The Eduventure II. An Approach to Educational Game Design.

Ulrich Wechselberger
Universität Koblenz-Landau
wberger@uni-koblenz.de

Abstract

Video games engage players and can train formal skills. However, the potential of educational games for knowledge acquisition lacks research. Moreover, many educational games suffer from low-grade design, therefore impeding the flow of the game and corrupting fun and entertainment.

This article describes the "Eduventure II", a research project investigating methods for "subtle" educational game design. Having the thought in mind that subtle embedding of knowledge into a game can preserve its motivational potential, the project team designed and implemented an educational game prototype. This prototype links knowledge to narrative, simulation and game play layers. The here presented text describes the theoretical background, issues, concept and implementation of the prototype, as well as the lessons learnt from a pedagogical perspective.

1. Introduction

Within the last years, game-based learning has become an important issue for economy, society and research. Our society demands lifelong learning, thus increasing the need for effective, motivating tools for education and training. Meanwhile, computer graphics and game technology made a quantum leap. Moreover, the game industry has become a professional territory, and computer games have become common and popular among young people. As a result, scientists, educators and pedagogues consider computer games as a potential educational tool.

This article, which is divided into three parts, addresses educational games from a pedagogical perspective. The first part (sections 2 and 3) describes research findings on learning effects and motivational potential of video games, leading to the project's research questions. Secondly, (section 4) the theoretical background, concept and implementation of the prototype are specified. Conclusions and future research topics are described in the third part (section 5).

2. Related Work

2.1. Definition of Terms

This article will be prefaced with a short paragraph on terminology. Juul defines a *game* as "a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are optional and negotiable" [1]. To simplify matters[1], this paper uses the terms *video game* and *computer game* synonymously, following Juul's definition: A video or computer game is, "generally speaking, a game played using computer power and a video display." [2] However, the terminology on game-based learning still seems to be somewhat fuzzy and vague. Nevertheless, one could distinguish between *serious games* and *educational games*. While the former focus on the technical potential of video games for training and simulation, the latter tend to concentrate on the pedagogical potential of video games for engaging and motivating the learners [3], [4]. Being more of pedagogical than technical nature, this article focuses on the didactical potential of educational games.

Computer games are often propagandised as powerful educational tools mainly for two reasons. First, they incorporate well-established learning principles. Secondly, computer games are fun to play and therefore engaging. The following section provides background information and research findings concerning these reasons.

[1] For the purpose of this article, it is not necessary to distinguish between game, video games and computer games. However, for detailed definitions of these terms also refer to Mitchell and Savill-Smith [9]

2.2. Learning Effects of Computer Games

For decades the play of children has been linked to their development and process of learning [5]. Moreover, scientists have indicated several learning principles embodied in computer games. For instance, Gentile and Gentile found seven factors beneficial for learning, including adaptation to player skills, interactivity, practice and overlearning [6]. Van Eck states that learning in computer games "takes place within a meaningful (to the game) context" and emphasizes the role of a relevant context for learning principles (such as situated cognition) [7]. Gee elaborated 36 educational values of computer games, including motivation to start and keep on learning, customization, possibility to test hypotheses and others [8]. Thereupon, one could consider computer games as effective teachers.

However, research findings about learning in video games are unsatisfying. On the one hand, there is evidence of computer games effectively supporting formal abilities like visual attention skills, spatial visualization, psychomotoric skills, problem solving, creative and critical thought [9]. On the other hand, research findings about knowledge acquisition are rare and conflicting. This may be due to certain theoretical problems which arise when dealing with complex issues such as knowledge construction (cf. also 4.2.2). The present article focuses on the use of educational games for knowledge acquisition.

2.3. Motivational Effects of Computer Games

Playing games is fun. For this reason educators and pedagogues have been considering play and games as "chocolate-covered broccoli" [4]. With play and games they have been trying to persuade children and students to deal with something "more useful" they would otherwise avoid (for example curricular contents). Where does this motivational potential come from? The *power a player can wield* over his environment while still remaining challenged is considered to be an important source of the entertainment emerging from playing games amongst many scientists [10], [11], [12]. This can even lead to a mental state Csíkszentmihályi called "flow" [13]. Computer games can amplify this effect by providing instant feedback (and thereby instant gratification). They also provide other motivating features such as better aesthetical graphical representation, a wider range of options and scenarios, more customization possibilities and so forth [14]. Accordingly, computer games appear to have great motivational potential.

