Utility Games – gaming as a design strategy to achieve utility effects

The objective of this study is to introduce the concept of utility games, to develop a characterization of such a game category, and to explore design and evaluation issues particular for this category. By utility games, we refer to games predominantly designed for utility purposes, and where gaming is viewed as a design strategy to achieve the utility. Four utility games were analysed, with the following dimensions: the overall context, the utility objective, the game setting, evaluations performed and challenges related to design and evaluation. The analysis shows that the utility aspects and the game design are highly interrelated and affect each other on all levels of the design, and that evaluations of utility games have many dimensions to consider. A summary of lessons learnt and some recommendations to utility game designers are provided.

Keywords: Utility Games, design strategy, utility effects, gaming, educational games.

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Introduction

Computer games have become one of the fastest growing and most economically successful kinds of software (Zaphiris & Ang, 2007). This success is, according to (Dickey, 2006), because they are designed to engage players. This engagement is desired in many other situations, such as learning or training situations. Therefore, game designs are being re-used for purposes other than entertainment (Raybourn, 2005). The idea is to use the power of engagement that gaming can result in, for useful purposes besides amusement. This combination of utility and gaming, has potential to attract acceptance beyond pure entertainment gaming for those not devoted to gaming already, because of the utility component. To incorporate an entertaining dimension to required activities, do not only enhance the experience but can also increase the result of the activity (since we usually do better when we have fun).

The objective of this study is to introduce the concept of utility games and utility gaming, and to develop a characterization of such a game category. By utility games, we refer to artefacts with a primary utility purpose for the user, rather than for others purposes described in Ahn (2006), which is of no or little utility for the user. Such other purpose can be to solve complex computational challenges by distributing the task to online players. In utility games, the primary goal is to have utility effects for the user. The gaming aspect is secondary and represents *the mean of achieving the primary goal* rather than as the goal itself (as for pure entertainment games). We use the concept in a similar way as Kangas & Cavén (2004) and educational games are examples of utility games.

Utility Games are closely related to the notion of "serious games", which is according to (Raybourn 2005) applications of interactive technology that extend far beyond the traditional videogame market, and which focus on games in for instance education, training, health, public policy (Zaphiris & Ang, 2007; Rayborn 2005). These games are designed to be entertaining, but include serious elements in the games, or use existing games for utility purposes. An example of the latter is presented in (Guy, Bidwell & Musumeci, 2005), where simulation games are used for town planning purposes. The distinction in terms of resulting games is not always apparent; the difference originates in the view of the game's role and the consequences this have for the design process. Utility games go one step further towards utility compared to serious games since they are predominantly designed for utility purposes, and the entertainment aspect is included as a motivating factor rather than as the overall aim. Consequently, for utility games we take the perspective of viewing games *as a design strategy* to meet the requirements of the utility activity.

The research goal of this paper is to develop an understanding of the particular category of games we refer to as utility games, and to explore design and evaluation issues particular for this category. This goal is addressed by

- developing a model of characteristics;
- using the model to analyse empirical examples; and
- exploring design and evaluation issues related to this type game category.

The work is a step towards a utility game genre description, and towards design guidelines and tailored design and evaluation methods for utility games

Method

The method used is a meta analysis based on design cases of utility games. The approach is inductive and explorative in nature, and the categorization dimensions have developed during the investigation. The following aspects of the utility games were analysed:

- **Overall context**: The games were characterized according to their *utility class* (what type of utility is aimed for), the *utility domain* (which area the utility belongs to), which *user group* the game is aimed for and which *use situation* it is intended for.
- **Utility objective**: The objective of the utility was broken into the *utility goal* (which desired effect that is aimed for) and the *game purpose* (in which way the game contribute to such goal).
- **Game setting**: The game setting includes the *game environment* (in which, virtual or physical, environment the game is played), the *game type* (often referred to as the game genre) and the *game-domain relation* (in which way the game environment relates to the domain, such as simulation for example).
- **Evaluation**: Methods and objective of evaluation were analysed, and results of the evaluations in order to identify evaluation challenges.
- **Design and evaluation challenges.** The major challenges during the design were identified, and classified according to where they derived from (the *game*, the *game-utility relation*, or the *utility*).

