Game-Based Learning with Computers – Learning, Simulations, and Games

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Abstract. For developing a sophisticated game-based training system it is important to consider both, the technical aspects of game development (i.e. games engineering) as well as the pedagogical aspects of games and technology enhanced learning (i.e. game didactics). How game-based training systems are engineered and how the underlying didactics is realized depends on the target group and on the learning objectives. A game-based training system, which requires a player to learn a wide variety of skills and strategies, has to be elaborate concerning content, interaction, and behavior. In order to describe the game aspects of a game-based training system more clearly, we separate them from engineering and didactic and discuss all three aspects separately. We analyze the components of game-based training systems and sketch useful game concepts for teaching and training. Finally, we describe pedagogical concepts like motivation and transfer, which support game-based learning.

1 Introduction

One question is why computer based games and game-based learning are interesting for research fields like computer science in general and in technology enhanced learning in particular. There are two answers for this question. First, games have a highly motivational character, which is often missing in traditional computer-based training systems. Secondly, computer games are interesting from the software development point of view, integrating diverse aspects like artificial intelligence and simulations, and other approaches e.g. the application of mobile devices (e.g. cell phones or PDA) [41]. Nowadays full price commercial computer games are highly complex software systems, which are developed by multidisciplinary teams. They require long development times, due to increasing demands of players regarding realistic computer graphics, intuitive user interfaces, and

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realistic behavior of computer generated characters (see e.g. [10]). Since game-based training systems are mainly suited for a comparably small target group, the system developers usually cannot afford high budgets like full price games, which are potentially sold millions of times (e.g. The Sims [47]). Although a variety of tools for developing computer games exists for free, it is very demanding to create an appealing game with a small budget. Therefore, sad but not surprising, most of the teaching and training systems come in a comparably boring traditional learning guise.

Also another aspect has to be taken into account: the way the computer has become part of everyday life, and also of education, has dramatically changed over the years. Today's researchers and teachers stem from an era, which might be called pre-digital or at least "early-digital". Most of the people at the age of thirty plus have had no computers at school. In contrast to this, today almost every school-age kid has access to computers – be it at home or at school – and is working (and playing) with it in a quite natural way. It can be said that today's learners already have integrated digital media in their learning process. Prensky has observed this and stated it in [31] and [35]. Moreover, he stated that the old computer games have in most cases nothing to do with teaching and training (games like Poker, Chess or Go are excluded from this observation) [35]. Prensky noted that this has changed over the years due to the growing complexity of computer games. Even if they are developed without a pedagogical focus, today's computer games often support training at different levels, i.e. training of facts, of skills, of behavior, etc.

In the following we will focus on game-based learning with computers, and game-based training systems. We will start in the first section with a terminological delineation and with a closer look at games in general. To allow for a structured analysis we distinguish three essential aspects of game-based learning and game-based training systems:

- Pedagogical aspects, i.e. how to teach and train.
- Technical aspects, i.e. in the context of computer games: computer science aspects, e.g. mobile games, simulation and AI. In the following the focus here is on simulations.
- Game aspects, i.e. what kind of game is used.

Figure 1 shows the interplay of the three parts. In [42], Smith offers a similar comparison, but he has not included pedagogics. Our comparison of systems revealed that only if aspects of all three parts are realized in a training system, it can be called a real "game-based" training system. Leaving out learning aspects creates simulation games, which are either games purely for entertainment or serious games for controlling business processes (e.g. logistic). Leaving out simulation aspects creates mainly simple edutainment games for primary school. Finally, leaving out game aspects, creates simulation for training purposes only. Such training systems are used e.g. for military training (e.g. [33]), pilot training (e.g. [11]), and even in the medical domain (e.g. [23]).

With Prensky's work in mind and based on the distinction between different types of teaching and training systems described above (and in figure 1), the

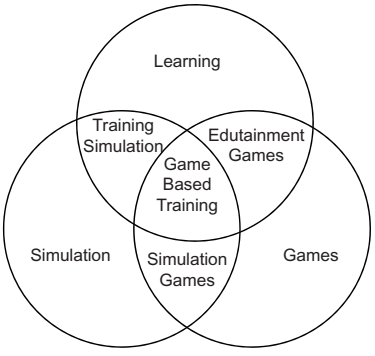

Fig. 1. Interplay of pedagogy, computer science and games

following questions arise: what is a pure computer game and what is a game-based teaching and training system? This question will be pursued in section two.

In [35] Prensky distinguishes between different types of games. He separates so-called "minigames" from complex games. Minigames are based on a trivial structure. As a game-based training they can only be used to teach and train facts. In contrast to this, "a complex game requires the player to learn a wide variety of often new and difficult skills and strategies." [35] The distinction between minigame and complex game thus takes place regarding the pedagogical complexity on one hand and the complexity of used computer science techniques on the other hand. Complex computer games are often based on simulations. In section three, the role of simulations in game-based teaching and training systems will be explored in more detail.

