DIGITAL KOMPETANSE | 3-2006 | VOL. 1 | SIDE 184–213

Simon Egenfeldt-Nielsen
IT-University of Copenhagen, sen@itu.dk | Center for Computer Games Research

# Overview of research on the educational use of video games

## Abstract

This paper overviews research on the educational use of video games by examining the viability of the different learning theories in the field, namely behaviorism, cognitivism, constructionism and the socio-cultural approach. In addition, five key tensions that emerge from the current research are examined: 1) Learning vs. playing, 2) freedom vs. control, 3) drill-and-practice games vs. microworlds, 4) transmission vs. construction, 5) teacher intervention vs. no teacher intervention.

KEYWORDS
education • video games • edutainment • learning • video games • overview • behaviorism • constructionism • cognitivism • socio-cultural • instructional technology • playing • teacher

More than once we have heard that research on video games is an emerging field in which there has been no prior research, even though this is clearly not the case. Unfortunately, amnesia shackles too many researchers. In providing a comprehensive overview of the educational use of computer games, the paper contributes to the cure for this amnesia and highlights key tensions emerging from the current research that should be considered by practitioners and researchers alike.

## The method behind this overview

The paper presents the most influential research on the subject based on an extensive search of the literature. The following database resources were used: Eric, Psych info, Medline, Ingenta, Emerald, ProQuest, Game Studies, Game-research.com, Simulation & Gaming and several others, as well as the most recent literature overviews, conference proceedings and websites of researchers. References found throughout these sources have been further expanded by examination of the references cited there.

Overall, the search resulted in more than 300 references based on search terms such as video games, instructional, educational, learning and the like. The most influential research, making up the body of this overview, is based on an informal overview of the articles other researchers used and the quality of their studies.

Areas of cognitive changes, for example eye-hand coordination and visual-spatial abilities, are not included, nor are studies examining the relationship between video games, violence, aggression, and social behavior. Also excluded is the area of business and military simulations. Although partly related, these have quite different settings and target groups compared to most research on the educational use of video games. Experiential learning is also missing from the overview, although this has a strong base in the related area of simulation of games. So far, however, experiential learning has had little success within the educational use of video games, although there are some exceptions (e.g. Egenfeldt-Nielsen, 2005). Finally, this overview does not deal with research on the non-electronic educational use of simulation and gaming[1].

## Why do we need an overview of the educational use of video games?

The educational use of video games is central to the broader area of learning with video games and throws up one or two unique problems related to educational scope. We still lack an exclusive overview (on the use of video games for education) focused on the implications of using video games within an educational context. The educational setting presents unique problems in terms of methods, focus, and relevant research questions.

The first research overviews within the broad area of learning from video games have appeared within the past 10 years (i.e. Cavallari et al., 1992; Dempsey et al., 1996; McGrenere, 1996). These serve as a viable starting point in combination with overviews that are more recent, inclusive, and thorough (i.e. Bergman, 2003; de Freitas, 2005; Kirriemuir & McFarlane, 2003; Mitchell & Savill-Smith, 2004; Squire, 2002). In addition to the literature on learning from video games, there are a number of useful overviews of learning from simulations. These have quite a different scope, with a focus more on simulations than on video games (Bredemeier & Greenblat, 1981; Clegg, 1991; Dorn, 1989; Lederman & Fumitoshi, 1995; Leemkuil et al., 2000; Randel et al., 1992; Van Sickle, 1986; Wentworth & Lewis, 1973).

However, even attempts at overviewing the broader field of learning from video games are skewed in some way. Some of the problems within the field reflected in these overviews are: 1) Lack of separation between different ways of using video games for learning (i.e. de Freitas, 2005), 2); underdeveloped theory on facilitating learning through video games (i.e. Kirriemuir & McFarlane, 2003); 3) weak theoretical knowledge of video games (i.e. Mitchell & Savill-Smith, 2004); 4) incomplete use of previous litera-

ture owing to the variation in terminology, place of publication, and researcher backgrounds (i.e. Squire, 2002)[2].

## Boundaries of learning from video games

Learning from video games spans a wide area of topics, not all of which can be treated successfully under the same heading. Certainly, an awareness of the different sectional views that exist is important to understanding the field. We have to be careful not to confuse learning how to play video games and accidentally learning from video games with a targeted educational effort of video games. *This overview focuses on the educational efforts with video games.*

The educational use of video games is characteristic in that the learning experience has a specific goal. There is little doubt that we can learn from video games (like any other activity in life), but the harder questions relating to who, what, where, why, and how quickly we learn are not readily solved. Unfortunately, many researchers still settle for examining whether we learn from video games, neglecting to examine whether the results from a video game differ from those of other activities in, for example, efficiency and requirements (for example the monumental work by Gee, 2003). The lack of control groups in research set-ups demonstrates this vividly. In most studies, researchers examine the effect of a course which includes video games without making any comparison with a similar course without video games (e.g. Adams, 1998; Kafai & Neulight, 2005; Squire, 2004), although there are exceptions (e.g. Lieberman, 2001; Wiebe & Martin, 1994). Problems related to the use of control groups suggest that it is useful to look at alternative methods to experimental set-ups, e.g. ethnographic classroom research, cultural studies, and design-based research.

An important distinction when determining the educational use of video games is the different game titles used. The first, most obvious category, is commercial educational video games, often known as edutainment. Edutainment focuses on teaching the player certain specific skills: mostly algebra, spelling, problem-solving, and other basic skills. Edutainment titles include *Math Blaster*, *Pajama Sam* and *Castle of Dr. Brain*. Edutainment titles have a strong educational component but often do not reflect the motivational drive of commercial titles (Facer et al., 2003; Leyland, 1996).

The second category comprises commercial entertainment titles used fairly haphazardly for education. These rarely focus exclusively on one topic and on basic skills. Commercial entertainment video games in this category include *SimCity* and *Civilization*, titles used by several schools. The educational goals of commercial video games are indirect rather than direct, goals that can lead to a skewed focus in the learning process. However, their strength is that the motivational part is well documented from success on the commercial entertainment market (Kirriemuir & McFarlane, 2002).

The third category is research-based educational video games; these often challenge the existing formula of edutainment (e.g. Hancock & Osterweil, 1996; Malone & Lepper, 1987a). Edutainment originating from research often presents new approaches and has strong documentation for learning outcomes. However, these titles often lack the budgets and technical quality to compete with the more commercial titles. They make a greater impact only if published on the commercial market with some modifications. Exemplary titles are *Oregon Trail*, *Logical Journey of the Zoombinis, Phoenix Quest* and *Global Conflicts: Palestine*.

## What is edutainment?

> To this point, video games with "educational" features have not fared well in the marketplace. The "educational" content tends to come at the expense of the gameplay and control is taken out of the hands of the player… Game buyers (as opposed to concerned parents) are wary of edutainment. (Leyland, 1996, p. 1)

Edutainment, an amalgamation of "education" and "entertainment", is a broad term covering the combination of educational and entertainment use on a variety of media platforms, including video games. It became current within video games up through the 1980s, with the critique accelerating especially in the 1990s. Electronic Arts were first to use the edutainment label for video games when marketing the popular title *Seven Cities of Gold* in 1984. Parents warmed to the combination of entertainment and education, preferring play during which their children learned something. The term edutainment is fairly wide-ranging, with many games subscribing to the category. Although less attractive today, game companies still incline towards strengthening the appeal for parents, compared to 20 years ago (Buckingham & Scanlon, 2002; Mamer, 2002).

Behaviorism, cognitivism, and, later, other educational theories shape the face of edutainment. Early on, popular edutainment titles spanned the entire field of learning theories, although research-based titles presented an alternative to the dominating behaviorist titles. During the 1970s, a number of research-based titles were developed, and up through the 1980s there remained room for edutainment titles hailing constructivist learning theories. The current status of edutainment is that titles with a different learning approach than behaviorism are outmaneuvered commercially by traditional edutainment concepts, a development accelerated by consolidation in the edutainment market in the mid-90s (Andersen & Dalgaard, 2005; Buckingham & Scanlon, 2002; Konzack, 2003; Leyland, 1996; Willis et al., 1987).

## Practical barriers to the educational use of video games

Over the years, researchers and educators have recognized that using games in general, and video games in particular, entails a number of very basic problems. Those usually mentioned first relate to the constraints within an educational setting, e.g. short lessons, physical space, variations in game competence among students, installation, costs, and teacher preparation time. In addition, the perception of video games still influences the learning experience. Both students and teachers approach the educational use of video games with skepticism. One recent study indicates that students may be reluctant to engage with video games based on this skepticism, which stands in stark contrast to the usual idea of all students embracing video games (Egenfeldt-Nielsen, 2004; Gros, 2003; Hostetter, 2003; Kirriemuir & McFarlane, 2002; Prensky, 2004; Squire, 2004).