In particular the design and evaluation challenges are interesting for developing guidelines and recommendations. However, to be able to analyse empirical-based design and evaluation challenges often require close insight to the particular design process, which is difficult to have without participating. Therefore, the selection of cases is based on the author's involvement in the designs.

The four Utility Game cases

We base our analysis on four different prototype utility games, which differ in many respects. The games belong to different utility classes, and vary with respect to utility domain, game environment and type, as well as purpose and user groups. The cases are (in fading scale of author involvement): an educational game based on a graphical model of arithmetic (Pareto, 2004), an auditory adventure game for a museum (Pareto & Snis, 2006a), a social simulation game for children with autism (Andersson, Josefsson & Pareto, 2006), and a virtual reality system for stroke rehabilitation (Goude, Björk & Rydmark, 2007).

Utility game 1 – Arithmetic understanding

The first utility game to be considered is an educational game, which covers arithmetic concepts (integers, arithmetic operations, relations between operations). The main users are children learning mathematics at school, but can be used at leisure time and for other user groups as well, for instance individuals with math learning disabilities (Pareto, 2005). The game environment is a 2D graphical microworld which runs on ordinary computers. A microworld is a small, complete model of some domain of interest, intended for learning through meaningful and playful interaction (Rieber 1996). There are four game types with about forty variants of games in total. The games are two-player games, in which human or virtual players can compete or collaborate.

Utility objective

The utility objective is that users should develop a better understanding of the concepts of arithmetic. The game environment focuses on concepts and not computation, and tries to convey mathematical intuition. It must be faithful to mathematics. The game environment is designed to be playful and fun, self-motivating and engaging, and exploratory in nature. The aim is to provide a self-regulating learning situation, for which games are suitable candidates according to Rieber (1996). A visually rich, constructive representation plays a central role in

how people think about objects and concepts (Norman 1993), and thus a graphical game environment where graphical objects are manipulated interactively is a suitable choice.

Game Setting

The main idea with this utility game is to present mathematical concepts in a more concrete and familiar setting than the formal language with digits and symbols. For this purpose, a microworld of graphical objects is designed and used as a metaphor for arithmetic.