Not only the complexity of a teaching and training game plays an important role – also the size of the group, which will participate on the game, influences the selection of strategies. There are some pedagogical strategies, which lend themselves for specialized education in small groups. Other strategies must be used if a big and heterogeneous group takes part in a lecture. Especially game-based learning has to be carefully adapted to the intended group size and group structure. In most cases, game-based trainings with the wrong pedagogical concept can only reach small parts of a big heterogeneous group. What kind of didactics must be used for game-based learning and how can game-based learning support the transfer from game to reality or keeping the learner's motivation at a high level? Possible answers to this question will be given in section four, followed by a concluding discussion in the last section of the paper.

2 Game-Based X and Games

When looking at the comparably young field of computer based games for teaching and training, a large number of terms can be found: game-based learning

and educational games, game-based training and digital games, training games, serious games etc. Given this amount of terms, this section shall start with a terminological delineation. Afterward we will look at different aspects of game-based training system development.

2.1 Game-Based X

The term game-based learning (GBL) is most commonly used for learning with games in the broad sense. This term is not necessarily related to computers, as game-based learning has a very long tradition in theory and practice of pedagogy and psychology (e.g. [17], [49]). Game-based learning can be found in early education, e.g. in kindergarten and at primary school (e.g. [9]). Children learn and train almost everything in a game-based manner. Game-based learning can take place with educational games – these are games specifically designed for educational purposes. Some of them are realized as computer games. For example, writing and first aspects of mathematics (e.g.[18]) are taught with educational games, and foreign language education can start in a playful manner, sometimes via song singing, sometimes by role play, classics education can take place by support of a website (see [8]). Small children train their social skills in games. Even in fields like biology or history, facts are presented in games and stories. Naturally, educational games can be computer based. This aspect will be focused in this article.

The term game-based training is often used as a substitute for game-based learning, especially if "training" is focused instead of the "learning". Surprisingly, this often takes place when adult education is addressed – the connotation exists that adults "train" to do something, whereas kids "learn". The term game based training system (GBT) is in most cases related to computer based training environments. The term training game often means the same, but also includes non-computer games. These systems are usually used in later stages of education, especially in adult education. Often, these GBTs are not even perceived as games. For example, case-based training (e.g.[29]), role-play (e.g. [32]), and storytelling (e.g. [7]) are part of game-based learning approaches in adult education. Case-based training is often used at Universities in medical, business, and in law education (e.g. [25]). Teaching and training based on role-playing is used in business, but also in management training, in psychology, and in seminars (e.g. leadership or communication seminars) (see e.g. [42]). Whereas the main purpose of computer based game-based training systems is teaching, from the engineering perspective quite a lot of them are based on modeling, simulation, and artificial intelligence (AI) techniques. Simulation of complex models and AI enable training systems to show reactive and proactive behavior. They allow the learner to act and interact with flexible and adaptive content and virtual characters, which can show quite realistic behavior.

Digital games are usually video, computer, or mobile games (see e.g. [4]). These games are not primarily designed or developed for educational purposes.

Even these games lead to some sort of learning, but this is not focus of our article. We focus on what is also called serious games [3] – these are the games developed for non-entertainment purposes. The term occurs in the late 1990s in the Anglo-American region. Located at the interface between entertainment industries and serious business training, it is used to contrast the traditional games for playing with the more serious educational approach.

2.2 Is It a Game?

The term game is traditionally often associated with winning or loosing, especially in the field of not-digital games. In Artificial Intelligence, but also in Bussiness Sciences, Social Sciences, and in Mathematics, game-theory has an important part in research. Salen and Zimmerman [38] give a good overview over different kinds of games, the related cultural and psychological aspects and approaches, and relations to fields like game-theory, information theory, and system theory, to name but a few. This field is much to broad to be covered in a single article. Thus, we keep our comparably narrow focused on the relation between what we call here "game-based" and the related special training systems, with our background in computer science and pedagogy.

As mentioned in the introduction, the development of a teaching and training system takes place based on pedagogy and computer science. If the system shall be "game-based", then game's aspects have to be integrated as well. Depending on how much of each of these three overlapping fields will be used (see figure 1), the system can be perceived to be a "game" or a "game-based training" system.

