Serious Games – An Overview

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Abstract

This report discusses some issues concerning serious games, that is, (digital) games used for purposes other than mere entertainment. The starting point is the serious games concept itself, and what the actually means. Further, serious games allow learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc., but they are also claimed to have positive impacts on the players' development of a number of different skills. Subsequently, some possible positive (and negative) impacts of serious games are discussed. Further, some of the markets such games are used in are considered here, including, military games, government games, educational games, corporate games, and healthcare games. This report also identifies some (mainly academic) actors in the North American and the European serious games market. This report is part of the DISTRICT (Developing Industrial Strategies Through Innovative Cluster and Technologies) project: Serious Games Cluster and Business Network (SER3VG), which is part of the Interreg IIIC Programme.

Introduction

Today's "serious games" is serious business; as stated by Ben Sawyer, co-founder of the Serious Games Initiative, the *serious games* market is now at $20 million, and *digital gaming* is a $10 billion per year industry (van Eck, 2006), and the market is expected to grow over the next decade. As noted by Michael and Chen (2006), serious games are also becoming ever more important in the global *education and training market*, which in 2003 was estimated at $2 trillion. It is also predicted that "by 2008, 40 percent of U.S. companies will adopt serious games in their training efforts" (ibid., p.xvi).

Serious games can be applied to a broad spectrum of application areas, e.g. military, government, educational, corporate, healthcare. A key question, when discussing serious games, is what the concept itself actually means. Even a brief survey of the literature soon reveals that there seems to be as many definitions available as there are actors involved, but most agree on a core meaning that serious games are (digital) games used for purposes other than mere entertainment. Another question of interest concerns the claimed positive effects of such games, or of applications from related and sometimes overlapping areas such as e-learning, edutainment, game-based learning, and digital game-based learning. In addition to obvious advantages, like allowing learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc. (Corti, 2006; Squire & Jenkins, 2003), serious games, it is argued, can have positive impacts on the players' development of a number of different skills. Even so, it is not the case that all games are good for all learning outcomes (van Eck, 2006). A third question of interest concerns the actors involved, e.g., researchers, game developers, and the consumers, and their roles in this developing market. The aim of this report is to take a closer look at some aspects of these issues. We begin with a brief discussion on serious games and related concepts, and then discusses serious games in more

detail, such as different definitions and perspectives on the concept. Then, we turn to the issue of the positive (and negative) effects of these games. In the final section, we identify some (mainly academic) actors in the North American and the European serious games market. This report also provides a list of serious games conferences and organisations, and some examples of serious games (Appendices A and B).

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Serious Games and Related Concepts

This report focuses on the domain of serious games. There are, however, related and sometimes overlapping domains, such as e-learning, edutainment, game-based learning, and digital game-based learning. *E-learning* is a rather general concept that refers to computer-enhanced learning, computer-based learning, interactive technology, and commonly, distance learning (Hodson et al., 2001; en.wikipedia.org). *Edutainment* – education through entertainment – was popular during the 1990s with its growing multi-media PC market (Michael & Chen, 2006). In general, edutainment refers to any kind of education that also entertains even though it is usually associated with video games with educational aims. The primary target group was preschool- and young children, with focus on reading, mathematics, and science. However, edutainment software failed success since it resulted in what has been described as "boring games and drill-and-kill learning" (van Eck, 2006). Computer video games for non-entertainment purposes were developed long before the edutainment era, however, and as edutainment failed to prove profitable – and technical advancements in providing realistic settings grew, and multiplayer gaming developed – the concept of serious games was re-examined during the late 1990s (en.wikipedia.org). With the U.S. Army's release of the video game *America's Army* in 2002 (www.americasarmy.com; Gudmundsen, 2006), the serious games movement got started. The same year the Woodrow Wilson Center for International Scholar in Washington, D.C. founded *the Serious Games Initiative*, and the term "serious games" became widespread (www.seriousgames.org/index2.html).

In general terms, serious games are associated with 'games for purposes other than entertainment' (further discussed below). Serious games encompass the same goals as edutainment, but extend far beyond teaching facts and rote memorization, and instead include all aspects of education – teaching, training, and informing – and at all ages (Michael & Chen, 2006).

Game-based learning (GBL) is described as "a branch of serious games that deals with applications that have defined learning outcomes" (en.wikipedia.org). Others consider game-based learning and serious games more or less the same (e.g., Corti, 2006). According to Corti (ibid.), GBL has the potential of improving training activities and initiatives by virtue of, e.g., its engagement, motivation, role playing, and repeatability (failed strategies etc. can be modified and tried again). *Digital game-based learning* (DGBL) is closely related to GBL, with the additional restriction that it concerns digital games. In the words of Marc Prensky, DGBL is the "newest trend in e-learning" (twitchspeed.com/; see also, e.g., Kiili, 2005; Squire et al., 2005). DGBL is, Prensky (2001a; 2001b) argues, based on two key premises; firstly, the thinking patterns of learners today have changed, that is, today's students are 'native speakers' in the language of digital media. Secondly, this generation has experienced a radically new form of computer and video game play, and "this new form of entertainment has shaped their preferences and abilities and offers an enormous potential for their learning, both as children and as adults" (ibid., p. 6). In the next section the concept of *Serious games* is discussed in more detail.

The Concept of Serious Games

Today, the term "serious games" is becoming more and more popular. A Google-search on "serious games" renders about 1090000 hits [2007-01-03]. The term itself is nowadays established, but there is no current singleton definition of the concept. Serious games usually refer to games used for training, advertising, simulation, or education that are designed to run on personal computers or video game consoles. According to Corti (2006, p.1) game-based learning/serious games "is all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as to develop new knowledge and skills". When searching the web, a number of different definitions are available. The number of hits when explicitly searching for definitions of serious games amounts to 1.8 million hits [2007-01-03]. It could be argued there is no need, for purposes other than purely academic, to define serious games but vaguely. However, while different groups use the very same term they also appear, at the same time, to refer to different things. The term "serious game" itself came into wide use with the emergence of the Serious Games Initiative in 2002 (seriousgames.org). The web-site of the serious games initiative provides the following description of serious games:

> "The Serious Games Initiative is focused on uses for games in exploring management and leadership challenges facing the public sector. Part of its overall charter is to help forge productive links between the electronic game industry and projects involving the use of games in education, training, health, and public policy."

Most web-pages, however, either do not define the concept or describe it vaguely. Commonly, many websites describe serious games as wanting to achieve something more than entertainment, and considers it more of a movement than a defined area of its own. For instance, it has been described as a movement that is "cross-appropriating video game technologies, techniques, structures and tools from the video game industry to other fields of human endeavour (outside of entertainment) like policy and management issues" (digitaldivide.net; en.wikipedia.org). It has also been described as the "use of computer and video games for non-entertainment purposes (i.e., public policy, education, corporate management, healthcare, military)" (minkhollow.ca; see also, e.g., dictionary.laborlawtalk.com; nyteknik.se; svt.se). These descriptions are in line with, e.g., the Internet encyclopedia Wikipedia, in which serious games are described as:

> "…computer games that are intended to not only entertain users, but have additional purposes such as education and training. They can be similar to educational games, but are primarily focused on an audience outside of primary or secondary education. Serious games can be of any genre and many of them can be considered a kind of edutainment, but the main goal of a serious game is not to entertain, though the potential of games to engage is often an important aspect of the choice to use games as a teaching tool. A serious game is usually a simulation which has the look and feel of a game, but is actually a simulation of real-world events or processes. The main goal of a serious game is usually to train or educate users, though it may have other purposes, such as marketing or advertisement, while giving them an enjoyable experience. The fact that serious games are meant to be entertaining encourages re-use…" (en.wikipedia.org, 20061206)

In Zyda's (2005, p.26) more formal definition, entertainment is explicitly brought up as an ingredient:

> "Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."

When comparing serious games with just computer games, Zyda argues that serious games have more than just story, art, and software. It is the addition of *pedagogy* (activities that educate or instruct, thereby imparting knowledge or skill) that makes games serious. However, he also stresses that pedagogy must be subordinate to story and that the entertainment component comes first. The focus on the entertainment component is in contrast with, e.g., the descriptions of serious games accounted for in the recent book *Serious Games: Games that Educate, Train, and Inform* by Michael and Chen (2006), in which they devote a whole chapter on discussing the concept of serious games.