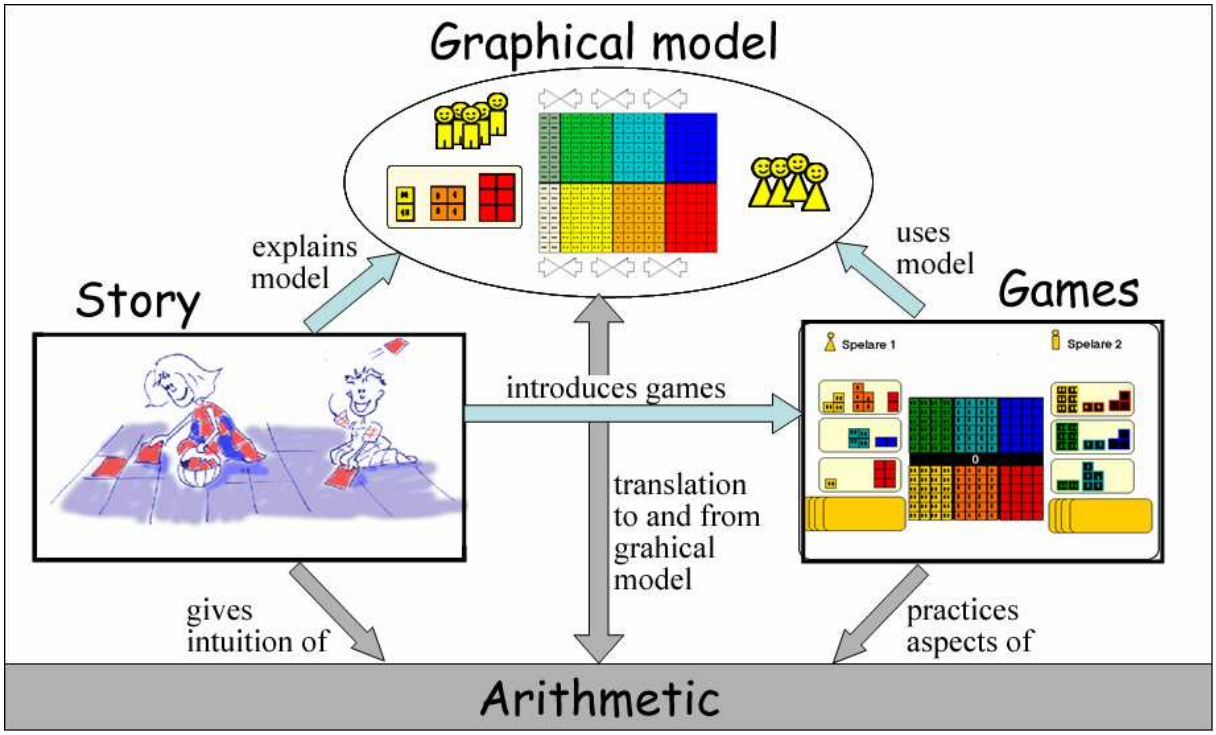

Figure 1 - The microworld of the arithmetic game

The microworld consists of a graphical model, a story and a set of games using the model. The model represents numbers as graphical objects (ones are red squares, tens are orange square-boxes containing 10 red squares and so on), and operations as animated actions on these (to put graphical numbers onto the game board means addition and to remove means subtraction). The game board have different compartment for each unit. Mathematical rules are built into the model, so for instance when the one-unit is full, the red squares must be packed into an orange square-box and moved to the 10-unit. The story explains this graphical model and how it operates: it is about the Squares Family - a family with many children that like to play games with coloured squares on their playground. All games are combined card- and board games, with the playground as game board, and cards containing graphical numbers. In the story, new concepts and new games are introduced. The story explains the graphical model, introduces the games and gives intuition of the concepts involved. Examples are shown in Figure 2: introducing the basic model and the game “within rope” (1), the minus world, i.e. negative numbers (2), and the decimal system (3).

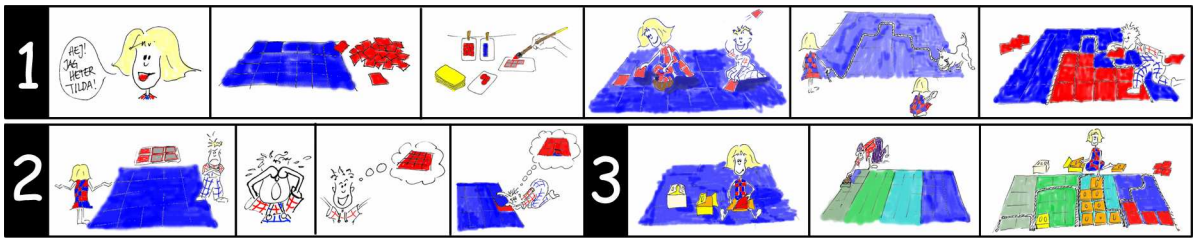

Figure 2 - Example storyboards from the arithmetic game

Each game is designed to practice a particular concept, aspect or problematic area in arithmetic, including number sense, the decimal system and relations between operations.

Evaluation

The arithmetic utility game is developed with extensive user involvement and formative evaluations throughout the project. These include interviews with children and teachers concerning mathematics and computer games, and concept evaluation tests concerning usability and playability. At three occasions 50-70 children at age 4-12 tested various stages of the game environment prototype. A comparative test aiming at mathematical understanding has also been conducted, and further studies will be performed in the fall 2007.

Figure 3 – User tests

Results from the evaluations indicate that the young children manage the easier games, whereas the older plays the difficult ones with various level of strategic thinking. All children understand the games much faster than any adult who tried! Almost all children enjoy playing the games and find them fun and challenging. Children's performances in the games are not in accordance with their performances in school math, there were examples of children doing poorly in school math (as judged by their teachers) who performed extremely well in the games. The first study of mathematical understanding indicate that the test persons managed to do exercises in the graphical model as well or slightly better than with numbers and symbols, after a couple of hours of playing the games. To summarize, usability and short-term playability has been confirmed in tests, whereas the main utility effect of gaining better long-term mathematical understanding remains to be shown.

