of the gameplay compatible with different platform?

TABLE II. THE PEDAGOGY REQUIREMENT CHECKLIST

Category	Description	Checklist
Collaborative Contents	Sharing instructional content from various resources	1. Is there a shared platform for collaborative content construction? 2. Is there a filtering mechanism for inappropriate shared input?
Team Exploration	Integrate team power in problem solving	1. Are there tasks designed in the gameplay for team problem solving?
Cultural Narrative	Build "advance organizer" in a mobile and multimedia format	1. Is there an "advance organizer" in which related cultural, historical, and geographical information are described with multimedia display?

TABLE III. THE DESIGN REQUIREMENT CHECKLIST

Category	Description	Checklist
Gamist	Design challenge and adventure scenarios	1. Do we design some challenges? (For example, different game level) 2. Do we design some "chances" and "fates" in the gameplay? 3. Do we design some adventures so that the uncertainty of the gameplay increases? (For example: cliff climbing)
Narrativist	Design conflict scenarios	1. Do we design some conflicts between moral, culture, and friendship? (For example: player needs to betray to his/her partner in order to win) 2. Do we design some circumstances that players need to make their decisions once and for all? (For example, need to donate all money in order to be continue in the game)
Simulationist	Design seamless transitions between virtual and physical world	1. Do we design interface between virtual and real world ?(For example: record and display the GPS trajectories of game players) 2. Do we design effective strategy so that the flow experiences of the gameplay would not break off between virtual and real world? 3. Do we design adaptive mechanism that evaluate players' on-task performance and adapt to the game scenario?

IV. CONCLUSION

Due to the fast development of information technology, the research foci of educational technology have experienced a series of shifts for the past thirty years. From CAI to u-learning, perusing new information technologies seems to have been a bandwagon effect. E-learning allows learners learn anytime and anywhere, but it also limits the interactions between instructors and students. Research evidences have shown that some "face to face" interactions are beneficial for increasing learning achievement during an e-learning process.

However, m-learning and u-learning provide an interface which links the real and virtual world. Wii and X-box are best examples of such real-virtual links. With mobile devices, learners are able to interact with each other in the real and virtual world simultaneously. Furthermore, m-learning and u-learning provide a new paradigm for edutainment research. IPG brakes the "magic circle", game players do not have to "immerse" in the virtual game world all the time. Mobile technologies enable game players roaming across the real-

virtual border back and forth. We consider that IPG has made a m-learning and u-learning a step forward.

Some empirical and theoretical studies in pervasive game have been done in the past decade. However, only few studies focused on learning. This paper drew a prototype of a meta-model of IPG design by synthesizing several valuable articles, and made a set of checklist as the reference for IPG developers. Validation process for model verification are underway, necessary revisions will be made after more rigid trustworthiness assessment are made.

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