Nowadays, it is sometimes discussed that learning also takes place in playing computer games (see e.g. different articles at http://www.markprensky.com). The intention of a pure computer game is primarily having fun – but internally, these games often require the development of knowledge and of a certain strategy to reach the next level (see section 4.4). Even if it cannot be denied that this requires learning, the question remains what is learned, why is it learned, and which parts of this knowledge are transferred from the game to the real world (see section 4.4). Next to keywords like motivation and transfer, which will be discussed later, one of the keywords in the development of a game is intention: the intention of a teaching and training game is to facilitate acquisition of knowledge in a playful way, based on a clear pedagogical strategy [1]. The game-like part of the teaching and training system shall help to keep motivation of the learner at a high level. Todays learners often play complex computer games. Prensky [32] assumes, that these learners might be better motivated to learn with a teaching and training system based on game technology, as these game-based trainings are (at least) more interesting than traditional ones.

The decision whether to construct a pure game, a game-based training system, or a teaching and training system (ignoring the game aspects) must take at least the following aspects into account:

Teaching and training content: Not every content lends itself for realizing a game-based setting. A rule of thumb can be: teaching and training in a

game-like, playful way can be used if a mere demonstration of something does not support the learning of facts, relations, and rules. This can for example be training of behavior. Training of knowledge and behavior in a game-based close to real life situation can encourage learning, as many aspects of reality are combined with the safety of the computer environment. An example is case based training in medicine [24]: students can train treatment processes without endangering patients or destroying expensive laboratory equipment. A game-based training system which supports this kind of learning can be used to complement classical teaching and training, and helps to deepen the acquired theoretical knowledge. Thus, if it is possible to develop models of close to real life situations, the realization of a computer game-based training system might be a good idea.

Learning theory: Role play and case-based teaching and training are examples of approaches, which quite naturally lend themselves to be realize in a game-based training system – meanwhile, as computer technology also allows for virtual interactive role plays, this is also possible in a computer based approach (e.g. Second Life http://secondlife.com/) . Another classical example is training with a microworld [40], which can be seen as a small world in a sense that it provides a closed environment which functions based on its own (and sometimes artificial) rules.

Realization as a computer system: From the computer system perspective, a wide variety of games exist. Even a simple HTML based quiz can be interpreted as a "quiz game", which is only a minigame by the categories of Prensky [35]. The more complex a game-based training shall be, the more demanding and sophisticated the used computer science technology must be. Complexity at this level of system development describes the underlying algorithms, the knowledge bases, the user interface, and some other technical aspects. For example, the technique to develop role-play games or role-play teaching and training environments is related to the research field of CSCW (Computer Supported Collaborative Work) [28]. In these settings, non-player characters can be based on certain models, which can be controlled by simulation engines. Another important aspect and future trend will be software engineering of computer games.

Kind of game: From the perspective of the world of games and related research, another level has to be added. This new emerging field is called ludology – a term which comes from the Latin word "ludus", which means "game". Ludology is said to be "the yet non-existent 'discipline that studies game and play-activities' [14] (see: http://www.ludology.org). Taking into account this level, it can be decided in advance, which type of game shall be developed. Examples for structurally simple games are puzzles and quizzes, which nonetheless can also be used in educational setting. Complex games, which are at the border between pure games and game-based trainings are strategic games, role play games, and adventure games. In areas like creativity research and the related learning theories, strategy games (e.g. where it is possible to construct cities, or develop companies or kingdoms) can be used.

3 Computer Science Aspects of Games: Properties and Simulations

When analyzing the field of game-based learning, as done in the previous section, some special properties of computer games occur, which are not easy to categorize. Thus, we have decided to integrate them in the following subsection. Additionally, as the field of computer simulations for game-based learning is a broad field, we offer a short overview and a special categorization of this field in an extra subsection.

3.1 Properties of (Computer-) Games

There are some special properties of games, which add to the list in the previous subsection, but which can not be part of the aspects' list above. These special properties are related to the collaboration and community aspect of games, the learning by watching (comparable to the learning theory's cognitive apprenticeship, see e.g. [2]), and the assumed relation between structure and motivation, which is special for games.

Collaboration and Games' Communities: Dyck et.al. [12] describe that players easily form communities. Many multi-player games quite automatically support to build "common interest" between players. This leads to forming of short time groups for a single task or of organized clans where every player has certain responsibilities (see e.g. [46]). The players meet online in massive multiplayer online games (MMOGs) or in real live (e.g. at a LAN party) to play their game as a group, to solve problems together or to fight against similar groups. Steinkuehler has observed and experienced this in playing the MMOG Lineage, and described it in her dissertation [46].

Learning by Watching: Beginners learn rules, first steps, and even complex game procedures simply by watching experienced players playing the game. Many games are offering learning by watching as part of the software: in-game tutorials offer playful step-by-step instructions to show the different possibilities without the necessity to read a reading written manual.