Design and evaluation challenges

During the development, we have faced and are facing the following challenges regarding design and evaluation of the arithmetic understanding utility game:

1. To design the metaphor so that the translation arithmetic – graphical model is both sound (everything in model corresponds to something meaningful in arithmetic) and complete (everything in arithmetic is represented in the model). Soundness is necessary, completeness desirable. *(game-utility relation)*
2. To balance the game designs to both practice important aspects of arithmetic, and to be interesting enough as games. *(game-utility relation)*
3. To make the games fair to both players, i.e., to ensure equal opportunity to win *(game)*
4. To design the story so that it both comply with mathematical intuition and is coherent as a story. *(game-utility relation)*
5. To assure transferability of knowledge acquired within the metaphor to ordinary mathematics. *(game-utility relation)*
6. To evaluate the effect of deep mathematical understanding. *(utility)*

Utility game 2 – Cultural awareness

The second utility game is an auditory adventure game designed for a regional museum. The museum provides exhibits reflecting the local culture, local handicraft and artworks. The game takes place in the museum's exhibition halls and uses the physical environment together with a location-aware handheld device with headphones, i.e., an audio-augmented physical environment game. The games will be available for loan by visitors of the museum, as an additional activity to do during the visit. To be appropriate for the situation of a museum visit, the games should not last more than one hour and are played in pairs or a small group. Single players can play the games but then the social dimension and immediate discussion is lost.

Utility objective

The museum's ambition in this project is to attract more visitors and to provide enhanced experiences for their visitors. The original focus in the project was to increase accessibility for disability groups (Pareto & Snis, 2006b), but in doing this we saw the potential of designing utility games on the same technical platform to enhance the museum visits.The museum is frequently visited by children and teenagers, as part of school projects or at the spare time accompanied with adults. Despite this, most of the exhibitions are still arranged around visual artefacts with written fact-based information, which is far away from the entertainment this group is used to. The purpose of the games is to stimulate in particular young visitors to curiosity and to engage with the exhibitions in a more active way.

Game Setting

There are three prototype game applications so far covering different areas of the museum, aiming for families, teenagers and Swedish-learning immigrants, respectively. The prototypes are developed by digital media students in close collaboration with the museum. The games are of adventure type with interactive non-linear narratives involving a pre-defined selection of objects in the museum. The players walk around with the device in the environment equipped with identification tags which tells the device where it is. The appropriate auditory information is transmitted to the players when at the location of an information-equipped object. The adventure stories are arranged around a given goal, as seeking for a treasure among the artefacts, and the players receive pieces of information when approaching the objects involved in the game. Objects in the museum are often used as characters in the stories, for instance the knight in armour or the sea star (see Figure 4). The objects can be visited in any order. Each object has several pieces of information associated with it, and the one selected depends on where the players have been and which sub goals have been solved at that point. The purpose of the narratives is to build up the adventures, and at the same time provide interesting facts about the artefacts.

Evaluation

The prototype adventure games have been tested for usability and playability by representative users (3-5 groups per game) and specialist teachers of the corresponding groups have judged the pedagogical aspects of the games. The test groups played the games while we performed participatory or non-participatory observations during the test. Individual or group interviews ware conducted after each test, by the observant.

Figure 4 – User tests of adventure games at museum

The tests indicated some usability issues with the current PDA prototype, but the playability and the entertainment value was considered very good for the family game and good for the other two games. The family game was originally too long, one group did not manage to solve the mystery within 1 ½ hour, and therefore that story is now shortened to fulfill the requirement to be playable within one hour. All test persons thought the games were fun and enhanced the exhibitions substantially. The teachers considered the games to be valuable pedagogical additions to a museum visit for their students. The prototypes are presently available for further evaluation by ordinary visitors in the museum.