A problem with the term "serious game" itself is that there appears to be a contradiction between its constituents; the terms "serious" and "game" may seem to be mutually exclusive. The first constituent, "serious", is according to Ben Sawyer (in Michael and Chen, 2006) intended to reflect the purpose of the game, why it was created, and has no bearing on the content of the game itself. Regarding the second constituent, already Wittgenstein (1953) showed that there are difficulties in defining the concept of a game. There simply are no necessary and sufficient conditions. In Michael and Chen (2006, p. 19) games are described as:

> "…a voluntary activity, obviously separate from real life, creating an imaginary world that may or may not have any relation to real life and that absorbs the player's full attention. Games are played out within a specific time and place, are played according to established rules, and create social groups out of their players."

The authors also note that some people will take exception to this description since it contains no reference to "fun". Not all consider "fun" an important factor, however, when it comes to games or computer based applications, especially not so when considering their role in learning, and even their use as an educational means is questioned. Stoll (1999), for instance, is critical to "the obsession of turning the classroom into a funhouse" (p.13), and argues that computers, or "teaching machines",

> "…direct students away from reading, away from writing, away from scholarship. They dull questioning minds with graphical games where quick answers take the place of understanding, and the trivial is promoted as educational. They substitute quick answers and fast action for reflection and critical thinking […] Turning learning into fun denigrates the most important things we can do in life: to learn and to teach. It cheapens both process and product: Dedicated teachers try to entertain, students expect to learn without working, and scholarship becomes a computer game." (pp.13-14)

As argued by Squire et al. (2005), however, the important issue is not whether all formal education is turned into a game or not. More importantly, they ask how educational technologists will respond to the "digital native speakers", i.e., "a generation of students who, raised on interactive games, expect the same kinds of interactive experiences from their educational media?" (p.34). Still others consider fun the prime factor in games and education and, according to Prensky (2001), games should be fun first and then should encourage learning. Fun has also been described a side effect of learning something new (Koster, in

Michael & Chen, 2006). Similarly, Michael and Chen (2006) argue, with regard to serious games, that the main point is to get players to learn something, and, if possible, have fun doing it.
Considering the above characteristics for games, serious games often violate voluntariness in that trainees may be ordered to play a particular game as part of their training. An example could be a military squad leader using a serious game for training before or preparing a mission. Another person using the very same simulation could instead regard it a game. Therefore, entertainment games used for other purposes can be considered serious games (chess, e.g., while being an entertainment game, has the underlying element of strategic skill training).
Michael and Chen (2006, p.21) define serious games as "*games that do not have entertainment, enjoyment, or fun as their primary purpose*", a definition clearly in line with the one adopted by, e.g., PIXELearning (PIXELearning.com, 2006-11-14); "*The use of computer game and simulation approaches and/or technologies for primarily non-entertainment purposes*". Michael and Chen do, however, remark that this is not to say that serious games are not entertaining, enjoyable, or fun, just that there is another purpose (cf. above); the accuracy of the process or effect being simulated for training is of primary importance. Nevertheless, education can be entertaining, but also the reverse is true. "Fun", however, is neither the only form of entertainment, nor the only way to engage players in a game. Besides fun, there are several elements that contribute to players' engagement, e.g., play which leads to intense and passionate involvement, goals that motivate, and rules that provide structure (Prensky, 2001, in Mitchell & Savill-Smith, 2004). According to Corti (2006), the motivational virtues of video games are what initially entice training and development professionals to turn to game-based approaches, but there is a lot more to game based learning/serious games than simply using fun as a means to engage learners.

In the present DISTRICT project, we want to emphasise the element of *engagement* in games. As recognised by many authors, serious games is not merely the application of games and game technology for non-entertainment purposes, in domains such as education, health, etc. In our view, games should be engaging and motivating, which is advantageous for, e.g., the development of a variety of skills and abilities. Hence, serious games is here defined as games that engage the user, and contribute to the achievement of a defined purpose other than pure entertainment (whether or not the user is consciously aware of it). A game's purpose may be formulated by the user her/himself or by the game's designer, which means that also a commercial off-the-shelf (COTS) game, used for non-entertainment purposes, may be considered a serious game.

For the purposes of The Serious Games Showcase and Challenge (sgschallenge.ist.ucf.edu), and the 2006 I/ITSEC Conference (Interservice/Industry Training, Simulation and Education Conference), "game" and "serious game", were defined as follows:

> "Entries will be considered a game if they involve an assigned challenge and employ a compelling form of positive and/or negative reward system. Entries will be considered a serious game if they use the gaming attributes described above to overcome a designated problem or deficiency, and provide appropriate feedback to the user about their efforts."

The element of enjoyment may seem implicit in this operative definition, but it is also explicitly emphasised in the event's general description:

> "… it is important to clearly define the problem or need that is being addressed, as well as the gaming or game technology solution involved. It is equally important that your entry be not only technologically sound in its development, delivery and user interface, but also engaging, enjoyable, and easy to use; providing a challenging and rewarding experience to the user."

An adequate question to ask is how serious games differ from entertainment games. Michael and Chen (2006) discuss the issue from a design and development perspective; contrary to many markets for entertainment games, the hardware used in many of the markets for serious games is years old and therefore less than optimal. The serious games market is also more likely to possess a wide variety of hardware and operating systems. Furthermore, this market includes, not only experienced gamers, but also possible first-time players and the games must therefore be even more accessible.

Hardcore gamers generally want the richest possible experience from their games. For serious games, however, it is more important that the model or simulation can be used to solve a problem, than providing "rich experiences" of the kind sought by hardcore gamers. Further, for serious games it is essential that the most important elements of learning are in focus, and that the assumptions necessary for making a simulation workable are correct – otherwise the simulation will teach the wrong kinds of skills. Entertainment games, on the other hand, allow players to focus on the fun parts and to use a number of techniques (random numbers, time compression, etc.) for simplifying the simulation processes. In serious games, Michael and Chen (2006) argue, it may be important to rethink the use of such simplifying techniques. For example, serious games should respond more to the conscious decisions made by players than to chance, and therefore randomness may be inappropriate. Another example is communication, which often is perfect (i.e., without delays and misunderstandings, etc.) in entertainment games, whereas some serious training applications should rather reflect that communication seldom is perfect. The differences between entertainment games and serious games are summarised in Table 1.

Table 1. Differences between entertainment games and serious games.

	Serious games	**Entertainment games**
Task vs. rich experience	Problem solving in focus	Rich experiences preferred
Focus	Important elements of learning,	To have fun
Simulations	Assumptions necessary for workable simulations	Simplified simulation processes
Communication	Should reflect natural (i.e., non-perfect) communication	Communication is often perfect

What exactly the conception of serious games includes, however, is not all agreed upon. For instance, the essay "*Serious Games: A Broader Definition*" (lostgarden.com), which discusses serious games from a business perspective, criticises descriptions of serious games as being too narrow. According to its author[1], great many groups are interested in serious games, but each group has a radically different understanding of the term. It is also argued there is more value within game development than merely games for "education, training, health, and public policy", as suggested, e.g., by the Serious Games Initiative's definition (cf. above).

[1] The author is anonymous (except for the name of 'Danc'), but the discussion is interesting and relevant enough to be considered here.

Hence, there is a need for a definition that includes the core reason for why businesses care. For many people the benefit of games is still questionable, partly due to the lack of overwhelming and concrete evidence showing that games are inherently useful tools, and partly because the broader world still sees games as toys. Game *technology*, on the other hand, is another matter. Stressing the importance of 3D, the author argues that in games it allows users to experience realistically simulated situations difficult to experience in the real world. Furthermore, people get an intuitive understanding that a 3D application replacing a certain real world activity could be of immediate value. In the author's view, many companies are not primarily looking for games per se, but rather 3D applications to solve business problems. However, game developers and designers are fooled by the recent interest in 3D technology, and when business people are saying "game" they are likely talking about a "3D application". However, not all 3D applications using modern game technology are "games", and they do not need to be fun or have any learning or reward systems. For instance, as described by the author, there is an application for building 3D airplanes – an application that solves a business problem. However, while the application is "game-like" and uses game technology, it is not a game; "game" is but a name for the application.
In the author's experience, most customers need a 3D application that only uses game technology and not game design, for which a simple solution could be to separate *game-based solutions* from other types of *3D applications*. However, the differences are not all clear. For instance, a 3D application user may reach his/her goals by manipulating a tool that has game attributes, even though it is not a game – would that be a serious game? Also, a training application may be experienced as being "fun" – would that be a game? Despite these uncertainties and border-line cases, the author suggests serious games be categorised into:

- **Games**: applications focused on learning, simulation and fun.
- **3D applications**: applications that use 3D game technology and techniques to solve business problems.