Structure and Motivation: Adventures and online role playing games contain complex structures, which are separated and capsuled in smaller quests. Quests are challenges and tasks a player has to solve in order to receive a reward. These quests are necessary to motivate players to do specific things, e.g. collect important items or learn essential skills and to stay in the game as long as possible. For this purpose quests are often overlapping. Players get new information and start new quests shortly before ending the last one. Therefore, it is quite seductive to play just a little bit longer after finishing the previous quest. Divide and conquer seems to be the strategy to keep the motivation of players high. The duration of quests depends on the complexity of its tasks, but the period of time between challenge and reward is decreasing over the last years. Game-based trainings also use this concept of segmentation in small tasks and rewards, and the crosswise

joining of tasks (e.g. in case-based training). Within one task the learner already gathers skills for the next task – such that even after finishing the first one, the learner's motivation is still high to solve the next task.

3.2 Simulation in Computer Games

Next to the competitional aspects, which is also described as winning or loosing in 2.2 and [38], Caillois refers to different types of games as competitional, chance, vertigo, and also as simulation [5]. It is sometimes difficult to decide, whether a game is a simulation or not. This is due to the fact that the term "simulation" has a slightly different meaning in computer science than in the everyday language [27]. Many games are a simulation in the sense of 'simulating a real-life situation' (i.e. to act 'as if'), offering a artificial game reality, or even imitating real-life. In contrast to this, simulation in the sense of computer science explicitly implies the development of models and their simulation over time. Aim of the computer science approach is often to run experiments on the model, thus the term simulation is for example defined as: "A simulation is an experiment performed on a model" ([6], p. 6). In the following, the sketched simulations are interpreted based on this viewpoint as execution of models.

In computer based game-based trainings, simulation can be found at different places. A first categorization suggests to distinguish which role the simulation has in the game. Three different types of simulations have been found:

Character Simulation: The simulation steers and controls the virtual character. A virtual character is sometimes also called non-player character or simply character. Often the virtual character is related with a two or three dimensional visual representation. The underlying models can be realized with quite different complexity, ranging from simple behavior models, over interaction models, up to complex communication models (see e.g. [36]). Simulation of a virtual character means model execution in a sense that the simulation part of the system takes over the control and steers the virtual character. The development of the character might be triggered by external inputs, e.g. another non-player, a real player, or changes in the game environment (e.g. in the virtual world). If the player steers or influences the development of a virtual character, the player can be seen as the 'human in the loop' which pushes the simulation forward. In a narrow sense, simulation of a character is no experiment on a model.

Simulation of the Environment: If the environment in a game-based training is based on a simulation, the game's progress is mainly steered by the simulation. Similar to the perspective mentioned above, the human player (in this case often a learner) takes over the role of 'human in the loop'. The player steers and guides the experiment. His decisions and his actions decide about the simulation's development and thus about the continuation of the game. Classical examples can be found in the military training domain. Another example are flight simulations, which are sometimes located at the border between actual emulations of airplains for serious training and more simple simulations for gaming purposes.

Simulation of other models: Instead of steering a character or steering the basic system functionality, simulation can also be integrated in teaching and training system for other purposes, i.e. for experimenting with models. Most simulations of this type can be found in teaching and training systems which have hardly any connection to gaming.

Regarding the three ways to use simulations in (game-based) teaching and training systems, another distinction, which shifts the focus a bit toward the role of the learner, can be made in the following way. Character simulations, simulations of the environment, and also simulations of other models are in most cases somehow influenced by the learner's interaction. Thus, all of these three are part of another category, which is:

Interactive Training Simulation: The learner interacts with existing, predefined models. Via interacting with the models the learner steers the simulation, either implicitly or explicitly. Interaction can take place at different levels. For example, the learner might have access to predefined model parameters. By changing the parameter values, the learner can experiment with the model and investigate changes in the model's behavior and thus in the simulation (e.g. [22]). If the construction of a model is the task of the learner (e.g. [26]), only parts of the model are predefined or roughly sketched (e.g. [45]).

This category is contrasted with another type of teaching and training system, the **demonstrative simulation**. This approach is not at all linked to game-based learning. Simulation in this context is only used to demonstrate how models behave over time. They can be used as tutorials, to show and explain experiments, and to explain the functioning of machines.

The different approaches of using simulations in teaching and training can be mixed, e.g. in a simulated setting, a virtual character might be embedded (e.g. [44]). Well known examples which are based on simulations are Sim City (http://www.simcity.ea.com), The Sims (http://www.simzone.de or http://thesims.ea.com), as well as several different Tycoon games (e.g. ZooTycoon, http://www.microsoft.com/games/zootycoon, or RailroadTycoon, http://www.railroadtycoon.de).