## Learning outcome from the educational use of video games

Overall, it has to be said that the current findings on learning outcome are positive and promising (Table 1). Some skepticism is warranted, however, because the lack of control groups, researcher bias, weak assessment tests, and short exposure time is not addressed sufficiently. A similar picture emerges if we look at the related research on the educational use of simulations. Although the overall picture here is also positive, methodological flaws and contradictory results are commonplace (Bredemeier & Greenblat, 1981; Dorn, 1989; Randel et al., 1992; Wolfe & Crookall, 1998).

*Tabell 1: Table 1. An overview of studies on the effectiveness of learning from video games.*

| Author(s) | Year | Genre | N | Subject | Results |
|---|---|---|---|---|---|
| Levin | (1981) | Action | – | Math | Video games are motivating, engaging, and ultimately successful in teaching children the planned maths concepts. Video games may be especially suitable for teaching ways of approaching maths that cater to individual differences. |
| White | (1984) | Simulation | 32 | Physics | Playing the game improves students' problem-solving ability related to physics in relation to how force influences motion. |
| Forsyth & Lancy | (1987) | Adventure | 120 | Geography | The adventure game results in children learning geographic locations with strong retention. |
| Dowey | (1987) | Puzzle | 203 | Dental health | Children learn best from a combination of teaching and video games. Although they learn about dental hygiene, this does not transfer into change of everyday practice. |

| Author(s) | Year | Genre | N | Subject | Results |
|---|---|---|---|---|---|
| McMullen | (1987) | – | 37 | Science | The drill-and-practice video game does not have any effect on the learning outcome, neither short-term nor long-term. However, students playing the video game indicate that they believe they learn more. |
| Jolicoeur & Berger | (1998a; 1998b) | | | Fractions Spelling | Students learn from video games, but educational software is more effective. |
| Wiebe & Martin | (1994) | Adventure | 109 | Geography | There is no difference in learning geography facts and attitudes between video games and teaching activities not on a computer. |
| Sedighian and Sedighian | (1996) | Strategy | 200 | Math | The learning outcome is critically affected by teachers' integration of video games and traditional teaching, but video games prove highly effective. |
| Betz | (1995) | Strategy | 24 | Engineer | Video games increase motivation and learning among students. |
| Thomas et al. | (1997) | Adventure | 211 | Sex education | Students learn from playing video games both on specific knowledge items and in self-efficacy. |
| Brown et al. | (1997) | Action | 59 | Diabetes | The study finds that children can learn about diabetes from video games and change everyday habits. |
| Klawe | (1998) | Adventure | 200 | Math | Video games are effective in teaching students about maths. |
| Adams | (1998) | Strategy | 46 | Urban geography | Video games increase motivation and teach students about the role of urban planners (affective learning). |
| Bensen et al. | (1999) | | | Sexual education | Video games are motivating and can improve knowledge related to sexual education. |
| Noble et al. | 2000 | Action | 101 | Drug education | Students taught through video games find the experience motivating and want to play the video game again. |
| Din Feng & Caleo | (2000) | – | 47 | Spelling and math | Children who play video games learn (mostly in spelling) better compared to peers who do not use video games. |
| Turnin et al. | (2000) | – | 2000 | Eating habits | Video games can teach students about eating habits and lead to significant change in everyday habits. |
| Lieberman | 2001 | Action | | Asthma, diabetes, | A review of a number of research projects supports the notion of learning from video games. |
| Becker | (2001) | Action | – | Programming | The study testifies to the increased motivation in connection with video games. Games are found to be more effective and motivating than traditional teaching. |

| Author(s) | Year | Genre | N | Subject | Results |
|---|---|---|---|---|---|
| McFarlane et al. | 2002 | – | – | All subjects | The study finds that teachers in general are skeptical towards the learning of content with video games. However, teachers appreciate the learning of general skills. |
| Gander | (2002) | Strategy | 29 | Programming | The study finds that video games are especially effective for teaching specific knowledge. |
| Rosas et al. | (2003) | Action | 1274 | Reading and math | Video games increase motivation, and there is a transfer of competence in technology from using the video game. |
| Squire et al. | (2004) | Simulation | 96 | Physics | Students using the simulation game performed better compared to the control group. |
| Egenfeldt-Nielsen | (2005) | Strategy | 72 | History | Students initially learn the same in history when using video games but have better retention. |

It can certainly be said that video games facilitate learning, but the evidence for saying any more than this is weak. Few current studies compare video games with other teaching styles, which is the ultimate test. Few incorporate debriefing explicitly, which the related area of simulations usually sees as central to the educational use of games and simulations (Lederman & Fumitoshi, 1995). Results showing that students learn from video games are not sufficient backing for the educational use of video games. We need to examine whether video games are worth the initial efforts in learning the interface, setting up computers and other problems (Egenfeldt-Nielsen, 2004). The question is: what is it that video games offer that sets them apart from existing educational practice? The different prevailing learning theories each have their own approach to answering this question. We first examine the contribution from behaviorism, because it is this that lies closest to the dominating perception and manifestation of edutainment.

## Overview of behaviorism

Behaviorism, which expanded rapidly during the 1950s, continues to be influential in research on educational media, including video games concentrating on the overt and observable behaviors essential for facilitating learning. For behaviorism, learning is a matter of reinforcing the relevant stimuli and response. Behaviorism has a long history, with theorists such as Pavlov, Thorndike, Watson and Skinner developing its foundation.

At the beginning of the 20th century, Thorndike provided an important theoretical background for behaviorism which has links with today's edutainment. He was instrumental especially in formulating the laws of exercise and effect. The law of exercise states that repetition is crucial to learning, and indeed this still holds true especially for the basic skills of reading, writing, and spelling (Good & Brophy, 1990). The law of effect states that we can strengthen a response by providing a reward after it. Thorndike's

account of future progress in instruction from 1912 is also strikingly similar to current educational software and video games in general:

> If, by a miracle of mechanical ingenuity, a book could be so arranged that only to him who had done what was directed on page one would page two become visible and so on, much that now requires personal instruction could be managed by print (Thorndike in 1912, Quoted in Saettler, 1968, p. 52)

Thorndike's prophecy in the above quote attests to the link between behaviorism and edutainment. It is possible to change feedback to the student using educational software or video games based on previous input. Educational software, especially video games with their strong rewards, is the manifestation of Thorndike's dream.

Skinner is also an important proponent of behaviorism during the 1950s. Only overt actions, i.e. not thought, understanding, or reflection, are interesting in a learning perspective. In 1958, Skinner actually built a drill-and-practice machine resembling later behaviorist edutainment titles. Behaviorism implies a narrow focus on the interaction between player and game – the video game will ask a question and the player will answer. When students link the question and the answer enough times, reinforced by a reward, learning will occur. The player answering the question 2+3 correctly with 5, while getting points as a reward, will achieve in arithmetic (Gleitman, 1995; Saettler, 1968).

### *Edutainment titles within a behaviorist approach*

We must not think of edutainment with a behaviorist approach as located within a fixed genre, but rather as different titles sharing certain assumptions about learning principles, motivation, and game design. Many of the titles on the market today fit best with a behaviorist approach, adhering to drill-and-practice forwarded through extrinsic motivation. The focus is on the player learning the right response to a given stimulus. The two laws of Thorndike are central in behaviorist edutainment titles: repetition and reward. *We can characterize titles within behaviorism as those where the player practices a specific area through repetition while receiving rewards after each proper response.*

One example is the recent *Math Missions Grades 3-5: The Amazing Arcade Adventure*, where the player earns money for every correct maths answer given and money buys playtime in an arcade. The playtime reward is a way by which to push the learning forward, and the only function of the reward is to strengthen a certain behavior and motivate further similar behavior. There is no connection between the arcade games and the maths questions. It is no different from a mother promising her noisy child an ice cream if he will be quiet and do his homework.

### *Discussion of findings – strengths and weaknesses of this approach*

The behaviorist approach is fairly evident in the most predominant edutainment titles up through the 1980s and increasingly sets the tone for titles in the years after that. Naturally,

this has resulted in a number of studies examining the actual learning outcome from such titles, although perhaps fewer than many would imagine. Most of the studies described in the previous section on learning outcomes take a behaviorist approach. Those described in detail below relate to a behaviorist approach, although such a categorization is not straightforward. Few studies within the field of educational video games directly ascribe to a theoretical orientation, and most tend to borrow from different learning theories. However, the approach to motivation is a sign of one's learning orientation, with behaviorist studies favoring extrinsic over intrinsic motivation. In addition, the focus on transmission of learning rather than construction can be seen as relating to a behaviorist approach (Good & Brophy, 1990).