These categories are also said to overlap in that,

- There are 3D applications that are not games
- There are 3D applications that are games
- There are games that are not 3D applications

The author also criticises the fact that many of the websites covering serious games focus much on the game aspect and less so on the technology and process transfer into 3D applications. Hence the author suggests the following definition:

> "***Serious Games:*** *The application of gaming technology, process, and design to the solution of problems faced by businesses and other organizations. Serious games promote the transfer and cross fertilization of game development knowledge and techniques in traditionally non-game markets such as training, product design, sales, marketing, etc.*"

To summarise, the are many different terms, that all point to what is here called serious games. Yet, the concept is defined in many ways; definitions agree on some matters, but also vary depending on different perspectives and interests. One issue most definitions agree upon, more or less, is that serious games are concerned with the use of games and gaming technology for purposes other than mere entertainment or "fun". Such purposes include education, training, health, etc. Although fun and entertainment is excluded in many authors'

definitions, or used for drawing a line between serious and other games, others argue they constitute key components of serious games. In the next section we define our own view on serious games.

Advantages of Games and Serious Games

An important issue when it comes to serious games concerns the acclaimed benefits of their use. Although serious games generally are considered to increase various skills, there may be a lack of evidence, which poses a potential threat to serious games. Disciplined studies of gaming are few, and as Squire et al. (2005, p.34) point out "[t]o date, we actually know relatively little about the consequences of game play on the cognition of those who play them" (cf. Squire, 2002). What we do know is that games, simulated environments and systems, etc., allow learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc. (Corti, 2006; Squire & Jenkins, 2003). We also know that analyses have been conducted over the years, consistently showing that games promote learning (Szczurek, 1982, VanSickle 1986, Randel et al., 1992, in van Eck, 2006). At the same time, it seems difficult to draw any firm conclusions from studies on computer and video games due to conflicting outcomes (Mitchell & Savill-Smith, 2004). Regarding games and their possible impact on gamers, Mitchell and Savill-Smith (2004) discuss a number of such issues. Possible negative impacts include: health issues (headaches, fatigue, mood swings, repetitive strain injuries, etc.), psycho-social issues (depression, social isolation, less positive behaviour towards society in general, increased gambling, substitute for social relationships, etc.), and the effects of violent computer games (aggressive behaviour, negative personality development, etc.).

Regarding positive impacts, games can support the development of a number of different skills, as discussed by Mitchell and Savill-Smith (2004); analytical and spatial skills, strategic skills and insight, learning and recollection capabilities, psychomotor skills, visual selective attention, etc., and even violent games can be beneficial in that they provide an outlet to alleviate frustration. More specific positive impacts have been reported, e.g., by Enochsson et al. (2004), who found a positive correlation between experience in computer games and performance in endoscopic simulation by medical students. The better performance of gamers is attributed to their three-dimensional perception experience from computer gaming. Similarly, in architecture and design, computer games can be used as a means of developing student confidence and abilities in spatial modeling, design composition, and form creation (Coyne, 2003; Radford, 2000). Guy et al. (2005) suggest playing with three-dimensional models as a means for enhancing town planning. Moreover, DeLisi and Wolford (2002) report on how spatial abilities, more precisely, the capacity for mental rotation, can be improved by playing games such as Tetris. Experiments, in which the test group used specially designed software for attention training, has shown that even nonsystematic experience with computer games improved attention behaviour of children (Navarro et al., 2003). Further potential benefits of games include improved self-monitoring, problem recognition and problem solving, decision making, better short-term and long-term memory, and increased social skills such as collaboration, negotiation, and shared decision-making (ELSPA, 2006; Mitchell & Savill-Smith, 2004; see also Rieber, 1996). For example, Squire and Steinkuehler (2005) report that playing on-line community games actually is a matter of creating knowledge together, being an activity which fosters various types of information literacy as well as developing information-seeking habits. These activities are examples of required knowledge in order to find information in any library or on the Internet. Other examples are that gamers develop their thinking strategies towards more analogical thinking rather than trial-and-error thinking (Hong & Liu, 2003) and that game elements such as competitive scoring, increasingly difficult levels, and role playing have proven useful in corporate training (Totty,

2005). Yet another benefit is pointed out by Squire and Jenkins (2003), who argue that games can be a powerful way of introducing new concepts and tie together disparate periods of history.

To a large extent the debate concerning negative effects of (violent) computer games resembles the debate on the effects of video violence, and the negative effects of gaming, such as increased aggressiveness, are still under debate. During a survey on gaming experience and driving behaviour, Backlund et al. (2006) found that traffic school students with a high experience in computer games were ranked significantly higher by their instructors regarding their driving skills compared to students with a low experience. However, no evidence was found to indicate that experienced gamers have a worse attitude towards fellow road-users or traffic safety. Another example is Baldaro et al. (2004) who evaluated short term effects on physiological (arterial pressure and heart rate) and psychological (anxiety and aggressiveness) factors of playing video-games. The study was conducted on expert players and the results indicate short term effects on physiological factors from playing violent games as opposed to non-violent games. However, the results showed no effect on hostility measurements. According to a survey by Durkin and Barber (2002) there is no evidence of effects on measures of aggressiveness. On the contrary, some experiments actually indicated reductions in aggression. Such ambiguities indicate a need for more investigation. Table 2 summarises the examples mentioned above.

Table 2. Overview of examples on reported effects.

	Motor skill/ spatial	Educational/ Informational	Social	Physiological
Backlund et al. (2006)	X			
Enochsson et al. (2004)	X			
Guy et al. (2005)	X			
Radford (2000)	X			
De Lisi and Wolford (2002)	X	X		
Navarro et al. (2003)		X		
Squire and Steinkuehler (2005)		X	X	
Baldaro et al. (2004)			X	X
Durkin and Barber (2002)			X	
Hong and Liu (2003)		X		

Despite these (and other) findings, it seems there is no conclusive answer to the question of evidence for the acclaimed benefits and potential consequences of games and game play. Yet, van Eck (2006) argues that the proponents of digital game-based learning actually have "gotten through the message that games in education are beneficial", and therefore they need a "new message" (p.17-18). He further argues that continuing to preach the effectiveness of games may create the impression that "*all* games are good for *all* learning outcomes, which is categorically *not* the case" (p.18). Subsequently, research now needs to focus on explaining *why* games are engaging and effective and, there is a need for practical guidance regarding *how* (when, with whom, and under what conditions) to integrate games and learning processes to maximise their learning potential. The reason games are effective, in the view of van Eck, is "not because of what they are, but because of what they embody and what learners are

doing as they play a game" (ibid., p.18). One of the reasons why games are effective is that learning takes place within a context that is meaningful to the game; learning in a meaningful and relevant context is more effective than outside that context, a point long argued in situated cognition (cf. Rogoff, 2003; Gee, 2004). Similarly, Squire and Jenkins (2003, referring to Card's 1985 science fiction novel 'Ender's Game') argue that games should be like the places where kids hang out because that is where much learning takes place; "educational games should be like school corridors, where kids experiment, interact, create, and share what they create with others, outside the rigid structures that contemporary games impose" (p.8). However, as argued by Squire and Jenkins (2003), the outcome of game playing also depends on the goals the player sets for her/himself.

Application Areas

According to Wikipedia (en.wikipedia.org), main users of serious games are currently the US government and medical professionals. However, other commercial sectors are beginning to see the benefits and are actively seeking development of such tools. Serious games can be applied to a broad spectrum of areas, but, as with almost anything, they can be categorised in a number of different ways. Some categorise serious games into pedagogical, idealistic, politic, or societal games (nyteknik.se, spel.bth.se). Other examples are education, healthcare, national security, corporate management, and more (www.coventry.ac.uk), or education, health, public policy, science, government, and corporate training (usatoday.com). Yet another, but similar categorisation is provided by Zyda (2005), who states that serious games technology can be applied to domains as diverse as healthcare, public policy, strategic communication, defence, training, and education. A number of further (military) application domains are provided in the call for contributions to The Serious Games Showcase and Challenge (sgchallenge.ist.ucf.edu), which has the purpose to identify innovative game based solutions to problems that could affect the Military both today and in the future. A partial list of what is regarded as military missions is provided, which includes medical, maintenance, aviation, combat, leadership, logistics, ship handling, strategic planning, military history, electronics, communications, engineering, flight deck operations, business management, finance, criminal investigation, intelligence/reconnaissance, combat awareness, acquisition, political science, health/nutrition, language and linguistics.