4 Learning, Motivation, and Transfer

Coming from pedagogy, social sciences, or psychology, a difficulty when dealing with concepts like "game-based learning" is the following: while doing a closer examination of the game-based aspects, the aspects of learning get out of focus and vice versa. What is the reason for this difficulty? There exist many different definitions of learning and of games. Often it seems like games and learning are contradicting each other. Some of these definitions are analyzed in the following. Afterward, some examples are given.

4.1 Learning or Playing?

Several researchers (e.g. [21], [16], [39]) try to describe games and playing. Summarizing, games and playing can be seen as consisting of the following aspects:

- Playing a game is associated with freedom. Games often take place outside of the ordinary life's restrictions and rules.
- Games are fictitious and symbolic. Playing thus means to accept or become part of the fiction and learn how to act and interact on the symbolic level.
- Playing sometimes allows a look behind the barriers of the innermost feelings of humans.
- Playing ends in itself – to play usually follows no other goal than simply to play.
- Games have rules.

In contrast to these aspects, learning seems to be something completey different (e.g. [43]):

- There is usually no stop in learning – the brain always learns. Some researchers even state that also the body always learns.
- Interpreted as knowledge acquisition, learning is focused and goal oriented.
- Learning can be formal, non-formal, and informal.
- From the pedagogical perspective, learning can be formalized: "learning" is perceived to consist of the learning objective, the learning process, and the learning result.
- In contrast to the last point, it is also agreed that learning itself cannot be determinated. There seems to be no causal connection of formalized aspects which could give the reason why learning took place.

Despite these opposite interpretations of playing and learning, many examples of game-based learning can be found, e.g. playful aspects of learning processes, or support of learning processes by integrating the motivating aspects of games. The following subsections will first show some examples, which combine both aspects. Subsequently the motivating factor of games and the transfer of knowledge will be described. Within this paragraph motivation is understood as the fundamental aspect of activation and maintenance of the learning process. Accordingly, transfer of knowledge is the basis to use acquired knowledge in other contexts.

4.2 Examples

There are several different areas, where game-based training systems and game-based learning can be found. These games are based on a pedagogical background and on didactic design with the aim to support knowledge acquisition in a context, which is likewise game oriented and rule based. One area for game-based learning is sports. Here, mainly psychomotorical competencies are trained (e.g. coordination of the own body in interaction with others), but also competencies regarding social interaction (e.g. team play) and emotional compensation (e.g. anger and frustration). Another area of successful application of game-based learning is language learning. Mainly knowledge regarding the language itself (vocabulary and grammar), but also psychomotoric knowledge (e.g. articulation) is trained (e.g. Nintendo Flash Focus or Ubisoft my French Coach

for Nintendo DS). In game-based language learning approaches also social and emotional aspects can be trained, both regarding the language itself (e.g. expressiveness) and the psychomotoric knowledge (e.g. cultural dependent habits of articulation). Last but not least, role-play offers a quite natural combination of games with teaching and training. To act "as if" occurs in every stage of education, and even small children train social interaction and psychomotoric abilities in role-play. Taking over other than the well-known traditional roles allows testing and trying different behavior, to explore new situations, to train how to act and react. Vice versa, observing role-play can lead to conclusions about own behavior. For example watching kids acting as 'mom' and 'dad' can sometimes give the parents a hint about how they behave. In the save context of the game the exploration of strange, possibly new, and often unknown situations can take place, without danger. Sometimes, role-play opens the door to establishing new behavior or understanding.

Whereas the mentioned sports game is somewhat far away from computer game-based training, sometimes it has been claimed that hand-eye-coordination is an aspect which is trained in human-computer interaction. However, hand-eye-coordination is no substitute for real life sport – and is in most cases not intended to be. As mentioned above, language learning can easily be supported by a computer program – as has e.g. been done by [13]. Both, human-human interaction in the classroom and human-computer interaction in a program, are somewhat artificial compared to real experiences made when visiting the foreign country and actually speaking the language. Regarding role-play, the main difference between computer based and real life training maps the differences between human-human interaction and computer-human interaction in teaching and training. The competencies, which can be acquired in computer game-based trainings are similar. Interaction with virtual characters are no substitute for face-to-face communication. Research in the pedagogical field of how media affects humans, especially in investigation of commercials and children, has not revealed a generalizable causal dependency between using modern media and social misbehavior or misuse of power. However, one result of the investigation has been the insight that time-intensive interacting with virtual worlds leads to a shift in realizing the difference between fiction and reality, which then lead to actions which should better stay in the virtual world (e.g. [30]).

The question of how playing and also teaching and training with the computer can affect knowledge acquisition leads to two 'magic' words: motivation and transfer. The following subsections will explore these fields a bit further.