The behaviorist approach has proved fairly effective within the area of health. Studies of health games have the advantage of being more capable of measuring overt changes in behaviors, and external signs of learning lend themselves to a behaviorist approach (e.g. Lieberman, 2001). Educational health video games often look to Albert Bandura's social learning theory, which expands from a behaviorist starting point. Proponents of Bandura's theory assume that the viewer, by watching and enacting specific activities, will learn the activities, especially when enforced by appropriate role models. Video games provide a safe frame for these activities and children can be made to repeat otherwise tedious actions.

Researchers studying health games have strengthened the support for learning from video games by comparing directly with other media forms. One of the most interesting studies is on the health action video game *Bronkie the Bronchiasaurus*, which compares video games with other teaching forms – an approach still rare in the research field. The edutainment title examined is also successful in bridging the gap between education and video games, not stripping the video game of its entertainment value (Lieberman, 1997; Lieberman, 2001).

Debra Lieberman (2001) compared playing the video game for 30 minutes with watching an educational video for 30 minutes. The children playing the video game expressed more enjoyment and learned the same as those watching the television program. Lieberman stressed that this was interesting given that the children watched the video only once – all its information is conveyed at once – while the video game delivered a limited amount of information in 30 minutes, the player repeating the 30-minute sessions several times. Players will rarely settle for playing a successful video game just once, which sets it apart from other media. This argument by Lieberman relates directly to Thorndike's law of exercise. The game measures up on the short trial period and promises additional motivating learning experiences.

Brown et al. (1997) reached similar results with the game *Packy & Marlon*, which aims to improve diabetes self-care among children. Players improved on self-efficacy, communication with parents about diabetes and self-care behaviors. In addition, the post-test

showed a 77 percent drop in visits to urgent care and medical visits in the experimental group compared with the control group. The study is notable because it shows that a video game can have a direct impact on everyday self-health management. The promising results by Brown et al. and Lieberman are supported to some extent by other similar research findings on the educational use of health games (Dowey, 1987; Johansson & Küller, 2002; Lockyer et al., 2003; Noble et al., 2000; Thomas et al., 1997; Turnin et al., 2000).

The critique of behaviorist edutainment titles extends from the very characteristics that set behaviorism apart from other learning theories, namely automatic repetition coupled with extrinsic motivation. This implies that much of the criticism relates to disagreements on more fundamental assumptions relating to how humans learn. However, criticism also addresses the low quality of technology, gameplay, and graphics, which relates more directly to the actual edutainment product. Still, the criticism of these titles resting on behaviorist principles has led to an overall negative attitude towards edutainment titles. Users, both children and parents, criticize the gameplay, learning principles, and graphics heavily when it comes to behaviorist edutainment. In addition, professionals, including educators and researchers, are increasingly joining the critics (Brody, 1993; Buckingham & Scanlon, 2002; Leyland, 1996).

According to critics, behaviorist edutainment probably does teach children bits of things (see above), but most titles are limited in their facilitation of learning experiences. Rote learning in spelling and reading for pre-school and early school children may see some gains from edutainment. However, edutainment does not really teach the player about a certain area; rather, it focuses on training, letting the player perform mechanical operations. This leads to memorizing the practiced aspects but probably not to a deep understanding of the skill or content – the activity will be parrot-like and the intended goal and competency will not be fully grasped by the student. Although this approach may work for areas such as spelling and reading, the scope of learning is limited. The learning results in weak transfer and little application of the skills, because these are not fundamentally understood. Video games may perform well in assessments that formulate questions close to the information learned. However, if the assessment strays from the specific information learned by being put in a new context or requiring the student to use the information, the results are hampered. The lack of teacher involvement also results in critique (Gee et al., 2004; Healy, 1999; Jonassen, 2001; Schank, 1999).

Another problem is the question of motivation. Behaviorist edutainment titles rely more on extrinsic motivation through rewards rather than intrinsic motivation. Extrinsic motivation does not relate to the game, but consists of arbitrary rewards; for example, getting points for completing a level. Intrinsic motivation, for example, would be the feeling of mastery from controlling the game. The approach to motivation partly explains why behaviorist edutainment titles usually lack an integration of the learning experience with the playing experience, which leads to the learning becoming subordinated to the

stronger play experience. The player will concentrate on playing the game rather than on learning from the game. There is common agreement that many behaviorist edutainment titles fail to integrate learning with the game. There is therefore a change of focus in the learning experience from the educational part to the game part, and this results in weak learning experiences, especially when the time-on-task issue is taken into consideration. The player will not spend much time on educational experiences, but rather will gain game experience (Brody, 1993; Fabricatore, 2000; Facer et al., 2003; Vandeventer, 1997).

The lack of integration between learning and playing is not problematic from a behaviorist learning perspective, because stimuli and response merely have to be linked through reinforcement. This has led to the criticism of behaviorist edutainment as relying on drill-and-practice. The criticism of the reliance on drill-and-practice mainly relates to the basic assumptions in behaviorism that carry over into behaviorist edutainment – training rather than understanding. Constantly, there will be people getting arithmetical problems like 2+2 and memorizing the results while not necessarily understanding the underlying rules (Andersen & Dalgaard, 2005; Buckingham & Scanlon, 2002; Facer et al., 2003; Konzack, 2003; Okan, 2003; Prensky, 2001).

Overall, studies with a behaviorist approach argue convincingly for use of behaviorist edutainment titles when we limit ourselves to learning outcome. However, learning theorists and game developers based in cognitive and socio-cultural traditions are skeptical and try to develop titles that fit within their own framework. They are dissatisfied with the dominance of behaviorist edutainment and want to raise the quality of the market (Children's Software, 1998).

## Overview of Cognitivism

Cognitivism is a general term for a number of influential theories that focus on the individual's construction of representations of the world. In the cognitivist approach, the learner is the center of attention. The cognitivist approach is critical of behaviorism's narrow focus on the relation between stimuli and response. The focus on behavior is seen as skewed and neglecting other important variables, namely the cognitive structures underlying perception and response. People have underlying schematas representing what they have learned. When students approach a new task, they need to take account of different schematas; schematas have limits and provide opportunities for learners that can be addressed through scaffolding information, chunking information, multimodal information, and through the presentation of material in ways that correspond with each individual's cognitive abilities. There are limits to the information one can process, better ways of solving problems, and different ways of perceiving information. The intrinsic motivation is crucial, and derives from the tensions between schematas and the external world most evident in the momentous work by Malone (Good & Brophy, 1990).

***Edutainment titles within a cognitive approach***

Edutainment titles with a cognitive approach attempt to build intrinsic motivation by integrating learning and game experience. The play experience challenges the player's schematas. More broadly, this includes attempts at presenting material in different ways, taking into account the limitations and potentials of the cognitive apparatus of humans. Cognitive edutainment titles stress the use of knowledge about how to organize material in terms of retrieval, encoding, chunking, modalities, and transfer problems.

These titles often aim to have elements of discovery and inquiry presenting meaningful learning experiences so that the player can construct his/her own representations in an active dialogue with the game. *We can describe the cognitive edutainment titles as aiming to engage players in a discovery process through a strong game experience that integrates learning and play while providing a strong experience akin to the limitations and potentials of the human mind.*

An example of a cognitive title is the research-based maths game *Super Tangrams*, where geometric shapes have to be manipulated. The player moves the geometric shapes so that they fit together in an outline, with the puzzles becoming progressively more difficult. Playing the game integrates with the learning goals, and play is motivated intrinsically – students will engage in the learning and playing experience motivated by the activity itself.

***Discussion of findings – strengths and weaknesses of this approach***

The research area of instructional technology increasingly became active in the 1980s in relation to video games with Thomas Malone's work (1980). Malone & Lepper (1987a, b) examined the differences between extrinsic and intrinsic motivation for distinguishing between different forms of drill-and-practice video games.

Intrinsic motivation arises directly from performing the activity, whereas extrinsic motivation is supported by factors external to the activity. Players exhibit intrinsic motivation when spending hours learning how to play *Counter-strike*. Players engage with the game and learn it because it is interesting in itself. An example of extrinsic motivation is parents' approval of their offspring playing an edutainment title to learn how to spell. By playing and learning, a reward is achieved that is not related to the activity. In behaviorist edutainment, the learning activity in itself is rarely motivated.