Yet, critics advise caution regarding the motivational benefit of computer games. Although video games are entertaining, working with video games in a classroom is not necessarily fun as well. Three problems may come up when trying to benefit from the motivational potential by using learning games in an educational context. First, play is free of functional pressures [15], [16]. Thus, a teacher cannot impose playing a game on a student without running the risk of disrupting the nature of play (and thereby corrupt part of its motivational source). Secondly, curricular objectives and game goals are often incongruent [17], [12]. As a result, games may become "teacherized" in an educational context [4], leading to the loss of their engaging potential. Thirdly, educational games are often of inferior quality. Ten years ago, Seymour Papert criticised the low-grade design of most edutainment products and educational games: "Shavian reversals – offspring that keep the bad features of each parent and lose the good ones – are visible in most software products that claim to come from a mating of education and entertainment" [18]. Things have not changed much since then. Others share the criticism on the design of educational games [12], [19], [20]. Indeed, many learning games do not combine the educational content with the game very well: The embedding of learning contents is stilted and artificial, thus impeding the flow of the game and corrupting fun and entertainment. In most educational games there seems to be little cohesion between the educational content and the game [21]. The here presented article concentrates on this issue by reflecting an approach to a more subtle educational game-design from a media didactical perspective.

3. Research Questions and Project Procedure

Against the background of the motivational issues abovementioned, the Eduventure II project dealt with the following questions:

(1) How do we embed learning content into an educational game without spoiling the structure of the game and the coherence of the subject matter?
(2) Does such a game motivate players more effectively?
(3) What practical experience do we gather that could be useful for similar projects?

In order to answer these questions, an educational game was designed within the project, which was supposed to serve as a test subject later. The project was divided into three subsequent stages:

(1) Selection and definition of the educational content; reflection on video game semiotics and combination of learning content and game structure; conceptual design of the game
(2) Implementation of the educational game prototype
(3) Evaluation of the design approach and game prototype

Due to a cut of fundings, we had to discontinue our work after half of the project. Nevertheless, we were able to design a game concept and implement a working, yet reduced prototype. Even though we had to omit the evaluation phase, we could gain some insight on player reactions. The next section deals with the details of our work.

4. Creating the Eduventure-II-Prototype

4.1. Educational Content of the Prototype

For many pupils, history is a dry subject, and they do not get engaged by history lessons. The interactivity of video games may be of great value when dealing with historical contents, because learners get engaged in the subject and are able to experience the educational content actively instead of just hearing about them passively. For this reason, the Eduventure II prototype focuses on German cultural heritage and history. Learning contents include the Revolutions of 1848 in the German states, conflicts between the civilian population and occupying forces from Prussia at the time, in addition to the fortification system the military used in order to secure the city. To summarize, players should learn …

- about the German civilian population that rebelled against the authorities in 1848, demanding freedom, democracy and national unity
- that after years of democracy under occupying forces from France, the city of Koblenz got under Prussian rule because of the Congress of Vienna, hence subjected to the nationalistic authority of Prussia
- about the disagreements between the citizens of Koblenz and the Prussian forces, based on ideological and organizational issues
- about the huge fortification system, built in conformance with the most recent findings in fortification technology, protecting the city of Koblenz
- why this fortification system was said to be impregnable by force, so that it could only be compromised by either treason or espionage
- to find their ways through the fortress
- that in 1848, the military forces armed the fortresses in Koblenz in order to awe the civilian population
- about the tasks arming consisted of
- what life was like for the Prussian soldiers who were stationed at the fortresses
- about the uniforms and equipment of the military forces

We decided about these contents mutually with the Head Office for cultural heritage of Rheinland-Pfalz. Simultaneously, we needed to compile an elegant concept to embed this knowledge in the video game. The next section describes our reflections on video game structure and the semiotics (i.e. the study of signs and symbols) this concept was based on.

Figure 1: Authentic virtual simulation of the fortress (left: virtual model; right: real-life building)

4.2. Theoretical Reflections on Video Game Semiotics

4.2.1. Semiotic Layers within Video Games. How does one embed knowledge into an educational game in a subtle and elegant way? In order to answer this question, one has to understand the semiotic structure of video games and elaborate adequate "information carriers" within them.

Within the emerging field of ludology and game studies, there have been several theoretical approaches to video games. Scientists refer to them as theatre, cybertexts, rule-based systems, simulations and second-order cybernetic systems [22], [23]. Nevertheless, these approaches do not fulfill our needs. They mainly refer to the nature of video games instead of their inherent "information carriers" we need to merge learning contents with.

