Understanding Pervasive Games for Purposes of Learning

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Abstract: Among the manifold of approaches to technology enhanced learning, game based learning is very attractive. In game based learning, the technological systems employed for the purpose of learning are digital games. Stand-alone serious games are rare. Games deployed for learning need to be embedded into suitable contexts. A particular approach promising from certain didactic perspectives and driven by a variety of characteristics of learning contents and training requirements is embedding those games into the surrounding physical world. Games embedded into the physical world are called pervasive games. The ways of embedding are paramount. There have been numerous attempts to design and to implement pervasive games, in general, and to deploy pervasive games for learning purposes, in particular. The majority of those pervasive games failed quite badly. Storyboarding the interaction between the real world and the virtual world of a pervasive game reveals the essential strengths and weaknesses of the game concept and allows for diagnosing didactic flaws of game play. Beyond its diagnostic power, the approach supports the design of more affective and effective pervasive games. Storyboarding is a methodology of anticipating human experience and, thus, a methodology of didactic design.

1 THE AUTHORS' POSITION

All of us–readers and authors of this manuscript–are aware of the fact that so-called digital natives[1] have other expectations when facing digital media than their parents and teachers. Playful learning, whenever possible, and using digital games for learning without any fear belongs to the widespread expectations teachers and trainers have to fulfill.

In response, game based learning and serious games are terms naming some prosperous field of technology enhanced learning.

When the learning contents is out there in the surrounding world, it seems plausible to bring the games out there as well–pervasive games concepts evolve.

In harsh contrast to the promises, most pervasive games failed badly.

There will surely be no superficial and short explanation for a large number of finally disappointing game developments. But understanding the past and shaping the future surely needs some pondering, some exchange of opinions, and several innovative ideas. The authors aim at some small contribution to this process by advocating their position,

- that there are decisive characteristics of pervasive games which may be well explicated by suitable approaches of storyboarding applied to pervasive games.

Using storyboarding a posteriori, it turns out to work as a diagnostic tool. Doing it a priori, storyboarding becomes a tool for design and development fostering to draw conclusions from lessons learned in earlier projects that failed.

Based on the authors' key position above, one is lead to some more viewpoints worth to be considered.

- Pervasive games may be classified according to their pervasiveness which is of didactic relevance.
- The crucial embedding of learning contents into game play may be characterized quite well by means of storyboarding terminology.
- The storyboarding technology, by its very nature, allows for an explication of the context conditions in which learning is likely to take place.

The basic terminology will be introduced briefly to be applied to a larger number of pervasive games.

[1]The term *digital natives* as polemically opposed to denigratingly called *digital immigrants* is, exactly in this sense, ascribed to Marc Prensky (Prensky 2001), although the idea as a whole dates back to (Barlow, 1996) writing: "You are terrified of your own children, since they are natives in a world where you will always be immigrants."

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2 INTRODUCTORY CASE STUDY

Before going into the details of discussion, the authors are aiming at an intuitive introduction. Instead of presenting notations in a formal way, a certain digital game is used to exemplify what the present paper is about, which concepts are in use, and how typical problems are formulated and attacked.

The game selected for an introduction by example is TREASURE (Chalmers et al., 2005) which is one of the earliest pervasive games. The purpose of the game TREASURE is to *learn* about wireless communication. The ideas underlying this game are easy in structure.

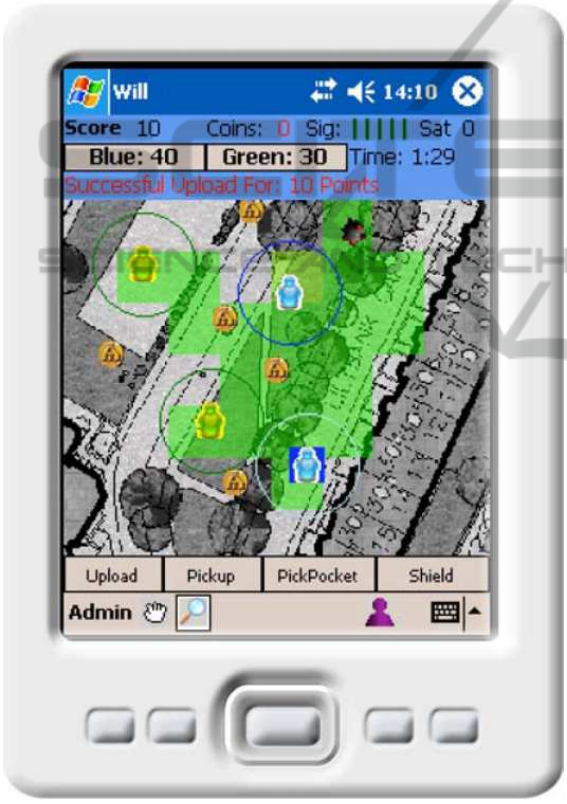

Figure 1: Interface to the TREASURE game as it appears in some PDA; picture taken from (Chalmers et al., 2005) with the permission of the authors as it appears in (Jantke, 2006).