Malone & Lepper (1987b) argue that very many educational video games have extrinsic game elements which can be in the way of the learning experience. These are some of the heavily criticized edutainment titles relating to behaviorism, where there is no connection between the video game and the learning part. The game part mainly works as a reward for some educational activity being accomplished. These authors argue that better intrinsic use of game elements in drill-and-practice video games can facilitate enhanced learning and sustained interest for a given topic over time. However, integration of learn-

ing elements within the game-play does not make it into the most educational video game design, as is evident from Konzack's (2003) analysis of a number of titles and several more common-sense observations by researchers (Leddo, 1996; Leyland, 1996).

Malone & Lepper (1987a, b) identify a number of categories that should be considered in drill-and-practice video games designed to enhance learning. The first is challenge, which implies that the game activity should be of an appropriate difficulty level for the player. This is done through both short-term and long-term goals, uncertain outcomes, and facilitating investment of self-esteem through meaningful goals. Furthermore, clear, constructive, encouraging feedback is essential. The second is curiosity, which points to the complex and unknown information in the game that should encourage exploration and organization of the information in relation to both the sensory and the cognitive areas. Third, Malone & Lepper stress the player's experience of control as critical. Through a responsive environment, a high degree of choice within it, and by equipping the player with the ability to perform great effects, a sense of control emerges. Fourth, involving elements of fantasy in the game universe facilitates intrinsic motivation. These fantasy elements have to appeal to the target group emotionally, serve as metaphors for the learning content, and be an endogenous part of the learning material. The fifth category is the role of interpersonal activity. This is the increased motivation resulting from the social context of the video game –most directly competition and collaboration with peers. In addition, the recognition of peers serves as motivation.

The question of intrinsic motivation is crucial to cognitivism, but other important elements in the educational use of video games have been researched from a cognitive perspective, too. The human mind's limitations and potentials run beneath the interest in flow experiences, audiovisual props, and control of the learning process.

Marshall Jones's (1998, 1999) work is often cited as the theory of flow in relation to learning from video games. Jones finds that the flow theory to a large degree explains the intrinsic motivational aspects of video games and can benefit the design of games. Video games are capable of facilitating flow experiences through a number of characteristics, for example, via interaction and challenges. To some extent, Jones's research echoes Bowman (1982) and Bisson & Luckner (1996) in describing how video games are constructed in a way that facilitates flow.

Klawe (1998) argues that researchers and educational designers have to aim at elements in video games that are particularly strong, e.g. unlimited number of activities, visualization, manipulation, symbolic representations, adaptive sequencing, feedback, and meaningful, contextualized activities. These relate directly to important questions concerning cognitivism, namely how to facilitate the learning process by being aware of the limitations of the cognitive apparatus of humans.

Lastly, cognitivism favors a meta-skills perspective, with problem-solving as the most researched. Cognitivism focuses less on the content side than behaviorism does; instead,

the skills to learning are important. Problem-solving has received much research attention over the years (Curtis, 1992; Gee, 2003; Greenfield, 1984; Grundy, 1991; Jillian et al., 1999; Kirriemuir & McFarlane, 2002; Ko, 2002; McFarlane et al., 2002; Pillay et al., 1999; Quinn, 1997; Walker de Felix & Johnson, 1993; Whitebread, 1997). Most of these studies connect problem-solving with video games. Problem-solving might improve between video games, but it is hard to transfer the improvement to contexts other than video games. It is also found that good general problem-solving skills are predictive of better performance in a video game (Ko, 1999).

Studies examining the learning outcome from a cognitivist perspective are limited, although Klawe (1998) provides a strong example with an overview of the research project E-Gems. This project focuses on two educational maths video games designed by the researchers in connection with the projects *Super Tangrams* in 1996 and *Phoenix Quest* in 1997. These are the bases of several empirical studies where researchers manipulate different variables to determine the most active elements in facilitating the learning process. On an overall level, the video games produced in the project prove motivating, popular, and highly effective in teaching maths to students. The results are particularly strong, as the different research designs and research teams replicate the results – totalling approximately 200 students in the controlled studies of *Super Tangrams* and a similar number in the research on *Phoenix Quest* (Klawe, 1998; Sedighian & Sedighian, 1996, 1997).

## Overview of constructionism

Constructionism shares certain assumptions with cognitivism about the individual constructing knowledge and the problems related to transmitting knowledge, but emphasizes the value of the role of external objects in facilitating the learning process. The main proponent is Seymour Papert, drawing on Piaget's constructivism. Initially, the mission was to teach children difficult subjects, like maths, in alternative ways, but slowly it became an established overall theoretical learning approach. The most influential tool for constructionist thinking is the programming language Logo. Logo lets students draw computer-generated drawings using mathematical concepts. The concepts are not explicit, but implicit when drawing figures. For example, the so-called turtle (not too different from an avatar in a video game) can draw a square. The student observes the turtle drawing a line and gives it the command to turn 90 degrees. Students repeat the command three times and draw a square. The active approach to knowledge and the use of external artifacts facilitating the learning experience is essential for constructionism (Papert, 1980, 1998).

***Edutainment titles within a constructivist approach***

Edutainment titles that adhere to a constructivist approach are often referred to as microworlds. These are open-ended universes (more or less game-like) in which a certain topic is represented in different artifacts that the player can interact with. A microworld simulates a part of the world that is simplified and constructed to facilitate working with concrete objects. When interacting with objects in microworlds, we are learning about the object's properties, connections, and applications. The player can engage and manipulate these artifacts and thereby construct a perception of the given topic. *We can describe the constructivist edutainment microworlds as simulating a part of the world allowing the player to explore this manifestation, resulting in strong learning experiences.*

An example of a microworld title is *My Make Believe Castle*, where the player actively engages in exploring and constructing different aspects of a castle. The focus is not on hard content as such, but rather on the general skills of creativity, problem-solving, critical-thinking skills, sequential planning, and memory.

***Discussion of findings – strengths and weaknesses of this approach***

For some constructionist thinkers, video games are the lost paradise. Here is a universe where the learner can engage with a microworld and construct different objects and connections that can work as virtual shared artifacts (Papert, 1998). The most noted contributions within this field are the works of Yasmin Kafai (1995, 2001), which have stood the test of time. Up through the 1990s, she developed the idea of children designing games, turning them into producers of knowledge, and letting them play with objects in different ways. According to Kafai & Resnick (1996), there is no doubt that programming and maths knowledge can be acquired through designing video games. Arguably, designing video games makes it possible for the learner to approach a subject in an active way, thereby constructing a personal representation of knowledge by using physical artifacts. The student's learning experience draws on different perspectives while giving rise to a variety of actions and thus to a fuller understanding of a given topic.

The focus is on the construction process and therefore research has focused on open-ended games. This has spanned students designing simple games, engaging in virtual worlds, exploring microworlds, and playing other open-ended video games. The basic assumptions about learning are different in constructionism compared to the predominant edutainment titles. In a constructionist perspective, learning does not transfer from the video game, and the challenge is not to design an educational video game with relevant content. Rather, the hard challenge is to facilitate playing that makes the player engage with the material, discuss it, reflect on it, and use the video game as a means for constructing knowledge. A prerequisite for such constructions may very well be relevant content, but the content is far from enough.

Kafai (1996) notes that the design of these microworlds proves a lot more difficult than drill-and-practice video games because the topic in the microworld has to be integrated. One cannot just take a well-tested action formula and use it as the blueprint as in the case of most current edutainment titles within a behaviorist or cognitivist tradition. The interest in microworlds has been especially strong in relation to maths and science (Goldstein & Pratt, 2001; Hoyle et al., 1991; Hoyles et al., 2002; Miller et al., 1999; Reiber, 1996; White, 1984), but attempts have surfaced in which constructionism is used as a different approach to video games (McCarty, 2001; Woods, 2002).

Although cognitivism and constructionism are capable of solving some of the critical questions hurled at behaviorist edutainment, they far from satisfy everybody. The socio-cultural approach is the full picture of the educational use of video games: player, video game, and context.

## Overview of the socio-cultural approach

The socio-cultural approach is a broad term encompassing a number of theories that rely on mediation for an understanding of the learning process. From this perspective, knowledge is the tool that mediates activity rather than memorized information. Activity theory, socio-cultural theory, and situated learning see a given activity as mediated by tools which include technology, language, communities, culture, and symbols. The socio-cultural approach is also noticeable in stressing the role of social interaction through the concept of proximal development (Vygotsky, 1978). Learning occurs when a teacher, parent, peer, or tool guides a student from an actual point of development to a potential point of development – each serves as a mediator for facilitating students' appreciation of a given activity. The main socio-cultural approach has the broadest orientation in using activity as the unit of analysis. This is in opposition to situated learning, which relies on the community and activity theory's focus on tools and labor. In particular, it is the works of theorists like Vygotsky, Wertsch, Leontjev, Lave, and Wenger that are representative of the socio-cultural approach, although each adheres to a different sub-area (Lantolf, 2000).