In the following, the categorisation of serious games into a number of markets, provided by Michael and Chen (2006), is adopted. The markets are: military games, government games, educational games, corporate games, healthcare games, and political, religious and art games, of which the first four are described in the next section (for more details, see Michael & Chen, 2006). This way of categorising serious games is very much in line with what is regarded as the core segments of serious games (www.seriousgamessummit.com). Despite such categorisations, notably many games could belong to more than one category.

Military Games

The military has a very long history of using games for training. Among the oldest war games are the board game *Chaturanga* from India and the Chinese *Wei Hei*, both from about four thousand years ago (Michael & Chen, 2006). These games with simple rules, allowing officers to become better planners for battles, have evolved into extremely complex simulators for tanks, helicopters, group training, etc. Along with the development towards more advanced simulators, the relative amount of money spent on games for the military has also changed, and simulation equipment and war games take up $4 billion (> 3 billion Euro) a year (ibid.).

Historically, military simulations have been, and still are dominant, but there is a move towards the use of "commercial off-the-shelf" components in both software and hardware

(Michael & Chen, 2006). For the military, game technology allows to create low-cost simulations that are both accurate and engaging, and for a severely lower cost than traditional simulations. The military is also the major user of serious games, but in a near future, the military will not buy static CD-ROM serious games. Rather, they will buy components that allow them to dynamically put together pieces of software and (or) hardware, and thereby set up their own games[2]. There are several commercial civilian wargames used by the military, for instance, *TacOps*, *Brigade Combat Team*, *Decisive Action*, and *Harpoon 3*, and examples of commercial games that have been adapted for military use include *WarCraft*, *Doom*, *Close Combat* and *Operation flashpoint* (Robel, 2004; Michael & Chen, 2006).

The first "serious game", designed and used for military training, was *Army Battlezone*, designed by Atari in 1980 (en.wikipedia.org). However, one of the most well known, and perhaps the leading example of a serious games application was released in 2002 – America's Army – which, in contrast to most video games, is free for download (americasarmy.com). The game emphasises authenticity and, for instance, all weapons and vehicles are strict virtual models of the real thing. Furthermore, unlike other games (e.g., Halo 2, Doom 3), it is only a relatively small step from virtual combat to the real thing (Grossman, 2005). By autumn 2004, America's Army had been downloaded over 17 million times, had a community of 4 million registered players, and the number of players increased by 100 000 each month (Michael and Chen, 2006). Obviously, America's Army is a popular game, and even though violent games is a controversial issue, it has been said "The violence, the combat – we recognize that's the part of the game people want to play", but it also "has to be fun…[i]f it's not fun, you don't have a game" (Major Chris Chambers, in Grossman, 2005).

America's Army provided a solution to a problem encountered by the U.S. Army in the late 1990s, namely how to reach and recruit new volunteer soldiers (Grossman, 2005). With an investment of 16 million dollars in America's Army (by the U.S. military), the game has been a success in that it has helped the Army to recruit soldiers at 15% of the cost of other recruiting programs (Grossman, 2005; Michael & Chen, 2006). Furthermore, besides recruiting volunteers, the game has also helped pre-training them, and with later modifications and extensions it has also been used by active soldiers to, e.g., prepare for missions (Michael & Chen, 2006). Another benefit (for the Army) of this particular game is that its target audience has found it to be a major source of information and knowledge about the Army; it is reported that 30% of Americans between the ages 16 to 24 claim to have learned some of what they know about the Army from this game (Grossman, 2005).

From a military perspective, video game playing (more generally) has a number of advantages, such as improved hand-eye coordination, improved ability to multitask, ability to work in a team using minimal communication, and willingness to take aggressive action (Michael & Chen, 2006). Many previous simulations and games have concerned combat, but more recent efforts also concern skills such as foreign languages and cultural training, and future application areas for the military field include massively multiplayer online games (MMOGs) and virtual reality trainers (ibid.).

Government Games

Training and simulation within the government range from a municipal level to a national level. Governmental games may concern a number of different kinds of tasks and situations, like different types of crisis management, for instance, dealing with terrorist attacks, disease outbreaks, biohazards, health care policy issues, city planning, traffic control, fire fighting, budget balancing, ethics training, and defensive driving (Michael & Chen, 2006; Squire & Jenkins, 2003). A major advantage of computer simulations is that they allow scenarios to be

[2] As presented by Roger Smith at the Serious Games Summit D.C. 2006.

run repeatedly. They can also carried out with varying degrees of severity, at different locations, etc., often with low costs in personnel and material resources. Simulation games also allow different types of first responders, e.g., fire fighters, police, and medical personnel, to practice situations that are too dangerous, impossible, or too expensive to carry out in reality to practice handling events that are otherwise dangerous, impossible or expensive to train on.

Educational Games

Educational games did not come into wide use until the 1990s with multimedia PCs, even though such games were created and used long before. At the time, educational games and other software evolved into "edutainment". However, interest in edutainment soon decreased, partly because the (poor) quality of the games themselves, and partly because of a growing interest in the Internet (Michael & Chen, 2006). The problems encountered in edutainment are reflected in phrases such as "edutainment, an awkward combination of educational software lightly sprinkled with gamelike interfaces and cute dialog" (Zyda, 2005, p.29), or "most existing edutainment products combine the entertainment value of a bad lecture with the educational value of a bad game" (Squire & Jenkins, 2003, p.8).

With the general renewed interest in serious games, game developers have moved from "skill-and-drill interactive learning paradigms towards situational and constructionist approaches" ELSPA, 2006, p. 17). Games in education is gaining acceptance, but their use is not widespread, and it is a controversial issue (ELSPA, 2006; Michael & Chen, 2006). Educational games is also faced with the challenge of providing research evidence of the acclaimed benefits, which currently is "complex and thinly spread", possibly because the study of games and gaming relates to several different disciplines; "as a result of the diversity and complexity of games themselves, and the range of perspectives taken by researchers, there are few hard and fast findings in the literature" (Kirriemuir & McFarlane, 2004, p.2).

Despite the "few hard and fast findings", research is showing positive effects of games as educational tools. Games can support development of a number of various skills: strategic thinking, planning, communication, collaboration, group decision making, and negotiating skills (Kirriemuir & McFarlane, 2004; Squire & Jenkins, 2003; see also Gee, unpublished manuscript). However, "hard facts and evidence" is for future research to provide. There is also a number of concerns to consider in order to realise the full potential of games as educational tools: resources (many schools have computers that are too old for new games, technical support, time for teachers to familiarise themselves with the game, etc.), how to identify the relevance of a game to statutory curricula, difficulty in persuading school stakeholders to the potential benefits of computer games, etc. (ELSPA, 2006; Sandford et al., 2006).

Corporate Games

Today's corporate training market is a large industry, expected to exceed 10 billion dollars by 2007 (though not all of it concerns serious games), which makes it of the same size as that of entertainment video games. Computer assisted training was brought to corporations during the 1990s with multi-media PCs, first with CD-ROMs, and later the Internet (Michael & Chen, 2006). However, while computer assisted training allowed corporations to cut costs for training staff, special equipment, locales, etc., differences in learning and engagement were not essential compared to previous classroom training. As new technology and media have become available, they have been adopted for corporate training, and now interest is growing in serious games and simulations, for several reasons; the number of employees familiar with video games is increasing, and their interest is quickly and effectively caught by interactive serious games. Compared to *non*-gamers, gamers have a deep understanding of risk versus

reward and they are also more likely to deal with trade-offs and to take measured risks (Beck & Wade, in Michael & Chen, 2006). With their multitasking skills gamers are also better prepared, we are told (ibid.), for the use of more sophisticated analysis tools than traditional spreadsheets and linear models, which are required due to the rapid changes in today's business climate and the streams of available data.

Corporate training can comprise a number of topics, some of them common for different corporations, while others are specific for a corporation's own needs. Michael and Chen (2006) provide examples of skills that corporations need to train their employees in: *people skills* (e.g., teamwork and how to perform well within the department and the overall company), *job-specific skills* (how to use software/hardware required by the job, etc.), *organisation skills* (how to organise resources and time, etc.), *communication skills*, and *strategy skills* (e.g., to set goals and to leverage resources to reach them). Besides the need to train some certain skills, there are also certain situations in which corporate training may be useful (Prensky, in Michael & Chen, 2006): when the learning material is technical or boring, when the learning objectives are difficult or complex, when the audience is difficult to reach, when sophisticated consequence analysis is required, and when communicating or developing corporate strategies.