Fabricatore proposed that, in order to overcome the gap between content and gameplay, educational game designers should embed knowledge naturally and with contextual relevance into gameplay [21]. We strongly agree with Fabricatore, but unfortunately he does not go into detail deeply enough for our purpose. Furthermore, there may be more information carriers than just gameplay. A promising and more detailed semiotic framework, suitable both for game analysis and design, was introduced by Lindley [24]. He refers to video games as ludic systems involving three layers of encoding, each having different tradition, language and methodology: game play, narrative and simulation. Various game genres may focus on different layers (cf. figure 2). According to Lindley, the *simulation level* addresses basic features and functions of the game world: It is “the level at which the authored logic and parameters of a game system together with the specific interactive choices of the player determine an (implied) diegetic (i.e. represented) world” [24]. Logic and parameters include, but are not limited to animation, physics, NPC (i.e. non-player character) behaviour etc.. Moreover, this layer of semiotic encoding is based on the “generative substrate”, an underlying set of rules, functions and constraints, developed by the game designers. Simulation games like Spore [24] or Civilization [25] lay stress on the simulation level. The second semiotic level is the *game layer*. Lindley follows Juul’s [1] perspective on games when he refers to the game layer as a “framework of agreed rules” [24]. Thus, game rules define the possibilities and boundaries of what a player can legally do while playing a game. They also specify the consequences of player actions. Many abstract games like Pong [26] concentrate on the game layer. The third level of semiotic encoding is the *narrative layer*. Lindley defines narrative as “a representation of the causally interconnected events of a story” [24]. According to Lindley, a common narrative structure of computer games consists of three acts: establishment of conflict, playing out its implication and solving the conflict (for a detailed description of story various structures also refer to [27]). Games like hypertext Adventures and game books (their analogue equivalents) focus on the narrative layer of game systems.

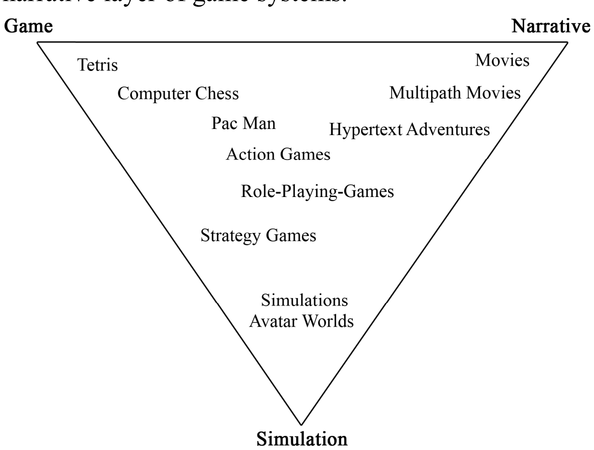

Figure 2: A classification plane based upon time form in ludic systems by Lindley [24]

With his three-layer-system, Lindley provides a helpful framework for our work. He breaks down computer games into different semiotic levels and thereby reveals adequate information carriers. As a result, we decided to merge the educational content of the learning game as closely as possible with the simulation, narrative and game play of the game system.

4.2.2. Expectations on Player Reactions. Embedding knowledge deeply into the semiotic layers of video games may lead to a good educational game design. Therefore, we believe to have found an effective approach to preserve game structure and entertainment. If educational games suffer from poor combination of learning content and game structure, thereby corrupting fun and entertainment, subtle and elegant knowledge embedding should help educational games to provide more motivation.

However, at this point, we started to be concerned about the didactical impact of our game. If we hid knowledge deeply within the game, would players still regard the items they encounter as relevant educational content? With reference to the impact of violent media, there seems to be no learning transfer from the game into the real world in most cases [28]. Some scientists trace this phenomenon back to mental structures referred to as *schemata* [29], [30]. With the help of schemata, an individual organises information and knowledge as abstract cognitive structures, thereby applying meaning to them. Moreover, the organisation of information and therefore its meaning to the individual is highly dependent on the situational context where the information was gathered. *Cues* affect identification and definition of the situational context. Thereby, they direct *framing processes* by which an individual links the information to a cognitive schema [31]. In brief, situational cues have an effect on the framing processes, thereby affecting knowledge acquisition. With the abovementioned subtle, entertainment-preserving design of our game in mind, we were led to a new question: If our learning game lacked cues indicating “This particular piece of information is educational content”, would players still link them to cognitive schemes regarding the real world? Or would they interpret the information as irrelevant to the real world, thereby overlooking the learning content and missing the embedded knowledge? Accordingly, we revised research question no. 2 and divided it into two separate questions:

2a) Can such a game motivate players more effectively?