4.3 Magic of Motivation

To keep learners motivated is very important for successful teaching and training. The notion of success in this context means, that learners are able to reach a teaching and training goal, that they remember the content, and moreover, that they are able to transfer the learned content to other situations. To keep the motivation on a high level is a goal, which is extrinsically very difficult to reach. One important aspect of games, which should be transferred to teaching

and training, is the high intrinsic motivation. In this context, the psychological, cultural, and pedagogical aspects of "play" are important to consider. This has been done for example by Caillois in [5] and will not be focused here. Unfortunately, a high motivation in the context of playing does not necessarily lead to a high motivation when it comes to teaching and training.

Where does the motivation in the context of game playing come from? The combination of several different aspects makes games interesting and helps to keep the motivation of the players at a high level. Games usually provide a large amount of interactivity. At least, there is the interactivity between computer (the game software) and the player. In more complex games, interaction between different player and probably also non-player characters is realized (e.g. World of Warcraft http://www.worldofwarcraft.com or http://www.wow-europe.com/en/). Each games has its rules, but to a certain amount the player has control and power. In games like Black & White (http://www.lionhead.com-/bw/index.html (developer) or http://blackandwhite2.ea.com/ (publisher)) the player even has some "god-like" powers of creation and destruction. Equally important is the symbolic form: a game allows the player to take over other identities, to become part of the game, and to play another than the everyday role. As symbolic forms, these identities fit to secret wishes and ideas – the symbolic characters offered in games are often similar to characters in movies or in tales. This "role playing" allows player to examine and to solve problems on a symbolic level. Likewise important is the adaptability of games. Usually, games provide levels of expertise, such that the player is seldom confronted with a boring (i.e. too easy) or annoying (i.e. too difficult) situation. Boring and annoying situations lower the level of motivation, thus game developers strive to avoid them. Similar relations between adaptation and motivation can also be found in teaching and training systems (e.g. see [20]). The technical realization of a computer game can also be fascinating and thus motivating. Modern technology offers a large amount of possibilities to construct virtual worlds, which are even able to reach different human senses.

During playing the game, a relation between computer and player is established. Via connecting the players senses structurally to the game, an autopoietic construction of sense leads to a focused awareness [48]. The player, who is not aware of this connection, feels a strong intention to understand the game, and is highly motivated. Intrinsic motivation and stimuli offered by the computer system alternate [48]. Moreover, certain aspects of games can raise the player's level of interest even before the actual interaction, for example the type of game (e.g. strategy), the game's context (e.g. fantasy), and, not to forget, the marketing (e.g. a game related to a famous movie, like "Lord of the Rings", e.g. http://lotr.ea.com or http://rotk.ea.com).

Similar to Wesener [48], Fritz [15] stated that the interests of the player and the offer of the computer game overlap, which results in a stimulation of the player. This stimulation optimally leads to positive emotions, but sometimes to negative emotions. Having success in a game is from the player's perspective often not related to certain actions. Success is even not related to knowledge

acquisition regarding the game's content. Often the effective usage of rules and relations which are the basis of the game, is most important. This can for example lead to a situation where the player uses the game's rules in another way than intended by the game developer. Success is for example to outwit the game. Thus, for having the feeling of success in a game, it is for some players more important to understand rules and relations than to grasp the game's content. The motivation to play shifts toward a motivation to learn how to play.

4.4 Magic of Transfer

Whether knowledge can be transferred to another context or not, whether it can be applied in another than the teaching and training context, is a sign for the applicability of the knowledge and of what is really "learned". At a top level, passive knowledge can be distinguished from active knowledge. Passive knowledge is available, but has no potential applicability and often a lack of transferability. Active knowledge can actually be used, i.e. transferred and applied to other than the original context.

Not much research has taken place in the context of transfer and transferability of knowledge between virtual worlds and the real world, neither in computer game-based training nor in computer games. In contrast to this, the examination of the transfer of knowledge is essentially important to understand how modern media, computer games, and new teaching and training scenarios affect the learning process.

In the context of learning, transfer can be distinguished in intramondial and intermondial. Intramondial means for example to re-use knowledge acquired in one computer game in another game. Transfer takes place in a certain world, e.g. a virtual one. In contrast to this, intermondial, i.e. transfer between worlds, means to re-use knowledge in everyday life. This distinction is more obvious in an quite negative example. If the knowledge of usage of weapons is intramondial, than the player is able to successfully act in similar games in a similar way. If the knowledge becomes intermondial, the player learns how to use weapons in everyday life. Combined with a shift between reality and game, this might be a disastrous and murderous mixture [37]. However, this transfer is difficult to reach and, moreover, difficult to prove.