As argued by Iverson (in Michael & Chen, 2006), serious games offer a paradigm shift in training as it changes the role of the trainee from passive to active, and it changes the role of the trainer from just delivering material to being a facilitator. An important aspect of the serious games development, as pointed out by Corti (in Michael & Chen, 2006), concerns assessment methodologies – it is important that results or effects of corporate training applications are measurable. Assessment methodologies may be both quantitative and qualitative, and they should allow the learner to get feedback regarding the consequences of actions.

Healthcare Games

Serious games applications related to health and healthcare are becoming more common, and today there exists a large number of them. Also, Ben Sawyer (co-founder of the Serious Games Initiative) expect healthcare to be the application area of serious games which will grow the most in the coming years (www.sgseurope.com/health.php?langue=EN). Health, abstractly speaking, is a very common aspect in all kinds of games since "health" is used as a means of representing access to different kinds of resources. For instance, the degree of "health" of many characters (a "person", a tank, etc.) is lowered by each received hit and it becomes easier to destroy, while performance of certain tasks, etc., instead increase the degree of "health". On a more concrete level, games can have direct or indirect positive physiological and psychological effects on individuals (cf. the previous section on advantages games; see also, e.g., Watters et al., 2006), which is exactly the aim of serious games in health and healthcare. Some examples showing the variety of types and areas for applications related to physical or mental health include:

- Physical fitness ("exergaming"); among several others, *Dance Dance Revolution* (De Maria, 2006) may serve as an example of video games and input devices, such as a dance-pad or a stationary bike, that can promote healthy habits. By adding the engaging elements of video games to physical activities, or vice versa, physical exercise seems to become more attractive (Michael & Chen, 2006).
- Education in health/self-directed care; games like *Hungry Red Planet* (www.hungryredplanet.com), funded by The National Institutes of Health (NIH) in the US, teach children nutrition skills and healthy eating habits. There are studies indicating that games can be helpful for patients to adjust their habits and lifestyles to

deal with their diseases (see Michael & Chen, 2006). For example, Archimage Inc.'s (www.archimageonline.com) *Nanoswarm: Invasion from Inner Space* and *Escape from Dian*, aim to prevent childhood obesity and type 2 diabetes by offering insight into how healthy eating and exercise can improve an individual's life (Gudmundsen, 2006; Dobson, 200X). Other games aim to motivate and educate young patients to fight cancer, enhance self-management skills to deal with asthma, etc.

- Distraction therapy; some games are used as distraction therapeutic tools, for instance, to help chronically ill children to deal with pain, distract them during uncomfortable treatments, or to lessen anticipatory anxiety before medical procedures like surgery (Michael & Chen, 2006; Cromley, 2006). An example is *FreeDive* from BreakAway Games (www.breakawaygames.com).
- Recovery and rehabilitation; games can be used to fasten recovery for certain operations and conditions. They have also been used for increasing motor skills (Sietsema et al., 1993). For instance, a game controlled with, e.g., a stylus might replace conventional physical therapy for a stroke patient (Cromley, 2006).
- Training and simulation; games can be used for, e.g., surgical training. It has been shown, for instance, that experience with video games is correlated with a better performance in laparoscopic surgery (Rosser et al., in Michael & Chen, 2006).
- Diagnosis and treatment of mental illness/mental conditions; games can be used for diagnosing and treating, e.g., attention deficit hyperactivity disorder (ADHD) and post dramatic stress disorder (PTSD). Some games, like *S.M.A.R.T BrainGames* (www.braingames.com), are designed to improve, e.g., the focus of children with ADHD (Cromley, 2006). Also commercial off-the-shelf (COTS) games are used for these purposes. An example is *Full Spectrum Warrior* (www.fullspectrumwarrior.com), which is used to both diagnose and treat post-traumatic stress disorder (PTSD) in war veterans (Michael & Chen, 2006).
- Cognitive functioning; video games as well as traditional games can be used for memory training, development of analytical and strategic skills, etc. (Mitchell & Savill-Smith, 2004).
- Control; games with with biofeedback equipment (e.g., sensors that measure heart rate and skin conductance) can teach an individual to better control mental and emotional states (Michael & Chen, 2006).

Evidently, there is great diversity in the set of applications for serious games in healthcare. Similarly, there are a number of diverse stakeholders in this market, which include hospitals, clinics, private practice physicians, therapists, personal trainers, government, corporations and other organizations and individual consumers (ibid.).

Actors in the Serious Games Market

To begin with, there is a vast number of actors in the serious games market and obviously not all can be accounted for. Instead, in the following, we provide examples of mainly academic actors in North America and Europe. The survey and the exemples are specifically aimed to represent serious games research, rather than game research in general. Also, this survey of actors is not all-encompassing, instead it is mainly based on school listings provided on the Internet[3]. The listed universities etc., were scanned for serious games research and related research projects. Considering the previous discussion on definitions of serious games, it is noteworthy that not all actors and research projects describe themselves as explicitly carrying out "serious games research". Instead some of them focus on simulation, education etc.,

[3] www.igda.org/breakingin/resource_schools.php; http://gamasutra.com/php-bin/companies. php?cat=153138

according to their own terminology. However, the actors listed below are ones considered by the authors to act within the field of serious games. Further, the actors have been geographically categorised, and project descriptions etc., have been retrieved from each actor's homepage(s). Obviously, not all actors were found, but in our minds the geographical distribution of actors is still representative for the spreading of serious games research in the mentioned regions. Also, to be noted, serious games research is conducted in regions other than those considered here, an example of which is Australia[4].

United States

For the time being, serious games research is most widespread in the US. Although games related research is not entirely new, the serious games movement got a start in 2002 with the Serious Games Initiative (SGI), founded by the Woodrow Wilson Center in Washington D.C. The SGI focuses on uses for games in exploring management and productive links between the electronic game industry and projects involving the use of games in education, training, health, and public policy. Further, the goal of SGI is "to help usher in a new series of policy education, exploration, and management tools utilizing state of the art computer game designs, technologies, and development skills" (www.seriousgames.org/about2.html).

Research at the GVU Center, at the Georgia Institute of Technology (www.gatech.edu/), focuses on the use of graphics (3D models, animation, virtual and augmented reality, visualisation) for crafting visual form and function to mirror reality to match human capabilities. The GVU Center also takes an interest in how to augment and design spaces to create, e.g., information-rich workplaces and intelligent battlefields. The Virtual Worlds Lab researches how to create immersive computer-generated experiences, with projects like "Fire Department Training" - a fire command training simulation which allows firefighters to practice fighting a fire in a single story dwelling, and where the system's user is able to direct firefighters to different sections of the house in order to optimally fight the fire.

Research on educational games is conducted, e.g., at the Center for Research on Learning and Technology (CRLT), at the Indiana University (http://crlt.indiana.edu/). For instance, the learning and teaching project "Quest Atlantis" uses "a 3D multi-user environment to immerse children, ages 9 to 12, in educational tasks. Building on strategies from online role-playing games, Quest Atlantis combines features used in commercial gaming environments with lessons from educational research on learning and motivation". Another example of games in education is "The Education Arcade" (http://educationarcade.org/about), in which the Massachusetts Institute of Technology (MIT) and the University of Wisconsin-Madison have joined forces "to catalyze new creative, teaching, and learning innovations around the next generation of commercially available educational electronic games". One of the projects, "Learning Games to Go", creates designs for "computer games that address middle-school math and literacy learning, with particular attention to underserved populations". The Comparative Media Studies Program at MIT (in collaboration with a number of partners) has developed a number of scenarios/games to illustrate their pedagogial potential (the examples below are described in Squire & Jenkins, 2003). One is "Civilization III", aimed to find out what players learn about social studies. In the game, players encounter history as the product

[4] The Virtual Environment & Simulations Labs (VESL) (within the School of Information Technology and Electrical Engineering, at the University of New South Wales, the Australian Defence Force Academy (http://seal.tst.adfa.edu.au/research2005/index.html). VESL addresses a number of research areas, e.g., application and technology of COTS Games as tools for training, teaching and research, and multi-agent simulations with focus on abstract models of military conflict, in which agent-technology is employed to represent and control the entities on the battlefield (VESL also provides a wargaming "Course of Action Analysis" tool, freely available for download). Another area is models of human behaviour and decision making, where data is collected for models that "drive" the avatars/agents in VEs and simulations so as to provide heightened immersion (VEs) and higher fidelity models (simulations).

of dynamic interrelated forces, e.g., economics and foreign policy, and they can engage in activities such as political negotiations. Another scenario is “Biohazard: Hot zone”, a game aimed “to help emergency first responders deal with toxic spills in public locations”. In the game, users work in teams, responding to a gas attack in a suburban shopping mall. The aim of the gaim is to help people prepare for potentially catastrophic situations.