2b) Do the players gain all the knowledge we put into the game? How do they frame the information embedded in the semiotic layers? What cues affect the framing processes of the players?

4.3. Game Description

4.3.1. Game Technology. The Eduventure-II-prototype is a modification [32] of the role-playing-game *Oblivion* [33]. With the game structure evenly distributed among all three semiotic layers of encoding (cf. figure 2), a role-playing game (“RPG”) served our needs best. However, we did not have the resources to build an educational RPG from scratch, so we decided to modify an existing game. Oblivion seemed like a fair choice because of its available “modding” tools and its progressive technology (e.g. graphics rendering, facial animation of NPCs, support of heightmaps and so forth). Custom virtual models were built and textured using 3ds Max [34]. Bethesda’s modding tool “The Elder Scrolls Construction Set” [35] was used for level design and the scripting of the gameplay.

4.3.2. Game Concept. The gameplay and story of the Eduventure II is similar to a classic RPG. Within the game, the player assumes the role of a thief, being hired by an éminence grise to infiltrate the Prussian fortress Ehrenbreitstein in the town of Koblenz during the Revolutions of 1848 in the German states. His objectives are to gather as much knowledge about the Prussian forces as possible, to capture the contents of a mysterious box brought to the headquarters of the fortress in addition to finding vulnerabilities in the Prussian system of defence. To accomplish this, the character joins a group of civilian workers. Together, they arm the fortress against potential attackers. Next, he waits for the night in a hiding place. After sunset, he sneaks through the fortress, searching for an adequate uniform he could wear during the day. Having found a uniform, he is able to enter the core of the fortress and finally fulfil his remaining objective.

This gameplay experience contains the educational content that were described in section 4.1, distributed over the three abovementioned layers of encoding. On the *simulation layer,* we encoded information about uniforms, equipment, architectural structures and tasks regarding the arming. For example, uniforms and virtual models are authentic (cf. figure 1). Also, civilian labourers working in the outer areas of the fortress illustrate some of the tasks that come up with the arming of the site. Furthermore, we encoded information on the *narrative level*. Story and virtual characters contain knowledge about the background of the revolutions, the conflict between civilians and Prussian forces, and what life was like for a soldier working at the fortress. For instance, dialogs with labourers and soldiers reveal details about the differences between the civilians and military forces. Also, some NPCs functioned as archetypical characters, demonstrating the rough mentality of the Prussian occupying forces. In addition, the recruitment of the player character as a secret agent (and therefore the initial point of the story) is linked directly to the political background in 1848. Moreover, we embedded educational content on the *gameplay layer*. Knowledge encoded on this layer includes Prussian fortification strategy, tasks the arming consisted of, as well as Prussian uniforms and equipment. For example, the player has to select an authentic uniform which disguises him as a Prussian soldier. Making the wrong choice would result in getting caught. Furthermore, the player has to fit into the group of civilian labourers he joined, assisting them with the tasks coming up as the Prussians arm the fortress. Last, but not least he has to investigate and exploit weaknesses within the fortification system in order to advance to the fortresses headquarters.

The purpose of this section was to offer a glimpse of the Eduventure’s game structure and knowledge encoding. The next section deals with some of our findings on test player reactions and describes what we learned from the making of the prototype.

Figure 3: A virtual Prussian soldier guarding the outer area of the fortress

5. Conclusion

5.1. Findings Regarding Player Reactions

Due to a cut of funding, our findings on player reactions rest upon occasional, informal observations with only a handful of individuals instead of a methodologically elaborated, quantitative evaluation (cf. also section 3). Although this may lead to a lack of validity (considering statistical standards), our first experiences seem to confirm both assumptions regarding reduced knowledge acquisition and increased motivation due to coherent game design (as mentioned in section 4.2.2.).

The graphical quality of the game engine seemed to attract young people. When presented an early version of the Eduventure at the computer expo “Cebit” in 2007, the prototype was as an eye-catcher. Young people (ages 8–12) were curious on their first impression and enjoyed the aesthetics of the virtual fortress and characters. The players did not know about the educational purpose of the Eduventure. They just moved around the virtual territory and interacted with the game for the sheer fun of it. Unfortunately, it is an open question if they recognized the educational contents of the game and thereby gained knowledge. However, they clearly had fun playing the game and were not “scared away” by stilted and artificial game design (cf. section 2.3). Thus, the Eduventure’s approach to educational game design seems to preserve game structure and entertainment.