Wesener tries to categorize different transfer processes according to a category of computer games [48]. The three categories he suggests are based on the content, the graphic complexity, the player's perspective and the potential interaction, and also aspects like the player's perception and activity.

Micro-virtual game worlds provide a linear structure of content. Player and non-player characters are represented as figurative substitutes – interaction in the game world takes place via these substitutes. The perspective on the game situation is subjective, only the direct environment is visible. Examples are HalfLife (http://half-life.com/) and Tomb Raider (http://www.tombraider.com).

Meso-virtual game worlds provide a primarily linear structure with some not-linear parts (e.g. capsuled as missions). Most of the time, the game combines a

figurative substitution with partly direct interactions, e.g. via menu structures. As the game world is more complex than the micro-virtual world, it is necessary to have more parts of the environment visible. Often, an isometric perspective is taken. Examples are Empire Earth (http://www.empireearth.com/) and Spellforce (http://spellforce.com/).

Macro-virtual game worlds are not bound to a linear structure, as the game world is complex enough to let the player explore the world on his own. Usually, direct identification takes place, i.e. no representative is given. In some games, game characters or figurative substitutes are offered. The perspective allows supervision of the complete world and switching between different views. Examples are Civilization 3 (http://www.civ3.com/), The Settlers 4 (http://www.thesettlers.com), and Anno 1503 (http://www.anno1503.com/)

These game worlds have different transfer processes, which can be distinguished according to Fritz [15] as:

- Fact level – transfer is mainly related to content and knowledge of facts. Examples are historical data and development, basic economic knowledge, knowledge from the field of natural sciences.
- Script level – allows mainly the transfer of plot, i.e. how to act and react in a certain situation. An example is start and landing of airplanes.
- Print level – at this transfer level, only single isolated actions or reactions without related meaning are transferred. Examples stem mainly from sports, like tricks in soccer play.
- Metaphoric level – transfer of symbolic presentations and hints. The player gets knowledge about how to handle for example standard icons, like the disc symbol for data storage, and small game sequences with hidden hints.
- Dynamic level – transfer of knowledge from a computer game to everyday life. Here, the overall topic of the game plays a certain role in the player's life, e.g. acceptance orders and rules, having power (or not), fighting, wining and loosing.

Combining the game categories mentioned above with the levels of transfer processes, this leads to the following. Micro-virtual worlds usually only support transfer at print and script level. Meso-virtual worlds add the fact level. Due to the partly open game structure, knowledge application and development of strategies are required and support the acquisition of cognitive competencies, which then support transfer of knowledge to real worlds. In macro-virtual worlds, the success in the game depends on the player's ability to understand and to apply rules and relations. These rules and relations are often not that far away from rules and relations in the real world. Thus, as a first step, knowledge from the real world is taken to perform in the virtual world – which is another form of transferring knowledge. As a next step, strategies from the real world are adapted to game situations and game context. In a third step, the adapted strategies and behavior developed due to new experiences in the game setting are transferred again, but now into the real world (dynamic level of transfer). Here again a transformation of the knowledge might be necessary.

5 Conclusion: Drawing Connections – Game-Based Learning

Computer games and computer game-based teaching and training systems have strongly influenced each other in the last years [44] (see: http://gamestudies.org/). Especially in the context of graphical interfaces or the human computer interface design, the influence becomes obvious. Similar to computer games, modern teaching and training systems offer elaborate and technically ambitious graphical interfaces, optically fascinating gadgets, life-like virtual characters, and complex and well designed navigation structures. In contrast, after several years of focusing the graphical user interface, computer game developers nowadays re-orientate toward establishing complex and demanding computer science techniques as the basis of their games. There, the insight has rooted that a game is only interesting for the long term when it provides interesting and continuously motivating interaction scenarios in addition to the nice user interface. As Prensky stated: "While eye candy is important for some things, most game designers tell you that it is the 'game play' that really make the difference in holding the players' attention and getting them to compete until they win." [34]. Whereas teaching and training system developers aim at aspects like motivation and interest, game designers strive to provide fine grained interaction and adaptation to make their games even more interesting and reactive. Nonetheless, even teaching and training system developers should not turn completely toward eye candy, but combine the best of both: complex and demanding interaction scenarios and the well designed interface.

How to keep a learner's motivation on a high level has been subject of investigation in the research field of teaching and training systems for quite a long time, and even longer in psychology (e.g. [2], [49]). As mentioned above, one important aspect is to have a teaching and training system which is flexible enough to adapt to the learner's current state of knowledge, to support the learner if necessary, and to raise the level of difficulty if required. Thus, the notion of adaptability is important in teaching and training systems. Additionally, it should be taken into account that there are different types of teaching and training strategies – not all of which lend themselves for establishing game-based approaches. Case-based training is traditionally close to game-based approaches and can easily use motivational aspects like adaptation and emotional involvement of the learner. One possibility might be to combine case-based and fact learning in a interlace process: start with case-based learning to make the subject interesting for the learner, continue with less game-oriented approaches, and shift again to game-based scenarios if the learner get's bored.

