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A systematic literature review of empirical evidence on computer games and serious games

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ABSTRACT

This paper examines the literature on computer games and serious games in regard to the potential positive impacts of gaming on users aged 14 years or above, especially with respect to learning, skill enhancement and engagement. Search terms identified 129 papers reporting empirical evidence about the impacts and outcomes of computer games and serious games with respect to learning and engagement and a multidimensional approach to categorizing games was developed. The findings revealed that playing computer games is linked to a range of perceptual, cognitive, behavioural, affective and motivational impacts and outcomes. The most frequently occurring outcomes and impacts were knowledge acquisition/content understanding and affective and motivational outcomes. The range of indicators and measures used in the included papers are discussed, together with methodological limitations and recommendations for further work in this area.

1. Introduction

Over the last 40 years computer games have increasingly replaced more traditional games as leisure activities and have had a transformational impact on how we spend our leisure time. Entertainment games provide engaging activities and it would appear that far from waning, interest in games for leisure is still growing. The availability of new consoles, platforms and technologies for the delivery of games is an important factor in this continued growth.

Much of the early research on computer games focused on the negative impacts of playing digital games, particularly on the impact of playing violent entertainment games on aggression. Anderson and Bushman's influential meta-analyses suggested that playing violent video games leads to increases in aggressive thoughts, aggressive affect and physiological arousal, reduced arousal to subsequent depictions of violence and decreases in pro-social behaviour (Anderson, 2004; Anderson & Bushman, 2001). Other negative effects of playing digital entertainment games have also been reported, such as difficulties in regulating the amount of time spent playing games (Ogletree & Drake, 2007), addiction (Griffiths & Davies, 2002), social isolation and nauseogenic properties of games with head mounted displays (Merhi, Faugloire, Flanagan & Stoffregen, 2007).

Despite this early focus on the negative impacts of computer games, there has also been interest in positive effects of playing games. In his meta-analysis of both positive and negative effects of playing violent games, Ferguson (2007) found that playing violent games was associated with better visual spatial abilities, but found no effect of playing violent games on aggressive behaviour.

The motivating features of digital games and the suggestions that game players might actually be developing useful skills (Subrahmanyam & Greenfield, 1994) led to optimism that games might provide a useful and attractive new method of learning (de Freitas, 2006). Initially interest focused on how COTS (commercial-off-the-shelf) games, which are primarily designed for entertainment, might be used in learning, but interest also grew in games-based learning (GBL), designing games for educational purposes. Modern theories of effective learning suggest that learning is most effective when it is active, experiential, situated, problem-based and provides immediate feedback (Boyle, Connolly & Hainey, 2011). Games appeared to offer activities which have these features. There has also been interest

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in Serious Games (Sawyer & Smith, 2008) and persuasive games (Bogost, 2007) which have been used to change behaviours and attitudes more broadly in the areas of health, public policy and advertising as well as education and training. However, while there has been much speculation about the use of games in these ways, there has been less in the way of hard evidence to support these claims (Connolly, Stansfield & Hainey, 2008). The aim of the current paper is to carry out a systematic literature review of empirical evidence about the positive impacts and outcomes of computer games and serious games with respect to learning and engagement.

2. Previous research

It is clear that playing digital games leads to a variety of positive outcomes and impacts but it is also acknowledged that the literature on games is fragmented and lacking coherence (Ke, 2009). This lack of organisation is regarded as an obstacle to progress in understanding the effects of games, developing more effective games and proposing guidance about how best to use games in learning.

2.1. Categorising games and their impacts and outcomes

Games and their outcomes and impacts have been analysed along a number of dimensions and it is proposed that these classifications should help in developing a more organized framework for understanding games. In categorizing games it is useful to consider the primary function of the game, that is whether the game was developed initially as a game for entertainment, a game for learning or as a serious game. Digital commercial games (such as Mario Brothers and Grand Theft Auto) were developed primarily for fun, entertainment and recreation, while the main aims of games-based learning (GBL) and serious games are learning and behaviour change. The terms serious games and GBL are sometimes used synonymously (Corti, 2006), although serious games have been developed for the broader purposes of training and behaviour change in business, industry, marketing, healthcare and government NGOs as well as in education (Sawyer & Smith, 2008).

Game genre provides an established classification of entertainment games which provides a useful way of identifying commonalities between games. There is no standard accepted taxonomy of genre, although Kirriemuir & McFarlane (2004) advocated Herz's (1997) system which is similar to that used by the games industry. Herz distinguishes action games (reaction based games including shooting and platforms), adventure games (solving logical puzzles to progress through a virtual world), fighting games, puzzle games (such as Tetris), role-playing games, simulations, sports games and strategy games. While genre is relevant to entertainment games, their relevance to games for learning and serious games is less clear. Recently new technologies such as mobile technologies, online games, virtual worlds and ARGs have expanded the ways in which games have traditionally been played, their medium of delivery and the different platforms available.