The video game as an embodied tool extends the action of a given agent and creates both opportunities and limitations for the agent using it. An activity consists of the relation between a subject and an object which is mediated by a tool. Tools can be a variety of artifacts, found in our social and cultural life, that endow us with a diversity of opportunities. When we use languages, we are drawing on a symbolic tool refined through generations. The socio-cultural perspective alerts us to the importance of considering tools and context when thinking about learning and education. Different contexts and tools facilitate a variety of learning experiences (Vygotsky, 1978, 1986; Wertsch, 1991).

### *Edutainment titles within a socio-cultural approach*

The area has yet to see the first edutainment titles extending from a socio-cultural approach. The lack of specific titles comes from the fact that the socio-cultural approach has less to do with the actual video game and more with the explorations, reflections, and discussions that are activated around video games among students and teachers. It is therefore natural that the socio-cultural is more about the perspective on the educational use of a specific title rather than the actual development of a given title.

Studies within the area examine commercial video games developed purely for entertainment from an educational perspective, because most existing edutainment titles are found to be useless from a socio-cultural perspective. The existing edutainment titles fail to facilitate meaningful, engaging, and deep learning experiences. The titles used are, for example, *Civilization III*, *SimCity 2000* and *Europa Universalis II*. The reasons behind the choice of these particular titles are not explicit. However, they are all simulations of a particular subject area that students can engage with – challenging, exploring, and discussing the video game in relation to their own game experiences. The possibility for the player to invest something of himself in the game is central.

### *Discussion of findings – strengths and weaknesses of this approach*

Since the beginning of the 1980s there has been interest in examining the social context around video game experiences (i.e. Strein & Kachman, 1984), and in the mid-1990s the socio-cultural approach really began to influence the area. In the Nordic countries, Jessen's study of video games described the informal play, culture, and learning experiences around computer games mediated through social relations in particular (1995, 2001). Jessen's study led to interesting findings concerning peer learning around video games and appreciation of the rich social interaction that mediated the game experience. The appeal of video games to children closely relates to the match between children's existing play culture and the video game culture. This research never really goes beyond the informal learning processes surrounding video games, but points to the importance of incorporating them. This is strongly supported by Squire (2004) in his PhD dissertation examining several classes playing *Civilization III*. The explicit goal was to facilitate history through *Civilization III*, especially through the surrounding social environment. Squire concludes that:

> The most important point in understanding how games engage players in educational environments may be that good games engage players in multiple ways and the interplay between these different forms creates dynamic learning opportunities. Different play styles and tastes enriched classroom conversations, often leading to discussions that produce important 'taken-as-shared' meanings. [...] Discussions between different player types drove them to articulate and defend different strategies, even rethinking their orientation to the game. (2004, p. 241)

From a socio-cultural perspective, video games do not lend themselves to learning by rote. Instead, the goal should be the exploration of relationships between variables, events, and complex patterns. In a socio-cultural perspective, video games are the tools for constructing a viable learning experience, but not the learning experience per se. Video games mediate discussion, reflection, facts, and analysis facilitated by the surrounding classroom culture and the student's identity. In other words, video games are interesting not for their content but for the way new explorations initiate negotiations, constructions, and journeys into knowledge (Gee, 2003; Jessen, 2001; Kaptelinin & Cole, 1997; Linderoth, 2002; Squire, 2004).

Gee (2003) speaking from a socio-cultural perspective, has given one of the strongest theoretical accounts for understanding the learning mechanisms in video games, although not necessarily directly useful in an educational setting. His overarching idea is that children learn to participate in new domains by playing video games. They learn to make sense of new areas, especially by engaging with others, discussing, reflecting, and sharing. A key area in play activity is the role of critical thinking, which the social practice around the video game constantly calls for.

Gee (2003) presents five main areas of interest concerning video games that are also of interest for educational purposes. He sees these as intrinsic qualities of video games that can be useful in a school setting to facilitate learning in a more meaningful and engaging way: The first quality is that of semiotic domains. Like other activities in life, video games are a semiotic domain that can be learned slowly. One learns to make sense of and navigate in the domain of the game, while being directed to other interesting domains, e.g. science. Video games can also work as a place to reflect on the engagement and processes in domains of practice. The second quality Gee points to is around learning and identity. Video games provide new opportunities for learning experiences when the student is involved with the material. Video games are good for creating agency and identification, and this sparks critical thinking and learning. The learning experience in video games becomes more effective because players immerse themselves within the environment. We can make mistakes without real consequences and we are encouraged to continue trying. The third quality is situated meaning and learning. Video games are well suited for new forms of learning, where one can interact with the game world through probing and choosing different ways to learn and see things in a context. We can interact, challenge the game, and over time build up a more accurate picture of an area. The fourth quality is of telling and doing, both related to amplification. Games can amplify areas and subsets of domains that players can practice. According to Gee, games are also suited to transferring between domains. It is possible to transfer knowledge learned in video games to other contexts. This last point concerns cultural models. The content in games represents ways of perceiving the world and carries a great deal of implicit information. It also has bearing on other domains of life and can be both good and bad, depending on one's values and norms.

## Overview of tensions shared between each of the three theories overviewed

The four different learning approaches discussed throughout this paper – behaviorism, cognitivism, constructionism, and the socio-cultural approach – have some shared areas of tension that reflect fundamental differences in approaches to the educational use of video games and point to recurring problems within the area. These tensions will have implications for how we develop edutainment in the future and for what direction future research should be aimed.

### *Learning vs. playing*

We have seen that each of the four different approaches puts a different emphasis on the relationship between learning and playing. For behaviorism, the playing part mostly works detached, providing extrinsic motivation, whereas with the other approaches it is critical to develop a close relationship based on the implicit notion of developing intrinsic motivated educational experiences with games evident in the approach of cognitivism, constructionism, and the socio-cultural. Many of the problems encountered in this review are neglected by the behaviorist approach owing to its split between playing and learning, whereas this is a central problem for the other approaches to confront.

One example of the problem related to learning versus playing is when the game's goals and system work against the learning goals. Students will often tend to focus on achieving the game goals while neglecting the learning part. This is a risk in the educational use of commercial video games, where the game goals are often not educationally relevant. A game like *Age of Empires* may have historically relevant settings and narratives, but the main focus is on mastering resource management to beat the opponent, which attracts most of the student's attention while playing. The problem is not limited to the educational use of video games, it can also be found in the behaviorist edutainment titles that dominate the market. For example, when a student plays *Math Blaster*, an all time classic, the game's goals and system are about being fast and about shooting down asteroids (that then release questions on algebra). Of course, the student learns algebra, but swiftness and shooting skills take up much space and sometimes work against really thinking about the algebra.

In studies of *Europa Universalis II* and *Where in the World is Carmen San Diego,* this line of argument is also supported. Most students skip important text or gloss over it because it is in the way of the game experience. Students put the game goals above the learning goals. This points to the major challenge of finding game designs that can make learning and playing work together, or, at least, not one against the another (Egenfeldt-Nielsen, 2005; Grundy, 1991; Healy, 1999; Magnussen & Misfeldt, 2004).

### *Freedom vs. control*

All research on the educational use of video games emphases the freedom and control that students gain in video games compared to traditional teaching. However, research shows that it also creates several problems in an educational context. This issue is less pronounced in behaviorist and cognitivist edutainment titles compared to the other areas because of the more fixed game universes, where there are fewer chances of detours. However, the problems grows as those of us in education begin to use the more open-ended and complex game universes like *The Sims* in educational settings.

The player has much freedom when using video games, which is contrary to the more explicit demands an educational situation makes on a student. The player feels that the control should not be tainted by outside interference (i.e. Egenfeldt-Nielsen, 2005; Squire, 2002), but students may also criticize the lack of direct educational interventions. Indeed, many studies show the benefit of careful guiding, supporting, scaffolding, introducing, and debriefing the video game experience. This is difficult when students want to make their own mistakes, decide how to play, and expect to maintain control.

The risk of freedom, control, and play dominating learning may have to be dealt with by the teacher. The right approach seems to be an explicit framing of the game experience as education, i.e. stressing the goals from an educational perspective and pointing out to students that there is not the complete freedom and control one would expect when playing in one's spare time. Otherwise the lack of a firm setting confuses students who are uncertain about the expectations when playing and learning. If this explicit framing is not made, some students will shift between the different modes not focusing on educational goals and vary in commitment – thinking that after all it is just a game, so why bother about the educational agenda (Egenfeldt-Nielsen, 2005; Jillian et al., 1999; Leutner, 1993; Squire, 2004).