Some real urban environment such as a park, e.g., is virtually equipped with virtual treasures[2]. Teams of players are running around in pursuit of treasures. Team members in the real world are localized by means of GPS technology relating them to the virtual treasures and to each other. In certain areas, there are WLAN connections allowing players to contact their virtual treasure boxes on the server for upload.

[2]For the borderline between reality and virtuality, in general, and for its relevance to e-learning, in particular, interested readers are directed to (Jantke and Lengyel, 2012).

(Chalmers et al., 2005) describe variations of the game mechanics. The core idea, however, is lucid. The storyboard in fig. 2 is summarizing the essentials.

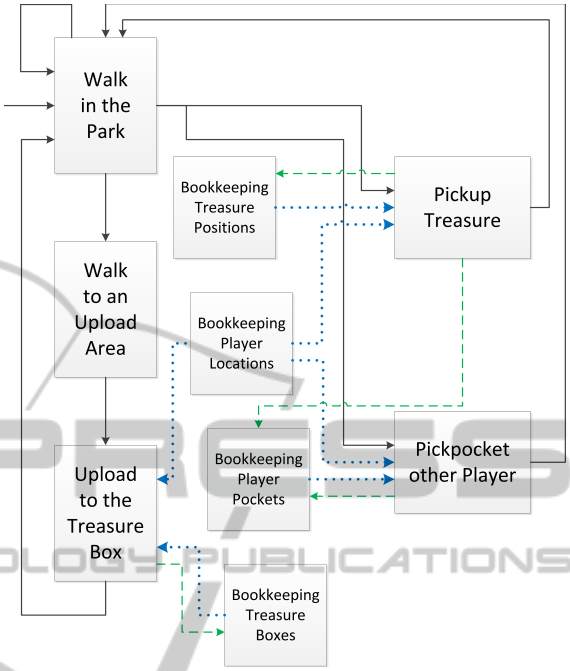

Figure 2: Storyboard of TREASURE's game mechanics.

Every node is an episode or a scene describing some action. Smaller inscriptions describe actions of the computer system as opposed to actions of human players. Solid lines indicate the passing of a human player from one action to another such as, for illustration, from just walking to picking up some treasure. Dashed green lines indicate that the player's action causes some actions of the computer system. In turn, dotted blue lines indicate the impact of earlier game actions on the player's current actions. For instance, virtual treasures can only be discovered and picked up where the computer system has placed them virtually. Arrows indicating update operations of the players' positions have been dropped.

Game playing means moving around, collecting virtual treasures, trying to pickpocket each other, and aiming at uploads of the own virtual treasure to the safe virtual treasure box. The bookkeeping of treasure locations and treasure boxes defines the termination of game play.

The simplicity of the storyboard above reflects the simple structure of the underlying game concept.

Furthermore, it exhibits that there are no actions of interest performed by the game system except bookkeeping and, thus, determining preconditions of player actions. The game system is not perceived as an actor, but more seen as a supervising game master.

3 STORYBOARDING GAMES

This paper uses storyboarding as a technology, but does not aim at anything such as an introductory course to storyboarding. The authors rely on the basics as introduced by (Jantke and Knauf, 2005) and confine themselves to those notions and notations needed for the purpose of characterizing pervasive games. Recent work on storyboarduing digital games such as (Jantke and Knauf, 2012), e.g., is worth some comparison.

Storyboards are hierarchically structured graphs. The composite nodes are named episodes, whereas the atomic nodes are named scenes. Composite nodes may be subject to substitution by some other graphs. In contrast, atomic nodes have some semantics in the underlying domain. They may represent documents such as videos, pictures, or text files in formats like pdf, e.g., but they may also represent some activities of human learners, co-learners, teacher, tutors, or those actions performed by certain digital systems.