Older students, who knew about the didactical intentions of the game, reacted differently. Apparently, they expected a distinct presentation of educational content, which they could not find. For instance, one student played the tutorial (introducing the background of the story and the recruitment of the player character) and the first mission (assisting the civilian labourers with the arming of the fortress) and then asked: “Okay, what am I supposed to learn from that?” Something similar happened with a different person. After watching a short mission of the game the person asked: “Now where is the educational content?” Concerning our goal to overcome the gap between educational content and gameplay in order to preserve entertainment and motivation (cf. section 2.3), this is a positive result. Subtle educational game design prevents the game from becoming “teacherized”, thereby supporting motivation and entertainment. However, when it comes to instructional potential, the subtle game design may cause players to overlook educational content: As mentioned in section 4.2.2, clues play an important role within cognitive framing processes, thereby affecting knowledge construction. However, in order to preserve game structure, the prototype did not contain distinct “educational” framing clues. This may be the cause for some players misinterpreting most game elements as “not educational”. It is still unclear if this, compared to conventional educational game design, leads to reduced knowledge acquisition.

In conclusion, subtle educational game design, which embeds knowledge into gameplay, story and simulation, preserves game structure, thereby entertaining and motivating players. However, compared to conventional educational game design, this approach leads to different framing processes. For now, it remains an open question if and how this affects knowledge acquisition.

5.2. Educational Game Design and Evaluation

We experienced that in practice, theoretical thoughts may lose some of their discriminatory power. Lindley’s framework of semiotic levels in video games is a great tool for analysis and reflection, but in practice, borders between layers may become blurred. For instance, gameplay and narrative layers are meshed in a role-playing game: The plot produces new playing objectives, which, in turn, have impact on the story. In some situations, the choice between two layers of semiotic encoding is more of a theoretical nature, as the practical game experience seems to be a mixture of semiotic layers. This raises the issue of evaluation methods. If one likes to measure the impact of a specific semiotic layer on player reaction (e.g. “Does it make any difference if we embed the knowledge in the gameplay instead of the narrative layer?”), he must make sure to keep these layers apart from each other in practical gameplay. Otherwise, one would produce measurement artefacts, thereby reducing the significance of his research results.

Apart from that, there are other factors influencing the impact of educational games. Scientists point out that not only the content, but also the amount of video game play, as well as interaction mechanics, have significant effects [36]. Furthermore, some contents may receive more attention than others, which leads to yet another influencing factor. We realized that, when put together, narrative, simulation and game play items may bias each other. As a result, during gameplay, one piece of educational information may not receive as much attention as another. For us, these effects were hard to foresee in advance, and we could only review them during the making of the game.

Last, but not least, we learned to appreciate the work of professional game designers. Though having decent experience in both playing video games and theoretical background, our team encountered difficulties in the design process. Good game design is a hard piece of work, and linking it with educational content makes things even harder.

Exploring the instructional and motivational potential of subtle game design (i.e. one that uses different layers of semiotic encoding) requires a working, well designed game with high discriminatory power. When it comes to complex games (like an RPG as used within the Eduventure II project), one has to invest quite a bit into the prerequisites before beginning with the real research. For this reason, our future work will most likely concentrate on less complex game genres like casual games or browser games. Moreover, we would encourage interdisciplinary projects, bundling resources and competencies of academics (from both educational and computer science) as well as professional game designers.

5.4. Future Work

The topic discussed in this article needs further research. Framing processes and knowledge acquisition within computer games are highly complex, theoretical concepts. For example, not only the game design and method of knowledge encoding may function as clues used during the framing process. The social and situational context in which the player encounters the game may play an important role, too.

The same holds true with our experiences in motivational aspects of the prototype. Embedding knowledge into the layers of the ludic system appears to be a promising option for preserving the flow of the game, thereby providing motivation. However, this field also needs further investigation and elaborated evaluation.

Further research on this topic will need …

- a theoretical framework covering both cognitive clues / framing processes and their impact on knowledge acquisition and entertainment
- statistically valid empirical methods for measuring learning outcomes and video game related motivation
- a distinct, elaborated evaluation scenario and a well-designed, educational game, meeting the requirements of the theoretical framework.

These aspects will be an issue in one of our team's research oncoming project, which explores the relationship between motivation and knowledge acquisition on the basis of cognitive framing processes.

Figure 4: Oblivions rendering engine produces great visual results

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