The Institute for Simulation and Training (IST) at the University of Central Florida (www.ist.ucf.edu/projects.htm), focuses “on advancing modeling and simulation technology and increasing our understanding of simulation’s role in training and education”. The IST has several labs conducting serious games related research, with projects ranging from health related simulations, education, to simulations for military training. For instance, projects carried out at the Department of Applied Research & Technology (DART) (www.ist.ucf.edu/dart/dartlab.htm) include “evaluation of virtual environment teamwork training and animation studies”, and research at the Media Convergence Lab “explores ways to integrate entertainment, training and simulation”. For instance, in the “Mr Mout” project, a cross domain simulation, the user can “command…troops across enemy lines and rescue hostages held by armed terrorists”, which allows users to “experience the next generation training for future force warriors”. The Medical Emergencies Simulation Lab has created facilities for training medical trainees in taking care of casualties simulated on a distant training field. Thus, “researchers have created a sophisticated medical simulation capability that can enhance military, civil defence and crisis management training”.

The Stanford Center for Innovations in Learning (SCiL), at the Stanford University (http://scil.stanford.edu/news/game4-06.htm), conducts “research to advance the science, technology and practice of learning and teaching”. One of the projects at SCiL, “Gaming to Learn”, is developing “The Triple A Game Show”, using virtual, on-line worlds and the concept of learning-by-teaching. Based on the fact that “students who prepare to teach someone learn more than students who prepare to take a test themselves”, the game provides a means to augment learning. In the game, students teach an agent on some subject. The game also allows students to collaborate, interact with a teachable agent, and let the agents play games that requre knowledge of certain topics in order to win.

At the Ackoff Center for Advancement of Systems Approaches (ACASA) at the Penn University of Pennsylvania (www.acasa.upenn.edu/), researchers have developed the “Heart Sense Game”. Heart Sense Game is a cartoon world videogame designed as a health behaviour intervention. The game is “a role playing game in which you help the hero try to solve a crime and simultaneously rescue his career and find romance”. The hero, and some of the many characters in the game, need your help to deal with heart attacks before they or others can help you. The goal of the game is to “help the player to overcome their own symtom recognition and resistive behavior issues before they have a heart attack themselves (or a loved one has one). The hope is that learning about these issues in a story world will help to reduce delay in seeking care if one ever encounters a heart attack in the real world”.

The Modeling, Virtual Environments and Simulation Institute (MOVES) at the Naval Postgraduate School (www.nps.navy.mil/moves/) focuses on several areas, among them game-based simulation, understanding, and analysis. Accordingly, MOVES has developed a research program “designed to explore application of emerging technology to critical DoD modeling and simulation needs”. One of the projects concerns importing geospatial data sets into 3D applications for training and education, in which a common problem is that the resulting environment often poorly represents its real world counterpart. Thus, the project “Simplifying the use of geospatial data in modern game engines”, concerns the technological aspects of importing such data sets into a modern game engine.

Canada

Serious games research in Canada include, for instance, "The Montreal GameCODE Project: Cultures of Digital Environments", developed at the Concordia University (Montreal; www.gamecode.ca/). It focuses on making sense of the social significance of digital games, and specifically encourages "the analysis of digital games and gaming in relation to the social, cultural and political conditions of living, working and playing in contemporary information societies". Research on educational games is also conducted at the University of Calgary (http://pages.cpsc.ucalgary.ca/~parker/DML/welcome.html). Researchers at the Digital Media Laboratory and the Red Crow College have developed the "I'powahsin Project", with the aim to create a portable (GameBoy) Game that will assist in the teaching of the Blackfoot aboriginal language. The game will be based on a Blackfoot story, and it will be unique in that it will be playable in the Blackfoot language. The project's goal is to "build a prototype GameBoy game that illustrates the potential of the device and the game genre for teaching, and thereby preserving, indigenous languages". Another project, "The Turtle Island" (involving a number of researchers at Canadian universities and colleges), aims to create a Massively Multiplayer Online Role-playing Game (MMORG) that will simulate the aboriginal cultures in ancient North America. The game is intended to assist preserving aboriginal cultures in North America by allowing "native game players to see their culture presented in the interactive medium, and to expose them to aspects of their culture that they perhaps have not encountered".

Research on educational games is also conducted at the Simon Fraser University – School of Interactive Arts and Technology (SIAT) (www.siat.sfu.ca/). The project "Simulation and Advanced Gaming Environments for Learning" (SAGE) is "a bilingual (English and French) project exploring the potential of games, simulations and simulation games to support learning in light of new technologies, new media and our knowledge of cognition and learning processes". Among its objectives are to "demonstrate the application of knowledge resulting from [their] research on SAGE impacts in the development, implementation, and testing of prototype SAGEs in the fields of health promotion, health care, and health education", and to test "implementation of SAGEs in authentic contexts, e.g. schools, businesses, and community settings". Another project at SIAT is "HealthSimNet" (part of a national network of research on simulations, games and learning). The project models "the ontology of health-care for HIV/AIDS sufferers and their networks of professional and lay support". The model forms the basis for development of an interactive simulation game that will be used to review performance from individual and organizational perspectives. Yet another project is "Advanced Gaming Technology for Training Business Majors", which explores emerging technologies for business strategy gaming, and their implications on the pedagogy of business education. The project focuses on "active intelligent agents, which, if necessary, would allow removal of the human player from the simulation loop to speed up the game. Intelligent agents…offer such new opportunities as benchmarking the actions made by the learners during the game". The aim is to develop "new technical solutions to business strategy gaming and recommendations on bettering the pedagogy of gaming".

In the next sections we move on from actors in North America to ones in Europe. In the following, examples are accounted for beginning with actors in the United Kingdom, ending with actors in Sweden.

United Kingdom

Moving on to serious games research in Europe, we find that most of it is concentrated to the United Kingdom and the Scandinavian countries. In the United Kingdom, the Serious Games Institute (SGI) (managed by Coventry University Enterprises Ltd., in partnership with the Warwick University; www.coventry.ac.uk/newthinking/html/serious.htm), is a "new initiative

designed to transfer the ideas, skills, technologies and techniques used in commercial entertainment games to local [Small-to-Medium-sized Enterprises] SMEs". SGI combines the knowledge of researchers with that of the local gaming industry, thereby integrating technology transfer, applied research and professional development. Another UK based networking association is Angils (www.angils.org/index.html), except it has a global vision of its activities, while SGI has an explicit regional focus.

At the University of Birmingham (www.iecs.bham.ac.uk/hit/sg.htm), researchers in Human Interface Technologies (HIT) focus on "theoretical and practical human-centred research issues related to future interactive technologies". One of their research areas is medical simulation, which includes, e.g., virtual environment training. Another area is serious games, conducted by the Birmingham Serious Games Team, with several projects running. Some projects focus on health, such as the "Interactive Trauma Trainer", in which the user's task is to save the life of virtual casualties. The user has to make appropriate decision regarding the urgent treatment of an incoming casualty, and apply appropriate interventions. The "Pulse!!" project focuses on the internal anatomical structure of the human body; the structure is not always as described by text books and so "surgeons may make false assumptions". Based on an experimental gaming implementation, the project aims at understanding why surgical errors are made. Yet another health related project is "Post-Traumatic Stress Disorder", which focuses on "the development of a 'serious game' software programme to assist psychiatrists and psychotherapists to help…service personnel who return from active service in Iraq…suffering form Post-Traumatic Stress Disorder". Other projects relate to the military domain. One such is "Part-Task Training for the Royal Navy's Dillon Minigun"; the project concerns the development of a game based trainer in desktop form for training "close-in combat and ship protection". Another project is "Alchemy 1 & 2 Unmanned Vehicle (Land/Air) Demonstrators", which investigates how low-cost, games technology-based simulations can be used "to support the development of new guidelines and standards relating to operator display and control requirements for ISTAR UAVs (Intelligence, Surveillance, Target Acquisition & Reconnaissance Unmanned Air Vehicles)".