The usage of composite nodes in a graph allows for the representation of anticipated experiences on different levels of granularity (see (Lenerz, 2009)).

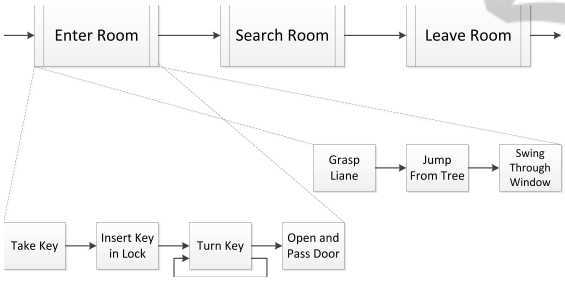

Figure 3: Cutout of some storyboard with three episodes.

Just for illustration, fig. 3 above is showing two alternative substitutions for an episode. The graphs for substitution on display contain only scenes which have a particular operational semantics. In general, subgraphs may also contain episodes.

Graphs may contain branches and loops, where there are different branches for indicating alternatives, multiple choices, parallelism of action, and the like.

Every storyboard specifies a usually rather large number of paths through the storyboard describing, for instance, varying experiences of game playing or different ways of learning.

The art of storyboarding is to anticipate and to specify the manifold of forthcoming actions including human-computer interaction, human-to-human communication and individual activities like pondering particular problems or reflecting own achievements. Seen from an e-learning perspective, storyboarding means technology enhanced didactic design.

4 PERVASIVE GAMES VS. SERIOUS GAMES

Game based learning is an established paradigm of technology enhanced learning (see, for instance, (Prensky, 2001), (Ritterfeld et al., 2009)), although it does not yet play any remarkable role in conference series such as CSEDU.

Contemporary taxonomies and classifications of serious games such as (Sawyer and Smith, 2008) and (Ratan and Ritterfeld, 2009) do not even mention the term pervasive game or the game property of being pervasive.

This particularly unsatisfactory state of the art bears abundant evidence of the need for pondering the peculiarities of those serious games that fall into the category of pervasive games as well.

No doubt, there are serious games which are not pervasive and there are pervasive games which do not deserve to be called serious. This paper's focus is on the intersection of the two categories, exclusively.

A game may be called pervasive if the experience of playing is based on a certain mixing of real world elements and virtual elements. Crucial to the human experience is the interplay between the real world and the virtual layer. Virtual actions may be the trigger for physical actions in the real world and vice versa.

Playing some pervasive game is characterized by

- face-to-face communication and social interactions among players,
- physical interactions between human players,
- physical activities in real environments,
- the dynamics of reality influencing game play,
- virtual world components expanding the reality.

The virtual game world may give new meanings to parts of the real world. For instance, some road may be seen as a river and some building becomes a castle. Beyond the limitations of conventional digital games, actions in the game world may have real-world preconditions and may require real-world actions.

According to constructivist approaches to learning (Thissen, 1997), human learners acquire knowledge in an active process which may be highly iterative. In dependence on the general domain and the specific subject of learning, experimentation, trial and error, haptic experience and the like may be crucial. In game-based learning, pervasive games are those bridging the gap to real experiences in the real world.

Even rather simple approaches to playing pervasive games for purposes of learning–compared to classroom approaches–may lead to some higher energetic activation, more positive emotions and attitudes towards learning activities (Kittl et al., 2009).

5 UNDERSTANDING GAMES BY MEANS OF STORYBOARDING

Storyboarding is not only some technology of a priori design, but also some means of a posteriori analysis and understanding. Storyboarding bears the potential of explicating an interactive system's characteristics which are decisive of the impact of interaction.

Some earlier papers in the area of pervasive games contain diagrammatic representations looking like storyboards (see (Markovic et al., 2007), fig. 5, e.g.), but the visualizations do not yet sufficiently well both separate and relate the two game world components.

5.1 Classifying Pervasiveness of Games

Roughly speaking, storyboards of pervasive games explicate three related, but different aspects of each game: what happens in the real world, what happens in the virtual world, and how the two parallel worlds communicate with each other.

INSECTOPIA (Peitz et al., 2007) is the name of an interesting, but not too complex pervasive game using bluetooth technology as the means to connect the real and the virtual world.