Design and evaluation challenges

The following challenges were identified:

- To invent interesting, coherent stories around specified artefacts in accordance with historical and cultural knowledge of the artefacts. *(game-utility relation)*
- To mix fact-based information with fiction without loosing credibility of the facts. *(game-utility relation)*
- To design non-linear narrative stories that was sensible to traverse in any order. *(game)*
- To provide equipment that supports both needs of individual listening and social interaction. Isolating headphones was used to support required concentration on auditory information in a non-quiet environment, which were partly removed during discussions.

Utility game 3 – Social training for children with autism

The third utility game concerns social training for children and adolescents with autism, in a 3D virtual environment with scenario-based game-like activities. Social training includes everyday social situation scenarios, such as going shopping, taking the bus or visiting a café. Virtual Environments has shown great potential for training social skills and social competency increase quality of life and reduce the need of care. General educational software is rarely suitable, since content at an appropriate level is often too childish. Furthermore, autistic children do not usually follow common developmental patterns, and can be very skilled in specific areas. The challenges are due to the heterogeneity of needs and capabilities combined with the intolerance to improper levels of difficulties typical for this target group. Since social interaction often is difficult for the users, the games are played alone with support from human supervisors or agents in the environment.

Utility objective

The utility objective is to practice every-day social skills, in a safe and controlled environment. The purpose of the virtual environment is to enable repeated practice of the same scenario, to control the level of difficulty and the characters behaviours, and to provide a safe environment to practice in for the autistic child (no human un-predicative reactions).

Game Setting

The 3D environment is a simplified simulation of every-day social scenarios, based on role-playing with virtual characters. The user plays the role of one of the characters in the scenario. The scenarios are shown in first person perspective, to help the user associate with the character (autistic children have empathy difficulties). All tasks must have clear and explicit goals. The explorative nature of many game environments is not suitable for autistic children, since they often have great difficulty handling open choices. We have identified eight critical design parameters that need to be adjustable in the environment, *independently* of each other. These include environment characteristics such as level of richness in details and exploration freedom, and scenario characteristics such as level of difficulty in scenario content, number of steps and alternative paths. Understanding autistic behaviour and its implications for the game design, was much more intricate and involved than we first anticipated. At this point there

exists some sample scenarios (see Figure 5), but the game environment is not yet developed enough to be tested with intended users.

Figure 5 - Sample scenario and level description of social training virtual environment

Evaluation

To evaluate the design requirements on the game environment, an estimation test was conducted. The critical design parameters importance, their variation range, as well as the need for *independent* adjustment of these were estimated and verified by experienced specialist (autism) pedagogues. All specialists confirmed that the full spectrum of levels represented by the parameters was needed. They repeatedly expressed the importance of flexibility and adjustment, and the idea with independent adjustment of the parameters was much appreciated and desired.

Design and evaluation challenges

During the conceptual design, we identified the following challenges:

- To understand the implications of user needs to game design. *(game - utility relation)*
- To invent interesting and fun enough exercises that illustrate natural social interaction *(game - utility relation)*
- To construct the environment with flexible enough parameters. *(game- utility relation)*
- To assure transferability real world situations. *(game - utility relation)*

Utility game 4 – Stroke rehabilitation

The fourth utility game is a virtual reality workbench with haptic interaction, used for stroke rehabilitation (Broeren et al., 2006). The stroke patient practices hand and arm movements and cognitive skills by playing 3D games at the workbench. The user steers the games in 3D and gets force feedback from the haptic device. User movements are logged and analysed in the system. These analyses are used for progress reports to rehabilitation personal as well as for the patient. The system is suitable for patients who need physical training of upper limbs or cognitive training, and is intended for daily use at rehabilitation centres or in the patient's home.

Figure 6. Stroke workbench

Utility objective

The utility goal is to rehabilitate stroke patients. The purpose of the workbench is to provide a stimulating environment for doing exercises beneficial for rehabilitation, and to provide an administrative tool for individual exercise planning and progress analyses.