At the University of Sheffield, the Computer Graphics Research Group (www.shef.ac.uk/dcs/research/groups/graphics) conducts research in, e.g., computer games technology, and issues such as human character animation, "which facilitates development in…computer games and virtual training environments". The project "Serious Games: Engaging Training Solutions" (in collaboration with other universities), aims to "apply skills and technology used in video games to create serious training applications". Among other things, the project seeks to research "the factors that make games successful and identifying which are relevant to training", and to build "different 'proof of concept' serious game solutions to specified training needs with sector experts and potential clients".

Futurelab (a not-for-profit organisation, collaborating with, e.g., academics, corporations, and practising teachers) (www.futurelab.org.uk/research/lit_reviews.htm), takes an interest in transforming the way people learn. Futurelab focuses on "the potential offered by digital and other technologies", and develops "innovative learning resources and practices that support new approaches to education for the 21st century". Among a vast number of projects, an example of a serious games related one is "Teaching with games". The project investigates "the place of mainstream commercial computer games in the classroom", and aims to provide "evidence of the implications and potential of the use of these games in school, and an informed strategy for future educational development requirements". Another project is "Astroversity" (in collaboration with the International Centre for Digital Content, ICDC, at the John Moores University (www.ljmu.ac.uk/). Astroversity is a game for students, played in groups of three. The game is designed to develop collaborative and scientific enquiry skills, and the task is structured so that individual students cannot complete it in one attempt. Instead

a group of three is required for the most effective solution. A novel aspect of the game is "the use of multiple methods of representation, requiring students to switch between a virtual online world and a paper-based representation which they create" as part of the game. Yet another example is "Iya-ola**"** (in collaboration with Attic Media)**.** The Iya-ola game (or prototype) provides "children with a means of trying out their Spanish with Spanish-speaking children, whilst the Spanish children have an opportunity to practise their English". As the game progresses and learners advance and rehearse in the game format, they then join an audio-visual chat with another learner (or learners) in a Spanish-speaking classroom (the other children have also been playing the game, only in English). The children then help each other solve a puzzle that demands the use of the practised languages.

Norway

The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), is a Scandinavian independent research organisation, which generates "new knowledge and solutions […] based on research and development" (www.sintef.no/content/page3____226.aspx). SINTEF runs the project "Providing Real Integration in Multidisciplinary Environments" (PRIME), which aims to enhance work environments by means of serious gaming. For corporations, the project will provide an opportunity to learn by experience within a virtual environment that is safe and allows risk taking without damaging the business. Thereby, PRIME aims to provide "business professionals a learning environment where they can experiment with new ideas and learn how to handle the entire life cycle of products and processes for all stakeholders of the organization".

Denmark

The Center for Computer Games Research, at the IT University of Copenhagen (http://game.itu.dk/), focuses on game aesthetics, game design, game spaces, game worlds, gaming cultures, and learning in games. Under the label of "Educational potential of commercial game technology", the aim is to "develop a prototype for the next generation of educational computer games based on commercial games technology". An example is the project/network "Serious Games Interactive", which has developed the game "Global conflict; Palestine". While playing the game the user learns about the Israeli-Palestinian conflict, by playing a journalist who navigates between Palestinians and Israeli sources to get her/his article. The game will also have "extensive support for educational use with features like encyclopedia, primary sources, assessment and teacher's manual".

Finland

The Agora Center/Agora Game Lab, at the University of Jyväskylä (www.jyu.fi/en/research/units/), focuses on the planning, development, and training requirements of electronic games. One of the projects, "Gameli" provides a simulation game environment that aims to support understanding and learning of natural scientific phenomena. The game supports both learning by playing and learning by designing game world simulations. Another project, "Project Finland", concerns an interactive developmental game where users learn about Finland's environment, social change, and global connections (www.peda.net/veraja/jyu/ac/agl/tutkimus/projektit/muumi).

Germany

At the Otto-von-Guericke University (http://games.cs.uni-magdeburg.de/index.php?id=forschung&L=2), the Group for Graphical and Interactive Techniques in Computer Games "explores the techniques and tools for future computer games and at the same time takes into

account technical aspects as well as aspects regarding the content". One project, "Playful Learning – Learning Environments for Children", focuses on digital educational games and the qualities leading to learning success (e.g., knowledge creation and contextual learning). Further, research by the Workgroup Computer Games focuses on the development of the environment "Squeak", which is a tool for researching, learning and playing with new media (www.squeakland.org).

Sweden

Defence Gaming (www.defencegaming.org/) is an initiative from the Swedish Defence Materiel Administration (FMV), the Swedish Defence Research Agency (FOI) and the Swedish National Defence College (FHS) to study, research and explore the conjunction of computer and video games world and the military. One of the projects has developed a game that illustrates typical situations in peace support operations; "Foreign Ground - A Digital Game for Decision Making in Foreign Cultures" (in collaboration with the Technical University of Luleå, www.ltu.se/ske/d1139/1.613). The prime activity of the game is not combat situations, instead it focuses on communication with civilians, conduct of own personnel, and to solve tasks and handle situations by means other than violence. The game presents challenging situations in which the trainee learns to handle situations that require fast decision making and action. Another projects is "Geospecific Terrain for 3D-engines", which studies the differences between developing a 3D-terrain based on a traditional 3D-engine from the simulation/training industry, and a gamebased 3D-engine. The project "Computer Games as a Base for Training Simulators" has focused on the use of COTS computer games as a base for training simulators. In the project several games have been inspected for features such as the ability to build large geospecific terrains, localised speech and text, ability to modify/add content for weapons, vehicles and uniforms/soldiers, command structure, and scenario tools.

The InGameLab, at the University of Skövde, researches the fields of computer games and other interactable media such as training simulators. A strategy is to merge the domains of training simulators and computer games, in which the element of motivation and engagement is considered important (www.seriousgames.se). The computer games research is in a strong developmental phase linking computer games research to established research areas, and to the many computer games graduate study programs at the university. At the core of this research effort are the labs, which include a driving simulator, a cave, and labs with home and office settings, respectively. The aim is to create dynamic projects comprising local companies, research and education. One project run by the InGameLab is "Spel & Trafiksäkerhet" (Sp&Ts) ("Games & Traffic safety"), in collaboration with, e.g., insurance companies and driving schools. The aim is to investigate the use of games as a means to attain safer traffic behaviour. Another project is "Serious Games Cluster and Business Network"[5] (in collaboration with the University of Coventry), which aims to analyse the field of serious games and to develop demonstrators in order to advance the field. The InGameLab is developing "FireFighter", a demonstrator for training smoke-helmeted fire fighters.

In summary, we have identified a number of serious games actors, according to the criteria described in the beginning of this section. As previously mentioned, we believe the examples mentioned here provide a representative picture of the geographical distribution of serious games actors in the regions chosen regions. We also assume that the chosen approach has captured many of the actors with "mature" research, that is, ones that have (more or less) established serious games research, rather than being at the point of starting up research in the domain. When starting up research in new areas and (or) projects, often some tasks have

[5] The present report is part of the Serious Games Cluster and Business Network project.

lower priority than others, such as providing project descriptions and other information on web-pages and to keep them updated. With that in mind, some of the above examples may be outdated, while other projects may not have been encountered at all. As for the ratio between geographical areas, it is also difficult to know at what pace new serious games actors and projects appear, and it may be the case that more projects have begun recently in European countries, than in the US. Had all serious games research (ideally) been available on the Internet, the result of this survey may have had a different outcome.

Serious games research in the US seems to be more "visible" than in the European countries, a plausible reason being that research in the US has matured to a level not yet reached in many European countries. Not all actors in these regions are represented though, for a number of possible reasons. For instance, some research may not (for whatever reason) have been made available in the first place. Also, an important factor is in which language research is made available (not all researchers, universities, etc., have English as their first choice of language).

Within Europe, serious games research is most clearly discernible in the UK, with boundary crossing research established at many locations and geographical areas. Besides the UK, serious games research appears to be mainly concentrated to the Scandinavian countries, in which such research to some extent already has been established, but also is in a strong developmental phase. Similarly, it can expected that we will see a substantial growth in serious games research and number of various actors in several regions over the next few years.

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Conferences and Organisations

Angils.org (www.angils.org). The European-based (UK) networking organisation Angils brings together corporations, groups, and other organisations with industry, with focus on Serious Games and emerging technologies across digital entertainment, the knowledge industries and the media.