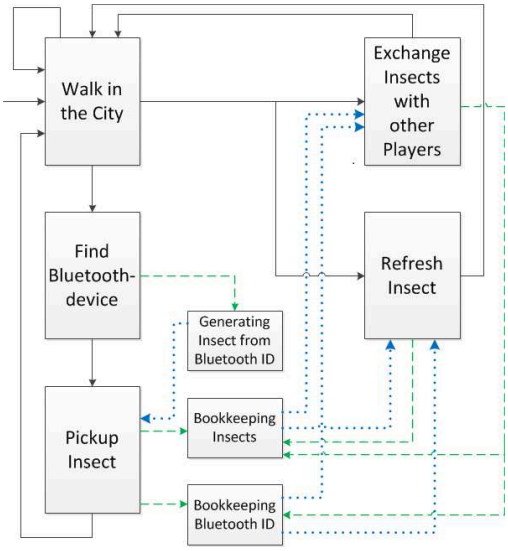

Figure 4: Essentials of the INSECTOPIA game play.

Humans playing INSECTOPIA walk around to collect virtual insects in the real world. Via the Bluetooth interface of his internet connected smartphone, INSECTOPIA is constantly looking for other enabled Bluetooth connections within range. When the human player, intentionally or just by chance, is getting into the reach of some other activated Bluetooth device, INSECTOPIA uses whose Bluetooth-ID to generate a virtual insect on the players smartphone.

Metaphorically speaking, pervasive games are like board games, in which the real world serves as the board, the human players are the pieces moved around, and the computer technology implements the game mechanics. For a particular pervasive game,

1. it may be freely played anywhere,
2. it may be played where virtual objects are set up,
3. it may be definitely bound to some fixed location.

INSECTOPIA is of the first and TREASURE is of the second type as can be deduced from the *Bookkeeping Treasures Node*. What follows is a third type example.

In January 2007, it was proudly announced that the German city of Regensburg, a beautiful place, gets *the first permanent high-tech city game of the world* (see (Borchers, 2007), first sentence of the article). Launched in May 2007, the tracks of the game on the Internet vanish already in Summer of the same year– not really a *permanent* success.

(Ballagas and Walz, 2007) allow for some deeper insights into the game's characteristics.

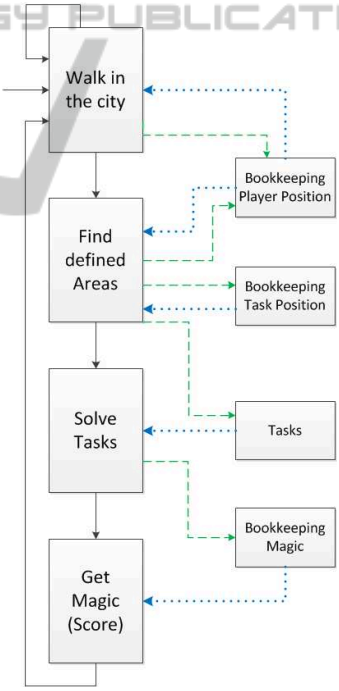

Figure 5: Essentials of the REXPLORER game play.

REXPLORER offers the possibility to explore the history of the German city of Regensburg in a playful manner. In this game, the player is guided by GPS to certain points of interest in the city. At these points, historical knowledge is imparted to the player through story-driven multimedia learning content.

5.2 Storyboarding Issues of Learning

The introductory game case study of TREASURE (see figs. 1 and 2) describes a pervasive game developed and implemented with some specific learning goals in mind: learning about wireless communication with emphasis on the seams in communication networks. When playing the game, human players are acting in the real world aiming at experiencing scenes such as “Pickup Treasure”, “Pickpocket other Player”, and “Upload to the Treasure Box” (see fig. 2 for details). They are only learning by becoming aware of the system-executed communication activities indicated by the dashed green lines and by the dotted blue lines, respectively, in fig. 2.

So, the storyboard does clearly indicate what is relevant to this pervasive game’s educational impact. This may be used, for instance, in designing assessment strategies.

This section aims at the presentation of another case study published, among others, in (Winter and Pemberton, 2010) and (Winter and Pemberton, 2012).

According to (Winter and Pemberton, 2010), INVISIBLE BUILDINGS is a cross-curricular whole-day learning experience integrating outdoor mobile location-based games with complementary indoor classroom-based activities addressing primary school children aged 9-10 years.

The game is played by means of GPS-enabled smartphones. These smartphones are attached to custom-made mock-up tools simulating, for instance, metal detectors. The metal objects found in the school ground are put there very much like the treasures of the TREASURE game are hidden in the park (fig. 1). Other mock-up tools allow for the discovery of virtual building structures underneath or may be used for digging virtually.