### *Drill-and-practice vs. microworlds*

Most current researchers shy away from the narrow focus on drill-and-practice games found in behaviorist edutainment, but when we look more closely many researchers still indirectly assume that parts of the game have drill-and-practice elements that can transfer facts and support skills. Indeed, research indicates that drill-and-practice is useful but works best in combination with other teaching forms (Cotton, 1991; Loftus & Loftus, 1983). Klawe (1998) stresses that video games should be used for maths activities that are otherwise difficult to introduce in a classroom while specifically pointing to the limitations of drill-and-practice.

> Most of the early mathematical video games focused on drill and practice of simple number operations and concepts. Such games are easy to develop. Moreover, playing such games [is] an effective and motivating method of increasing fluency for many students. However, drill and

> practice is only one of many components of mathematics learning and can be achieved via a variety of non computer-based methods. (Klawe, 1998, p. 9)

The preference for drill-and-practice is understandable given the design challenges facing other titles. Microworlds have proved significantly harder to design than classic drill-and-practice games (Kafai, 1995, 2001; Papert, 1998). It is quite evident that it is not from within the drill-and-practice perspective that new developments will come. Indeed, most behaviorist edutainment titles have remained almost untouched by time in the past 30 years. Still, we have to acknowledge that the behaviorist edutainment approach may provide low-hanging fruit that we ought not to lose through automatically deeming all behaviorist edutainment titles old-fashioned (Egenfeldt-Nielsen, 2005).

Most current research develops from a socio-cultural or constructivist perspective that favors the microworld approach. However, we see this only vaguely reflected in the industry; for example, in such recent attempts as *Global Conflicts: Palestine*, *A Force More Powerful*, and *The Calm and the Storm,* which offer the hope of a different formula for edutainment.

***Transmission vs. construction***

From the behaviorist perspective, the challenge of educational video games is in transmitting information from the video game to the player. There is no difference between different contexts, and the transmission of content is reliant on conditioning and reinforcement. From a constructivist position, the transmission of information is not sufficient to our understanding the educational process. Situations need to be facilitated where players actively engage in the video game and construct their own knowledge through the artifacts of the game world to make it more broadly accessible.

As discussed earlier, research points out that the immersive effect of video games leads to a lack of awareness of the contents, structures, and concepts integrated in the video game. This results in weaker learning overall and especially in the transfer of game experience to other contexts. Students may learn some content or skills in the game universe and apply them in the game context, but they are not constructed in ways that are accessible in other contexts.

In an earlier study by Klawe & Phillips (1995), the use of paper and pencil during gameplay was found useful for transferring video game maths experiences to other classroom practice. The use of paper and pencil forces students actively to construct knowledge. This is supported by recent research that constructed the game prototype *Global Conflicts: Palestine*, with a journalist exploring the Israeli-Palestinian conflict and jotting down notes in a physical notebook. This works very well, because the notebook is a meaningful part of the game world as a journalist and can be used as an artifact crossing from game setting to other teaching (Buch & Egenfeldt-Nielsen, 2006). The two studies

point to the importance of not relying solely on the video game and instead actively pursuing links with other teaching forms, thus providing for a fuller learning experience.

There is continuing disagreement among the above approaches over how transfer is achieved. On the one hand, many researchers assume that the learning must be by stealth and that it is undetectable by children. This is reliant on the premise that an educational video game resembles a traditional video game. It must not give itself away, because children will then shy away from the educational title (e.g. Brody, 1993). The game experience has to integrate learning elements and not let the game elements stand out. On the other hand, if the players are not aware of the learning elements, this will undermine the learning experience and, especially, the transfer value. The transfer has to be made explicit, and here the teacher can play a crucial role.

***Teacher intervention vs. no teacher intervention***

Researchers are consistently finding that teachers play an important role in facilitating learning with video games, in terms of steering use in the right direction and also in providing an effective debriefing that can catch misperceptions and interesting differences in students' experiences while playing. Many edutainment titles adhering to behaviorism and cognitivism neglect this, whereas it is central in the socio-cultural approach. Teachers may also use educational titles in ways that extend a title's narrow focus on, for example, behaviorism or cognitivism. However, many teachers while appreciating this intuitively fail to take charge when using video games (Egenfeldt-Nielsen, 2005; Sandford & Williamson, 2006).

Many researchers argue that video games are not explicitly educational, but that they provide opportunities for interested teachers. Therefore, they also see the teacher's role as imperative for the learning experience. This is true particularly for the commercial entertainment titles that find their way into educational settings which have not been developed with curriculum explicitly in mind. The problem is that if we rely too much on teachers we may be disappointed by their reluctance to engage with games and their lacking knowledge of how to use games (Cavallari et al., 1992; Egenfeldt-Nielsen, 2005; Grundy, 1991; Klawe, 1998; Squire, 2004).

## Conclusions

The different approaches to educational experiences with video games are largely not clear-cut when we encounter them in research, but instead are a mix. The different learning approaches clearly have something to offer on different levels especially when we have to develop edutainment that can work in the educational setting. The split between different titles adhering to behaviorism, cognitivism, constructionism, or the socio-cultural does not suggest that one is bound to approach the titles exclusively from that angle.

Rather, the categorization points to the underlying assumptions that the teacher can expand on. Indeed, a broader approach to a behaviorist edutainment title may broaden its application and use in an actual educational setting.

Although there may be internal inconsistencies on a theoretical level, this is not necessarily the case on a design level. The behaviorist and cognitivist perspectives are valuable for examining the narrow relation between video game and students focusing on the role of motivation. Constructionism shows us how video games can be used as a shared artifact for constructing knowledge. On a socio-cultural level, we appreciate and examine the environment that emerges around video games in negotiating and constructing knowledge. Here, questions of collaboration, debriefing, and discussion are crucial to understanding: How can we construct, mediate, and support the knowledge acquired in relation to video games?

Most previous research and design gives prominence to one or two characteristics in learning from video games, which is probably too limited. We need to gain a more inclusive understanding of the different learning perspectives if we are to understand the full scope of the educational use of computer games. Indeed, to see the educational use of computer games as a homogeneous field is not beneficial – for a start, there are different teaching forms and edutainment genres that will benefit different educational goals.

## Notes

1 Overviews of the areas see Egenfeldt-Nielsen & Smith (2004), Egenfeldt-Nielsen (2003) and Dorn (1989).

2 See my previous discussion on these problems (Egenfeldt-Nielsen, 2005)

## References


Adams, P. C. (1998). Teaching and Learning with SimCity 2000. *Journal of Geography, 97*(2), 47–55.

Andersen, T. & Dalgaard, H. (2005). *Edutainment – læring med computerspil.* Copenhagen: Systime.

Becker, K. (2001). Teaching with Games – The Minesweeper and Asteroids Experience. *Journal of Computing in Small Colleges, 17*(2), 22–32.

Bensen, C., Stern, J., Skinner, E., Beutner, K., Conant, M., Tyring, S., et al. (1999). An Interactive, Computer-Based Program to Educate Patients About Genital Herpes. *Sexually Transmitted Diseases, 26*(6), 364–368.

Bergman, P. (2003). *Digital Games and Learning: A Research Overview.* Unpublished manuscript.

Betz, J. A. (1995). Computer Games: Increase Learning in an Interactive Multidisciplinary Environment. *Journal of Educational Technology Systems, 24*(2), 195–205.

Bisson, C., & Luckner, J. (1996). Fun in Learning – The Pedagogical Role of Fun in Adventure Education. *Journal of Experimental Education, 9*(2), 108–112.

Bowman, R. F. (1982). A Pac-Man theory of motivation. Tactical implications for classroom instruction. *Educational Technology, 22*(9), 14–17.

Bredemeier, M. E., & Greenblat, C. S. (1981). The educational effectiveness of simulation games: A synthesis of findings. *Simulation & Games, 12*(3), 307–331.

Brody, H. (1993). Video Games that Teach? *Technology Review, 96*(8), 51–57.

Brown, S. J., Lieberman, D A, Gemeny, B A, Fan, Y C, Wilson, D M and Pasta, D J. (1997). Educational video game for juvenile diabetes: Results of a controlled trial. *Medical Informatics, 22*(1), 77–89.

Buch, T. & Egenfeldt-Nielsen, S. (2006). The learning effect of Global Conflicts: Palestine. Media@Terra conference, Athens.

Buckingham, D., & Scanlon, M. (2002). *Education, edutainment, and learning in the home*. Cambridge: Open University Press.

Cavallari, J., Hedberg, J., & Harper, B. (1992). Adventure games in education: A review. *Australian Journal of Educational Technology, 8*(2), 172–184.