Apply Serious Games (www.applyseriousgames.com). The first ASG-conference was held in London, UK 2006. The goal of the conference was to bring together game developers, learning suppliers, publishers, etc., to explore, for instance, effective immersive learning content, correct application design, commercial viability, and innovation in action across many applications.

The American Society of Trainers and Developers (ASTD) (www.astd.org/astd). ASTD is the largest association dedicated to workplace learning and performance. ASTD provides resources and organises conferences with a focus on, e.g., e-learning.

Christian Game Developers Conference (www.cgdc.org). The Christian Game Developers Conference is a gathering with the purpose of encouraging game developers to apply Christian principles to their industry.

Cyber Therapy Conference (www.interactivemediainstitute.com/). The Interactive Media Institute (IMI) is a non-profit organization working for the application of advanced technologies for patient care. The Institute is actively working with experts in utilizing virtual reality, multimedia, computer-generated avatars, personal robots, and other technologies to treat patients with both mental and physical disorders. The CyberTherapy Conference, held in Switzerland, brings together researchers, clinicians, and funders to share and discuss the field of CyberTherapy. Technologies include virtual reality simulations, videogames, telehealth, the Internet, robotics, and non-invasive physiological monitoring devices. The 11th Annual CyberTherapy Conference was held in June 2006.

Defence Gaming (www.defencegaming.org). Defence Gaming is an initiative by different Swedish defence government agencies to study, research, and explore the conjunction of the computer and video games world and the military.

Department of Defense (DoD) Game Developers' Community (www.dodgamecommunity.com). The aim of DoD Game Developers' Community is to bring together the community developing games within the US military. The web site, among other things, supply information on most major games developed for the Department of Defense and gives design advice on building games.

Digital Games Research Association (DiGra) (www.digra.org). DiGRA is an association for academics and professionals who research digital games and associated phenomena. DIGRA encourages research on games, and promotes collaboration and dissemination of work by its members. The aim of the annual conference (www.digra.org/digra_conference; www.gamesconference.org/) is to bring together all who can provide insights about digital games, from academia to industry, across a wide range of disciplines and expertise, and so be able to get a greater holistic understanding of games, their impacts, and potential.

Education Arcade, Games in Education Conference (www.educationarcade.org/, currently [2006-12-07] redirected to www.educationarcade.org/node). The conference explores issues in the development, use, and marketing of educational games. The initiative seeks to encourage research and development of educational games.

Entertainment and Leisure Software Publishers Association (ELSPA) (www.elspa.com). ELSPA is a UK association, comprising interactive entertainment industry, protecting,

promoting, and providing both for its members and for the industry as whole. Activities include, e.g., industry reports and research, and official games charts and analysis.

Futurelab (www.futurelab.org.uk) is a non-profit organisation commited to sharing the knowledge and experience learnt from their research and development in order to inform positive change to educational policy and practice.

Future Play (www.futureplay.org). The conference focuses on three themes: a) future game development, which addresses academic research, and emerging industry trends in the area of game technology and game design, b) future game impacts and applications, which includes academic research and emerging industry trends focused on designing games for learning, for gender, for serious purposes, and to impact society, and c) future game talent, which is designed to provide a number of industry and academic perspectives on the knowledge, skills, and attitude it takes to excel in the games industry.

Games for Change (G4C) (www.seriousgames.org/gamesforchange/). G4C is the social change/social issues branch of the Serious Games Initiative. G4C focuses on non-profit organizations and promotes games for societal change. The organization has an annual conference.

Games for Health (www.gamesforhealth.org/). The Serious Games Initiative founded Games for Health to develop a community and platform for games being built for health care applications. The annual conference brings together researchers, medical professionals, and game developers to share information about the impact games and game technologies can have on health care and policy.

Games, Learning, and Society Conference (www.glsconference.org). The conference brings together academics, designers, and educators to discuss how game technologies can enhance learning, culture, and education. One aim of the conference is to prevent the issues of learning and the social role of games from getting lost in the cause of industry-building.

G.A.M.E.S. Synergy Summit (www.synergysummit.com). G.A.M.E.S. is an acronym for Government, Academic, Military, Entertainment and Simulation. The conference, which started in 2005 and is expected to be annual, brings together leaders and participants from each of the above sectors.

International Association of Games Education Research (IAGER) (www.iager.org). IAGER is a non-profit member organization dedicated to promoting and improving educational games through educational game research and shared resources. IAGER intends to hold an annual conference.

International Simulation and Gaming Association (ISAGA) (www.isaga.org). ISAGA is an international organization for scientists and practitioners developing and using simulation, gaming, and related methodologies. The main goals include to enhance the development and application of simulation and gaming methodologies in particularly the social, human, and technological domains. ISAGA has an annual conference.

The Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) (www.iitsec.org). The conference promotes cooperation among the Armed Services, Industry, Academia and various Government agencies in order to improve training and education programs, identify common training issues, and develop multiservice programs.

Learning in Video Games (learninginvideogames.com). The website provide news, articles, and other resources on the use of video games for learning and educational purposes.

Medicine Meets Virtual Reality (www.nextmed.com/mmvr_virtual_reality.html). The conference is intended to be a forum for, e.g., encouraging and sharing research on virtual reality tools for clinical care and medical education. The intended audience is

healthcare professionals and educators, computer technologists, biomedical futurists, and military medicine specialists.

The Serious Game Initiative (www.seriousgames.org). The Serious Games Initiative focus on the use for games in exploring management and leadership challenges facing the public sector. Part of its aim is to help form links between the electronic game industry and projects involving the use of games in education, training, health, and public policy.

The Serious Games Summit D.C. (www.seriousgamessummit.com). The Serious Games Summit D.C., produced by the CMP Game Group and held in Washington D.C., places focus on exploring new ways to broaden the spectrum addressed by serious games. The core segments of serious games - military, government, healthcare, corporate training and education - play a major role at the conference. A short form of the conference (www.gdconf.com/conference/seriousgamessummit.htm), targeted toward game developers, takes place before the annual Game Developers Conference (GDC) (www.gdconf.com/).

The Serious Games Summit Europe (www.sgseurope.com). The European version of The Serious Games Summit D.C.

Social Impact Games (www.socialimpactgames.com). Social Impact Games is a web site which catalogues serious games. Currently [2007-01-20] over 200 serious games are listed.

Visuals and Simulation Technology Conference and Exhibition (ViSTech) (www.halldale.com/vistech/). The first ViSTech conference and exhibition was held in 2005. It aims to bring experts in the visual technologies closer together with professionals in simulation and training. The conference is directed toward commercial and military designers, manufacturers, and users of visual system technology, and covers the use of game technology in military and government applications.

Games

This list contains some examples of serious games products of both commercial and academic origin (the list is based on one person's judgment on the purpose of the games). In general, pure entertainment games which may well be used for other purposes have not been included.

Americas Army (http://www.americasarmy.com/); First person shooter game which promotes the US Army. Also used as an instrument for recruiting soldiers.

The Triple A Game Show (http://scil.stanford.edu/news/game4-06.htm); A game about eco-systems which uses a learning-by-teaching strategy to enhance learning.

Brain age (http://www.brainage.com); A Nintendo DS game with various games and exercises in drawing, speed counting and drawing.

Bridge Builder (http://www.bridgebuilder-game.com/); A game for building bridges by which the user learns about construction and engineering.

The Business Game (http://pixelearning.com); A game-based learning product teaching business dynamics and introducing enterprise to young adults and teens.

A Force More Powerful (www.afmpgame.com); A simulation game that teaches the strategy of nonviolent conflict.

Food Force (http://www.food-force.com/); A game for learning how to deliver food aid to areas in crisis and how to help people rebuild their lives after a disaster. Sponsored by UN World food programme.

Futurelab – Racing Academy (http://lateralvisions.co.uk); A teaching game about physics and mechanical engineering in a virtual community.

The Intel IT Manager Game: The simulation of an IT department (http://itmg2.intel.com/eng/); An advergame where the player manages an Information Technology (IT) department.

NanoMission (http://www.nanomission.org/); An educational serious game that aims to teach players about the concepts of nanoscience through real world practical applications.

Navy Training Exercise (http://nte.navy.com); A recruiting game for the US Navy.

The Utrecht Blob ((http://www.utrecht.nl/smartsite.dws?id=144537); A game about the city of Utrecht. The user learns to find the way through Utrecht and paint buildings.

3rd World Farmer (http://www.heavygames.com/3rdworldfarmer); A game teaching the player about the economics of farming.