The whole learning activity is composed of indoor and outdoor episodes as shown in fig. 6 (see fig. 1 of (Winter and Pemberton, 2010), for comparison).

Publications such as (Winter and Pemberton, 2010) and (Winter and Pemberton, 2012), unfortunately, do not provide sufficient detail for a reliable expansion of the storyboard shown in fig. 6. Therefore, the authors confine themselves to an in-depth discussion of just one part of the game play under consideration.

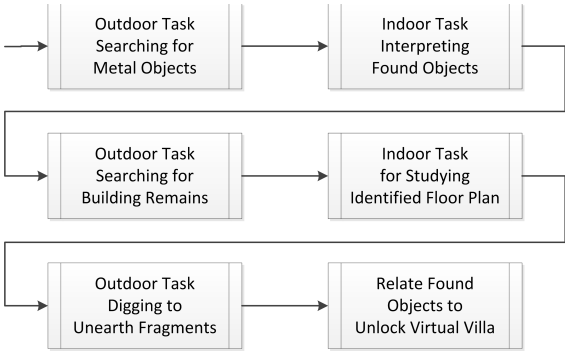

Figure 6: Top level storyboard of INVISIBLE BUILDINGS.

The particular episode shown in figure 6 entitled *Outdoor Task Searching for Building Remains* expands as shown in fig. 7 below.

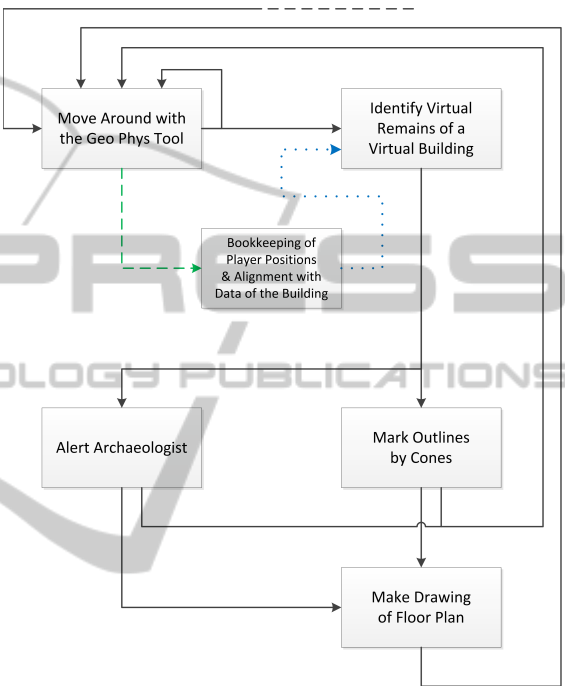

Figure 7: INVISIBLE BUILDINGS storyboard expansion.

The episode expanded in fig. 7 is entered by walking around with the virtual Geo Phys tool. It may be left at any scene on display to continue by playing the next indoor episode.

The game system’s tracing of player positions does possibly trigger the scene of discovering some virtual building remains. Subsequently, players have both to alert the archaeologist and to mark the newly found positions of the remains.

When playing this episode is completed, the floor plan drawn by the players is carried over to the next indoor episode in which the players’ floor plan is further investigated and interpreted.

The storyboard above reveals that in the game INVISIBLE BUILDINGS the game system does not perform substantially more interesting activities than in the other pervasive games investigated before. But it definitely encourages a larger variety of human learning activities.

The INVISIBLE BUILDINGS pervasive game has

some peculiarities which make it unlikely to be played frequently[3]. As reported in (Winter and Pemberton, 2010), section 3.3, an enormous amount of staff is required to play the game. Adults such as teachers and parents all "played a role in the project and a professional actor was introduced to play the part of an Indiana Jones-style archaeologist".

6 CONCLUSIONS

Storyboarding is a methodology of didactic interaction and media design. A posteriori storyboarding of pervasive games helps to understand decisive characteristics and deficiencies of those games. Due to the peculiarities of triggering real life activities, pervasive games are forming a particularly promising category of serious games. As a methodology of instructional design, a priori storyboarding becomes crucial.

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[3]There are extreme cases such as the pervasive game EPIDEMIC MENACE which, according to (Lindt et al., 2007), has been played exactly twice (ibid., p. 3, section 3).