In addition to categorising games themselves, it is useful to think about dimensions along which the outcomes and impacts of games can be classified. The most important categorization for the current study concerns the learning and behavioural outcomes linked to playing games. The immense popularity of digital entertainment games suggests that players enjoy playing games and these positive emotional experiences can themselves be viewed as positive outcomes of playing games. While engagement in games is self evident, our understanding of enjoyment in games is poorly developed. Sweetser & Wyeth (2005) claimed that understanding game usability has had priority over understanding game enjoyment, while Vorderer, Klimmt & Ritterfield (2004) have suggested that research has neglected to consider the nature of media enjoyment generally.

Playing games is increasingly linked to learning and several models have been developed that identify distinct learning outcomes that playing digital games can have. Garris, Ahlers & Driskell (2002) made a basic distinction between skills based learning outcomes (including technical and motor skills), cognitive outcomes (including declarative, procedural and strategic knowledge) and affective outcomes (beliefs or attitudes). This latter category reflects the potential of games to change players' emotions in addition to helping them learn.

O'Neill, Wainess & Baker (2005) identified five "families of cognitive demands" in playing games: content understanding and problem solving which are content specific skills while collaboration/teamwork, communication and self-regulation are regarded as content independent skills. Wouters, van der Spek & Oostendorp (2009) proposed a model of four kinds of learning outcomes that games might have – cognitive learning outcomes, which they divided into knowledge and cognitive skills, motor skills, affective learning outcomes and communicative learning outcomes.

Modern accounts of effective learning acknowledge that many variables contribute to or influence task or academic performance. In recognition of this, Connolly et al. (2008) proposed a broad model for the evaluation of games for learning that includes motivational variables such as interest and effort, as well as learners' preferences, perceptions and attitudes to games in addition to looking at learner performance. The current review adopted a broad ranging approach to categorising outcomes relating to learning and skill acquisition but also affective and motivational outcomes of playing games.

3. Research questions

3.1. Empirical evidence on impacts and outcomes of games

Despite the optimism about the potential of games for learning, several authors have noted that there has been a dearth of high quality empirical evidence to support these claims (de Freitas, 2006; Wouters et al, 2009). Consequently the aim of the current paper is to address the question: "What empirical evidence is there concerning the positive impacts and outcomes of computer games?". In line with modern accounts of effective learning, impacts and outcomes are defined very broadly to include 'softer' emotional, motivational and attitudinal outcomes as well as "harder" knowledge acquisition and skills outcomes (Connolly et al., 2008). The review will also cover COTS games,

which are primarily designed for fun but which may nevertheless have value in promoting or enhancing skill or knowledge acquisition. This emphasizes the twin strands of engagement with games and learning with games.

The review builds on the results of a number of reviews that have previously been carried out in the area of games-based learning, including the 2004 literature review of Games and Learning by Kirriemuir & McFarlane (2004) and our own more recent work on serious games (Connolly et al., 2008), as well as studies on games developed purely for fun and entertainment. The review will focus predominantly on UK research, but will draw upon research conducted elsewhere where relevant.

3.2. Categorising games and their impacts and outcomes

A further question for the current review was whether the multidimensional framework which was developed for categorizing games was useful.

4. Method

4.1. Data collection

4.1.1. Databases searched

The electronic databases searched in this review included those identified as relevant to education, information technology and social science: ACM (Association for Computing Machinery), ASSIA (Applied Social Sciences Index and Abstracts), BioMed Central, Cambridge Journals Online, ChildData, Index to Theses, Oxford University Press (journals), Science Direct, EBSCO (consisting of Psychology and Behavioural Science, PsycINFO, SocINDEX, Library, Information Science and Technology Abstracts, CINAHL), ERIC (Education Resources Information Center), IngentaConnect, Infotrac (Expanded Academic ASAP), Emerald and IEEE (Institute of Electrical and Electronics Engineers) Computer Society Digital Library (CSDL).

4.1.2. Search terms

The search terms that we used included terms for games in conjunction with terms for possible outcomes, impacts or effects of playing games. Our search terms help to determine the scope of our definition of digital games since many of the terms include the word "game" such as "computer game", "video game", "serious game", "simulation game", "games-based learning", "online game", but more specific terms were also included such as "*MMOG*", "*MMORPG*" and "*MUD*". The games terms were derived from a previous search carried out on the evaluation of computer games (Connolly et al., 2008) and addressed the variety of games that might be played:

("computer games" OR "video games" OR "serious games" OR "simulation games" OR "games-based learning" OR MMOG OR MMORPG OR MUD OR "online games")

Terms for outcomes or effects of playing games were derived from consideration of terms used for impacts and outcomes as well as specific impacts and outcomes such as learning and skills as well as engagement, motivation attitudes, affect and behaviour:

AND (evaluation OR impacts OR outcomes OR effects OR learning OR education OR skills OR behaviour OR attitude OR engagement OR motivation OR affect)

4.1.3. Selection of papers for inclusion in the review

A number of further criteria were specified to select appropriate studies for inclusion in the review. To be included in the review, papers had to (a) include empirical evidence relating to the impacts and outcomes of playing games. This was to address the main aim of the study in addressing the perceived lack of empirical evidence concerning digital games, (b) date from January 2004 to February 2009, (c) include an abstract and (d) include participants over the age of 14 years. This latter criterion was used since the sponsor who commissioned the research was interested in the use of games by adolescents and adults. Using these four conditions 129 papers met the inclusion criteria and were identified as relevant to the current review.