Game Setting

Encapsulated in the haptic workbench, is a library of games (Figure 7). Currently, about twenty games have been produced, including upper limb exercises and coordination-training activities (Goude, Björk & Rydmark, 2007). The purpose of using games is mainly motivational: any

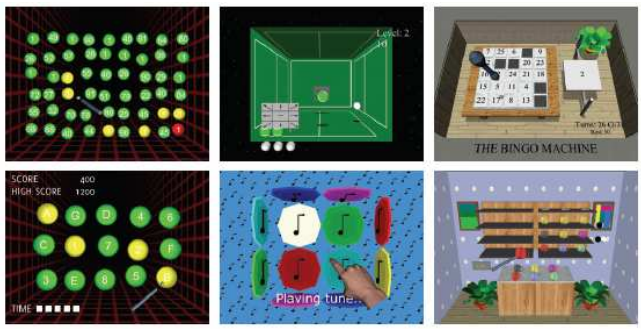

Figure 7 - Game library examples

activity that yields appropriate hand movements and cognitive training could be used. However, to achieve rehabilitation effect, repetitive long-term usage is often required and games are good candidates to pursue such behaviour.

Evaluation

For a rehabilitation system, the treatment effect is of main concern and must be validated in medical studies, for instance (Broeren et al., 2006). The system has been tested in laboratory setting, which indicates that patients enjoy working with the VR/haptic equipment and the system is usable in this setting. Usability of the system in a non-specialist health care context is currently tested. This study will also indicate motivational aspects and playability of the games in a real situation. Long-term motivational effect is yet to be established.

Design and evaluation challenges

The following challenges have been discussed with the designers:

- To select games based on value for rehabilitation training *(game - utility relation)*
- To match needed training with user interests *(game - utility relation)*
- To keep the long-term motivation for playing the games *(game - utility relation)*
- To configure and fine tune games relative to progress *(game - utility relation)*
- To use open source games with a haptic encapsulation interface (game)

Results of analysis

The result of classifying the utility games according to the characteristic model is as follows:

Table 1 – Characterization model

	Utility game 1	**Utility game 2**	**Utility game 3**	**Utility game 4**
Utility class	Learning	Learning	Habilitation	Rehabilitation
Utility domain	Arithmetic understanding	Cultural awareness	Social training	Stroke rehabilitation
User group	School children	Young museum visitors	Children with autism	Stroke patients
Game environment	Virtual microworld	Audio augmented physical environment	Virtual 3D Environment	Virtual Reality with haptic interaction
Game type	Board- and card games	Adventure games	Role-playing	Any that require interaction movements
Game-domain relation	Metaphorical	Augmented narration	Simulation	Haptic encapsulation
Utility goal	Understand arithmetic concepts & relations	Learn about museum objects	Practice social interaction	Rehabilitate physical and cognitive abilities
Game purpose	Stimulate mathematical & cognitive reflection	Stimulate curiosity of cultural objects	Repeatedly practice in safe environment	Stimulate physical and cognitive exercises
Use situation	School-leisure	School-leisure	Health care - leisure	Health care - leisure

The table shows that the cases illustrates various instances of the characteristics in most dimensions, and can therefore be seen as reasonable representations for the analysis.

The analysis of viewing gaming as design strategy to achieve utility yielded the following results:

1. *The game can have different roles in the overall system.*
    a. The game part can have different purposes in the overall system, e.g., to motivate long-term usage, to invoke curiosity of conceptual reflection or to provide an unthreatening environment.
    b. The relation between the game part and domain can vary, e.g., it can be metaphorical, an augmented narration, a simulation, or a haptic encapsulation.

2. *The motivational force is a combination of the utility fulfilment and the entertainment value*; it is the combination which is powerful. Therefore, it should be valued accordingly and the entertainment value should not be compared to pure entertainment games, it should be compared to other ways of achieving the utility effect.

3. *Evaluation of utility games should reflect all aspects of the games*: that is basic usability, the motivational effect of the game as well as the utility effect. These aspects must often be evaluated separately, and the order depends on the particular utility game. However, all three are needed to assure the overall objective with utility games.