Children's Software. (1998). *Stanford Children's Software Stanford Conversation Transscripts*. Retrieved 14. december, 2004, from *http://www.childrenssoftware.com/stanfordtranscripts*

Clegg, A. A. (1991). Games and simulations in social studies education. In J. P. Shaver (Ed.), *Handbook of research on social studies teaching and learning*. New York: Macmillan.

Cotton, K. (1991). *Computer-Assisted Instruction.*: Northwest Regional Educational Laboratory.

Curtis, P. (1992). *Mudding: Social Phenomena in Text-Based Virtual Realities.* Paper presented at the Proceedings of Directions and Implications of Advanced Computing, Berkeley, California.

de Freitas, S. (2005). *Learning through Play. Using educational games and simulations to support post-16 learners.* London: London Learning and Skills Research Centre.

Dempsey, J. V., Rasmussen, K., & Lucassen, B. (1996). *The Instructional Gaming Literature: Implications and 99 Sources.* University of South Alabama.

Din, F. S., & Caleo, J. (2000). *Playing Computer Games versus Better Learning.*Unpublished manuscript.

Dorn, D. S. (1989). Simulation Games: One More Tool On the Pedagogical Shelf. *Teaching Sociology., 17*(1), 1–18.

Dowey, J. A. (1987). Computer games for dental health education in primary schools. *Health Education Journal, 46*(3).

Egenfeldt-Nielsen, S. (2003). *Keep the Monkey rolling: Eye-hand Coordination in Super Monkey Ball.* Paper presented at the Digra – Level up conference 2003, Utrecht University.

Egenfeldt-Nielsen, S. (2004). Practical barriers in using educational computer games. *On the Horizon*.

Egenfeldt-Nielsen, S. (2005). *Beyond Edutainment: Exploring the educational potential of computer games.* Unpublished PhD, IT-University of Copenhagen, Copenhagen.

Egenfeldt-Nielsen, S., & Smith, J. H. (2004). *Playing with fire: How do computer games influence players?* Göteborg: Nordicom.

Fabricatore, C. (2000). *Learning and Videogames: An Unexploited Synergy*. Unpublished manuscript.

Facer, K., Furlong, J., Furlong, R., & Sutherland, R. (2003). 'Edutainment' software: a site for cultures in conflict. In R. Sutherland, G. Claxton & A. Pollard (Eds.), *Learning and Teaching Where Worldviews meet*. London: Trentham Books.

Forsyth, A., & Lancy, D. (1987). Simulated Travel and Place Location Learning in a Computer Adventure Games. *Journal of Educational Computing Research, 3*(3).

Gander, S. (2002). Does Learning Occur through gaming. *Electronic Journal of Instructional Science and Technology, 3*(2).

Gee, J. P. (2003). *What Video games have to teach us about learning and literacy*. New York: PalGrave-McMillan.

Gee, J. P., Lieberman, D., Raybourn, E., & Rajeski, D. (2004). *How Can Games Shape Future Behaviors*. Retrieved 21. October, 2004, from *http://www.watercoolergames.org/archives/000263.shtml #howcan*

Gleitman, H. (1995). *Psychology – Fourth Edition*. New York: Norton.

Goldstein, R., & Pratt, D. (2001). *Michael's Computer game: A Case of Open Modelling.* Paper presented at the The Twenty Fifth AnnualConference of the International Group for the Psychology of Mathematics, Utrecht: The Netherlands.

Good, T. L., & Brophy, J. E. (1990). *Educational Psychology: A Realistic Approach. Fourth Edition*. New York: Longman.

Greenfield, P. (1984). *Mind and Media*. Cambridge: Harvard University Press.

Gros, B. (2003). The impact of digital games in education. *First Monday, 8*(7).

Grundy, S. (1991). A Computer Adventure as a Worthwhile Educational Experience. *Interchange, 22*(4), 41–55.

Hancock, C., & Osterweil, S. (1996). Zoombinis and the Art of Mathematical Play. *Hands On!, 19*(1).

Healy, J. M. (1999). *FAILURE TO CONNECT: How Computers Affect Our Children's Minds*. New York: Touchstone.

Hostetter, O. (2003). *Video Games – The Necessity of Incorporating Video Games as part of Constructivist Learning*. Retrieved 12-04-2004, 2004, from *http://www.game-research.com/art_games_contructivist.asp*

Hoyle, R. H., Harris, M. J., & Judd, C. M. (1991). *Research Methods in Social Relations*: Hartcourt Brace.

Hoyles, C., Noss, R., & Adamson, R. (2002). Rethinking the Microworld Idea. *Journal of Educational Computing Research,, 27* (1–2), 29–53.

Jessen, C. (1995). Computeren i børnehaven – Rapport fra et forsøgsprojekt. *Tidsskrift for Børne- og Ungdomskultur*(35).

Jessen, C. (2001). *Børn, leg og computerspil*. Odense: Odense Universitetsforlag.

Jillian, J. D., Upitis, R., Koch, C., & Young, J. (1999). The Story of Phoenix Quest: how girls respond to a prototype language and mathematics computer

game. *Gender and education, 11*(2), 207–223.

Johansson, M., & Küller, R. (2002). Traffic Jam: Psychological assessment of a gaming simulation. *Simulation & Gaming, 33*(1), 67–88.

Jolicoeur, K., & Berger, D. E. (1998a). Implementing Educational Software and Evaluating Its Academic Effectiveness: Part I. *Educational Technology, 28*(10).

Jolicoeur, K., & Berger, D. E. (1998b). Implementing Educational Software and Evaluating Its Academic Effectiveness: Part II. *Educational Technology, 25*(10).

Jonassen, D. (2001). Learning from, in, and with Multimedia: An ecological Psychology Perspective. In S. Dijkstra, D. Jonassen & D. Sembill (Eds.), *Multimedia Learning: Results and Perspectives*. Frankfurt am Main: Peter Lang.

Jones, M. G. (1998). *Creating engagement in computer-based learning environments.* Paper presented at the ITForum.

Jones, M. G. (1999). *What Can We Learn from Computer Games: Strategies for Learner Involvement.* Paper presented at the National Convention of the Association for Educational Communications and Technology.

Kafai, Y. (1995). *Minds in play: Computer game design as a context for children's learning*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Kafai, Y. (1996). Software by Kids for Kids. *Communications of The ACM, 39*(4).

Kafai, Y. B. (2001). *The Educational Potential of Electronic Games: From Games-To-Teach to Games-To-Learn.* Paper presented at the Playing by the Rules, Cultural Policy Center, University of Chicago.

Kafai, Y. B., & Neulight, N. R. (2005). *What Happens if you Catch Whypox? Children's Learning Experiences of Infectious Disease in a Multi-user Virtual Environment.* Paper presented at the Digra 2005, Vancouver.

Kafai, Y. B., & Resnick, M. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world.* Mawhaw, New Jersey: Lawrence Erlbaum Associates.

Kaptelinin, V., & Cole, M. (1997). *Individual and Collective Activities in Educational Computer Game Playing*. Retrieved 25042004, 2004, from *http://lchc.ucsd.edu/People/MCole/Activities.html*

Kirriemuir, J., & McFarlane, A. (2002). *The use of computer games in the classroom.* Coventry: Becta.

Kirriemuir, J., & McFarlane, A. (2003). *Literature Review in Games and learning*: Nesta Future Lab.

Klawe, M. M. (1998). *When Does The Use Of Computer Games And Other Interactive Multimedia Software Help Students Learn Mathematics?*Unpublished manuscript.

Klawe, M. M., & Phillips, E. (1995). *A classroom study: Electronic games engage children as researchers.* Paper presented at the CSCL 1995, Bloomington, Indiana.

Ko, S. (1999). *Primary School Children's Inferential Problem Solving in a Compu-*

*ter Game Context.*, University of London, London.

Ko, S. (2002). An empirical analysis of children's thinking and learning in a computer game context. *Educational-Psychology., 22*(2), 219–233.

Konzack, L. (2003). *Edutainment : leg og lær med computermediet*. Aalborg: Aalborg Universitetsforlag.

Lantolf, J. P. (2000). *Sociocultural Theory and Second Language Learning*. Oxford: Oxford University Press.

Leddo, J. (1996). An intelligent tutoring game to teach scientific reasoning. *Journal of Instruction Delivery Systems, 10*(4), 22–25.

Lederman, L. C., & Fumitoshi, K. (1995). Debriefing the Debriefing Process: A new look. In D. Crookall & K. Arai (Eds.), *Simulation and gaming across disciplines and cultures*. London: Sage Publications.

Leemkuil, H., Jong, T. d., & Ootes, S. (2000). *Review of educational use of games and simulations.* Twente: University of Twente.