Regarding the distinction of micro-, meso-, and macro-worlds, a connection to simulation and artificial intelligence suggests itself (see section 3.2). In a micro-virtual world usually no simulation (see section 3.2) and usually no AI is required. Even the figurative substitutes of player and non-player characters need no simulation, as the based on the linear structure interaction is prescribed. The game scenario is linear, thus the model is fixed in advanced. If simulation is used at all it would be a demonstrative simulation. However, in most cases the focus of

these games is not on an elaborate basic computer science technology but on a complex graphical interface. The meso-virtual and the macro-virtual worlds are the playgrounds for simulations. Whereas in the meso-virtual world in most cases the character simulation can occur, the macro-virtual world usually contains both, complex character simulations and simulations of the environment. Depending on the complexity of the game world, the simulated character's ability to act, to react, and to interact differ, as well as its adaptability to the learner. Accordingly, the transfer of knowledge might be influenced. If virtual characters are very simple, no complex interaction patterns have to be learned by the players. On the opposite, if the virtual characters are quite complex, providing a so called close to real life interaction, players might be in a situation where they have to use and apply knowledge of human interaction to the virtual character. Then, transfer on a dynamical level (in both directions as described above) takes place. Simulation of the environment and of other model can realize parts of a meso-virtual world (e.g. special engines or missions). They are mainly found in macro-virtual worlds, where in some cases the complete game can be seen as a simulation. Again, the intensity of transfer of knowledge between virtual and real world depends on how elaborate, interactive, and adaptive the environment or the other model has been developed. From the player's perspective, this means: how much prior knowledge is needed to act and interact in the virtual world, and vice versa, how much knowledge is acquired by acting and interacting in the virtual world.

Micro-worlds with their linear structure can also be located in game-based or game-like learning environments, e.g. in case-based training in clinical medicine. Going away from the linear structure, as for example done in Docs 'n Drugs [24], the teaching and training system is similar to a meso-world. Here, the micro- or meso-world is a close to real life world, in the examples a virtual hospital, where the learner as physician has to interact with a patient. In a micro-world situation, the learner has no choice to influence the linearity of the training case. In a meso-world situation, the learner can decide how to proceed. Whereas in the micro-world situation only one cognitive process is trained – the process of diagnostic reasoning – the meso-world situation allows additionally to train the cognitive process of general knowledge application (see [25]). The cognitive process of diagnostic reasoning is close to the above mentioned fact-level. The cognitive process of general knowledge application is related to the script level and to the dyamic level – i.e. how to act and react in close to real life situations and to successfully transfer this knowledge to everyday life. It would be a nice to construct a macro-world for interactive game-oriented learning in case-based situations, especially in training domains like clinical medicine. However, these macro-worlds are difficult to develop, as in serious teaching and training systems the requirements regarding realistic depiction of the real world are on a very high level. Moreover, it is difficult to realize didactically elaborate content in a macro-world. For example, Docs 'n Drugs started as something similar to a micro-world, has then be extended towards a meso-world, as the linear guidance of the learner has been loosened, and finally reached a level which is a step in the direction of

a macro-world. However, whereas the technical software level had reached the level of a macro-world, the teaching and training content (i.e. the training cases) remained on the level of meso-worlds. An interesting observation in supervising the students learning with Docs 'n Drugs has been that to loosen the structure of the training case has raised the learner's motivation to successfully solve the training case.

In teaching and training systems, the focus is on learning rather than on having fun. But learning, especially based on a technology like computers, can be fun. This has impressively been shown by the gaming industry, and by teaching and training system developers like [36], which combined Hollywood like storytelling and storyboards with simulations to get a very complex teaching and training setting. Motivation in learning is often compared with motivation to reach the next level in a game ("leveling up" [35]). In contrast to this, goals of teaching and training and goals in a game are hardly comparable. Even if a separation of teaching and training goals into different levels is possible and might be useful, the goals in a game are in most certainly not pedagogical oriented and cannot be mapped to the teaching and training goals. Sure the player of a computer game learns as well, as sketched in section 4.4. In pedagogical as well as in game settings, the transfer of knowledge between a virtual and a real world requires transformation and, initially, evaluation and validation of the knowledge. Based on different intensities of sensual input, human beings are usually able to distinguish between real world and virtual world (see [48]). They are in most cases able to separate different levels of reality. However, the question remains, which of these transfer processes can be used to successfully support learning processes. Research in this direction should follow.

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