4. *The utility goals and the game design are highly interrelated*. The utility goals can set requirements on most aspects of the game design. It can set requirements on the
    - game type: social training is based on dialog and therefore is a role-playing game type appropriate, and the games used for stroke rehabilitation must be compatible with the haptic device.
    - game world: the graphical model in the arithmetic microworld must be translatable to arithmetic, and the game world for autistic children should provide different levels of details in the presentation.
    - game story: the story should comply with mathematical intuition (math game), should involve pre-determined objects (museum game), or should provide the same story in several adjustable levels (autism VE).
    - game goals: it should be reasonable to finish within one hour (museum game), or the goals should be expressed in different levels of explicitness (autism VE)
    - interaction models: the interaction should require certain movements such as precision, follow paths, or speed (stroke rehabilitation), or the interaction model should give positive feedback to correct behaviour and nothing to erroneous to be suitable for autistic users.
    - game configuration: the game should be configurable with the respect to the required adjustable parameters, and the arithmetic game should provide varying progression paths and levels.

    Also, the motivational power of the games influences the utility effects: usage is required to get rehabilitation effects, usage is needed to understand the graphical model, and usage is required to get social training, as a result of the utility games.

5. *The balance between the utility and entertainment value in a utility game can vary*. We estimate the balance to be rather equal in the arithmetic game and the stroke rehabilitation system, whereas the entertainment value is more dominant in the museum game and less in the social training game.

Conclusion

To conclude we will summarize some lessons learnt from this study, and give a few recommendations to future utility designers.

Utility domains, user groups and use situations:

Utility games can be applicable to many different domains. Utility gaming means gaming as a mean to achieve some type of utility to the user, and because of this, non-typical gamers can be attracted by these games. New types of gamers include disability groups and people with health problems. Use situations of utility gaming can be organised within educational settings or as training recommendations, as well as voluntarily in leisure time.

Design of utility games

There are two kinds of requirements: utility requirements and game requirements. However, these two sets of requirements must be integrated, which often put additional requirements on the game due to the utility goals.

Designing utility games involves combining design methods from game and experience design as well as from usability and interaction design. Competence in the domain and in game design is needed all through the development, since both competencies are needed at all stages in the design process. This is also acknowledged in (Goude, Björk & Rydmark, 2007), who claim that developing games for VR rehabilitation involves multidisciplinary communication between the medical and game design fields.

It is difficult to design good entertainment games, and the utility aspect put additional restrictions and requirements on the design space and feasible design solution. In the study, most design challenges derived from the aim to combine utility and entertainment effects.

Evaluation of utility games

Utility games should be evaluated from both perspectives: the game experience and entertaining value, as well as the utility effect. The overall value is a combination of entertainment value and utility fulfilment, and therefore usability, playability, and utility effects should be considered from both perspectives.

Usability testing with relevant user group is needed as usual, but there should be a focus on the user experience. User-testing with simulated or real prototypes in the proper context is crucial for evaluating experience-based artifacts (Pareto & Snis, 2006a). Playability should be evaluated, just as for any game. For this, heuristics to evaluate the playability of games (Desurvire, Caplan & Toth, 2004) can be useful to combine with user experience testing. In addition, playability should be evaluated with respect to the role of the game (long-term usage, invoke curiosity, etc). Lastly, pure utility effects such rehabilitation effects need to be evaluated.

Further recommendation to utility game designers

We recommend future utility games designers to consider the following:

- To be clear about the desired utility effect, to estimate the potential of different game types as candidates for achieving such effects.
- To choose game genre and game environment that match the desired utility effect with great care, since this is perhaps the must difficult aspect of utility game design and yet one of the most important. The number of alternatives is waste and it is difficult to predict all consequences of the choice. A perfect match rarely exists, much of the challenge is in balancing utility and entertainment aspects. Game design patterns (Nguyen & Wong, 2002; Björk, Lundgren & Holopainen, 2003) are useful in the selection process to better understand and predict different game types, and later in the game design.
- To be explicit about the relation between utility domain and game environment, in order to guide the design process.

- Be explicit about the purpose of the game related to the utility goal and the type of motivational effect desired, in order to guide the evaluation process.

Finally, as Dickey (2005) we argue that game design is a powerful strategy, and should be considered when developing utility artefacts (not only educational software).

Future work

Future work include developing design guidelines as well as tailored design and evaluation methods for utility games.

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