Leutner, D. (1993). Guided Discovery Learning with Computer-Based Simulation Games: Effects of Adaptive and Non-Adaptive Instructional Support. *Learning and Instruction, 3*(2), 113–132.

Levin, J. (1981). Estimation techniques for arithmetic: Everyday math and mathematics instruction. *Educational Studies in Mathematics, 12*, 421–434.

Leyland, B. (1996). *How can computer games offer deep learning and still be fun?* Paper presented at the Ascilite, Adelaide , Australia.

Lieberman, D. A. (1997). Interactive Video Games for Health Promotion: Effects on Knowledge, Self-Efficacy, Social Support, and Health. In G. Street & Manning (Eds.), *Health Promotion and Interactive Technology: Theoretical Applications and Future Directions* (pp. 103–120). Mahwah, NJ: Lawrence Erlbaum Associates.

Lieberman, D. A. (2001). Management of Chronic Pediatric Diseases with Interactive Health Games: Theory and Research Findings. *Journal of Ambulatory Care Management, 24*(1), 26–38.

Linderoth, J. (2002, 19–22 August 2002). *Making sense of computer games: Learning with new artefacts.* Paper presented at the Toys, Games and Media, London.

Lockyer, L., Wright, R., Curtis, S., Curtis, O., & Hodgson, A. (2003). *Energy Balance: Design and formative evaluation of a health education multimedia game.* Paper presented at the EDMEDIA.

Loftus, G., & Loftus, E. (1983). *Mind at Play: The Psychology of Video Games*. New York: Basic Books.

Magnussen, R., & Misfeldt, M. (2004, 6–8. December). *Player Transformation of Educational Multiplayer Games.* Paper presented at the Other Players, Copenhagen.

Malone, T. W. (1980). *What makes things fun to learn? Heuristics for designing instructional computer games.* Paper presented at the Symposium on Small Systems archive., Palo Alto, California, United States.

Malone, T. W., & Lepper, M. (1987a). Intrinsic Motivation and Instructional

Effectiveness in Computer-based Education. In Snow & Farr (Eds.), *Aptitude learning, and instruction*. London: Lawrence Erlbaum Associates Publishers.

Malone, T. W., & Lepper, M. (1987b). Making learning fun: A Taxonomy of Intrinsic Motivation for Learning. In Snow & Farr (Eds.), *Aptitude learning, and instruction*. London: Lawrence Erlbaum Associates Publishers.

Mamer, K. (2002). *Ozark Softscape: Creators of MULE.* Retrieved 2001, 2004, from *http://www.geocities.com/conspiracyprime/e2_ozark.htm*

McCarty, C. T. (2001). *Playing with Computer Games: An Exploration of Computer Game Simulations and Learning.* Unpublished Dissertation submitted in part fulfilment of the requirements of the MA (ICT in Education) Degree., University of London, London.

McFarlane, A., Sparrowhawk, A., & Heald, Y. (2002). *Report on the educational use of games. Teachers Evaluating Educational Multimedia.* Cambridge.

McGrenere, J. L. (1996). *Design of Educational Electronic Multi-player Games: A literature Review*. Vancouver: Department of Computer Science.

McMullen, D. (1987). *Drills vs. Games – Any Differences? A Pilot Study.*: ERIC.

Miller, C., Lehman, J. F., & Koedinger, K. (1999). Goals and Learning in Microworlds. *Cognitive Science, 23*(3), 305–336.

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London: Ultralab: Learning and Skills Development Agency.

Noble, A., Best, D., Sidwell, C., & Strang, J. (2000). Is an Arcade-style Computer game an Effective Medium for Providing Drug education to School children. *Education for Health, 13*(3), 404–406.

Okan, Z. (2003). Edutainment: is learning at risk? *British Journal of Educational Technology, 34*(3), 255–264.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books.

Papert, S. (1998). Does Easy Do It? Children, Games and Learning. *Game Developer.*

Pillay, H., Brownlee, J., & Wilss, L. (1999). Cognition and recreational computer games: Implications for educational technology. *Journal of Research on Computer in Education, 32*(1), 203–216.

Prensky, M. (2001). *Digital Game-Based Learning*. New York: McGraw-Hill.

Prensky, M. (2004). The Motivation of Gameplay. *On the Horizon, 10*(1).

Quinn, C. N. (1997). *Engaging Learning.* Paper presented at the Instructional Technology Forum.

Randel, J. M., Morris, B. A., Wetzel, C. D., & Whitehill, B. V. (1992). The Effectiveness of Games for Educational Purposes: A Review of Recent Research. *Simulation & Gaming, 23*(3), 261–276.

Reiber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research & Development, 44*(2), 43–58.

Rosas, R. e. a. (2003). Beyond Nintendo: A design and assessment of educational

video games for first and second grade students. *Computers & Education, 40*, 71–94.

Saettler, P. (1968). *A history of instructional technology*. New York: McGraw-Hill.

Sandford, Richard and Williamson, Ben (2006). Games and learning: A handbook from Futurelab. Futurelab

Schank, R. C. (1999). Dynamic Memory Revisited. Cambridge: Cambridge University Press.

Sedighian, K., & Sedighian, A. S. (1996). *Can Educational Computer Games Help Educators Learn About the Psychology of Learning Mathematics in Children?* Paper presented at the 18th Annual Meeting of the International Group for the Psychology of Mathematics Education, Florida.

Sedighian, K., & Sedighian, A. S. (1997). *Aesthetic Response: Children's Reactions to Color and Graphics in Educational Software.* Paper presented at the ED-MEDIA 97: World Conference on Educational Multimedia and Hypermedia, Calgary, Canada.

Squire, K. (2002). Cultural Framing of Computer/Video. *Game studies, 1*(1).

Squire, K. (2004). *Replaying history.* Unpublished Dissertation submitted in part fulfilment of the requirements of the Doctor of Philosophy (Instructional technology). Indiana University., Indiana.

Squire, K., Barnett, M., Grant, J. M., & Higginbotham, T. (2004). *Electromagnetism Supercharged!* Paper presented at the International Conference of the Learning Sciences 2004, Los Angeles.

Strein, W., & Kachman, W. (1984). Effects of computer games on young children's cooperative behavior: An exploratory study. *Journal of Research and Development in Education, 19*(1), 40–43.

Thomas, R., Cahill, J., & Santilli, L. (1997). Using an interactive computer game to increase skill and self-efficacy regarding safer sex negotiation: field test results,. *Health Education & Behavior: the Official Publication of the Society for Public Health Education, 24*(1), 71–86.

Turnin, M. C., Couvaras, O., Jouret, B., Tauber, M. T., Bolzonella, C., Fabre, D., et al. (2000). Learning good eating habits playing computer games at school: A 2000 children evaluation. *Diabetes Research and Clinical Practice, 50*(1001), 239–239.

Van Sickle, R. (1986). A Quantitative Review of Research on Instructional Simulation Gaming: A Twenty-Year Perspective. *Theory Research in Social Education, 14*(3), 245–264.

Vandeventer, S. (1997). *Expert Behaviour among outstanding Videogame-playing Children.* Unpublished Dissertation submitted in part fulfilment of the requirements of the Doctor of Philosophy (Curriculum and Instruction). University of South Florida., Florida.

Vygotsky, L. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. (1986). *Thought and Language*. Cambridge, Massachusetts: MIT Press.

Walker de Felix, J., & Johnson, R. T. (1993). Learning from video games.

*Computers in the Schools, 9*(2–3), 199–133.

Wentworth, D. R., & Lewis, D. R. (1973). A review of research on instructional games and simulations in social studies education. *Social Education, 37*, 432–440.

Wertsch, J., V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

White, B. Y. (1984). Designing computer games to help physics students understand Newton's laws of motion. *Cognition and Instruction, 1*(1), 69–108.

Whitebread, D. (1997). Developing children's problem-solving: the educational uses of adventure games. In A. McFarlane (Ed.), *Information technology and Authentic Learning*. London: Routledge.

Wiebe, J. H., & Martin, N. J. (1994). The impact of a computer-based adventure game on achievement and attitudes in geography. *Journal of Computing in Childhood Education, 5*(1), 61–71.

Willis, J., Hovey, L., & Hovey, K. G. (1987). *Computer simulations: A source book to learning in an electronic environment.* New York: Garland Publishing, Inc.

Wolfe, J., & Crookall, D. (1998). Developing a Scientific Knowledge of Simulation/Gaming. *Simulation & Gaming, 29*(1), 7–19.

Woods, S. (2002). *Fair Game? Possibilities for the Design and Implementation of Face-to-Face Social System Simulation Games in a Computer-Mediated Environment.* Unpublished Submitted in part fulfilment of the requirements of the Bachelor (Design). Curtin University of Technology.