4.2. Data analysis

4.2.1. Coding of papers

The 129 papers meeting the inclusion criteria were coded using a data extraction proforma that was developed by considering previous research which categorised games and their outcomes and impacts along several salient dimensions.

4.2.1.1. Categorisation of games. Games themselves were categorized along the following dimensions:

Digital or non-digital games: While the focus of the current study was on digital games, we did not exclude papers about non-digital games.

Primary purpose of the game: Games were coded according to whether the game was originally designed as a game for entertainment, a game for learning or was a serious game.

Game genre: Classification of genre was based on Herz's (1997) system.

Subject Discipline: Where relevant, games were categorized with respect to the knowledge domain/curricular area that the game addressed along the following dimensions: health, society, maths, language, engineering, general knowledge, geography and science.

Platform/delivery: The platform for delivery of the game was categorised as video console, PC, online game, second life, mobile or alternate reality game (ARG).

4.2.1.2. Categorisation of effects of games. The current study focused on positive outcomes of playing games. The categories which we used in analysing positive outcomes and impacts of games were as follows:

Behavioural and learning outcomes and impacts: Previous research was used in developing the categorization of behavioural and learning outcomes and impacts. Categories used were as follows: knowledge acquisition/content understanding, perceptual and cognitive skills, motor skills, physiological outcomes, affective and motivational outcomes, behaviour change, soft skills and social outcomes.

Intended or unintended: Games can have intended outcomes, i.e. outcomes which the designer purposefully designed into the game or unintended outcomes, i.e. outcomes which were not purposefully designed into the game.

Generic or specific impact: The effects of games can be examined with respect to whether they address the effects of playing computer games generally or playing a specific game.

4.2.1.3. Coding of methods. Included papers were also coded in terms of a number of methodological dimensions.

Study design: The design was coded according to whether it used a quantitative or qualitative methodology or both. The design of each study was further coded according to whether it used a randomized control trial (RCT), a quasi-experimental design, a survey, a correlational design or a qualitative design.

Sampling: Sampling of participants was coded according to whether probability or non probability sampling was used and whether participants were assigned to groups randomnly.

Sample: Details of the sample included the mean age, age range, number and gender of participants.

Between-group comparisons: Where there was a comparison between groups, the number of groups and differences between groups were recorded.

Data collection: Studies were coded in terms of who collected the data and the reliability and validity of the data collection tools/instruments.

Data analysis: Statistical methods used and the rationale for the methods of data analysis are described, including whether there were confounding variables and how these were controlled for (e.g. use of ANCOVA). Qualitative measures such as dialogue coding are described.

Results and conclusions: A summary of the overall results (both statistically significant and non-significant) at immediate post-intervention was provided.

4.3. Quality of the studies

To assess the quality of the papers, each paper was read and given a score of 1–3 across the five dimensions described below, where 3 denotes high, 2 denotes medium and 1 denotes low on that criterion.

1. How appropriate is the research design for addressing the question, or sub-questions of this review (higher weighting for inclusion of a control group)? Papers were coded as:
   - High = 3, e.g. RCT
   - Medium = 2, e.g. quasi-experimental controlled study
   - Low = 1, e.g. case study, single subject-experimental design, pre-test/post-test design
2. How appropriate are the methods & analysis?
3. How generalisable are the findings of this study to the target population with respect to the size and representativeness of sample. To what extent would the findings be relevant across age groups (14+), gender, ethnicity, etc?
4. How relevant is the particular focus of the study (including conceptual focus, context, sample and measures) for addressing the question or sub-questions of this review?
5. To what extent can the study findings be trusted in answering the study question(s)?

The total weight of evidence for each paper was calculated by summing scores on each of the five dimensions. Possible scores ranged from 5 to 15 where 5 is a low score and 15 a high score. Coding of the 129 papers was carried out by four experienced coders who conferred about problematic codings and resolved any discrepancies.

4.4. Inter-rater reliability

To assess inter-rater reliability with respect to the quality coding of the papers, a sub-sample of 19 of the 129 papers (15%) was coded independently by two of the coders. The inter-rater reliability (ρ) for the total scores was .96, showing good agreement between the two coders concerning the quality of the papers.

5. Results

5.1. Papers identified by search terms

Table 1 below shows the number of papers in each of the databases that were identified using our search terms. As the table shows the search terms identified a large number of papers (7392) demonstrating the huge growth in interest in gaming during this time period.

5.2. Papers selected using our inclusion criteria

Table 1 also shows the number of papers in each database that met the inclusion criteria. Clearly most papers were found in the Science Direct database with Extended Academic ASAP and EBSCO the next most popular, followed by ERIC and the ECGBL conferences.

Table 1
Total number of papers identified from each database and number shortlisted as relevant.

Database	Number of papers identified in search	Number of papers meeting inclusion criteria
ACM	33	0
ASSIA	48	5
BioMed central	70	2
Index to theses	0	0
Science Direct	4261	51
EBSCO	1027	15
ERIC	295	12
EXTENDED ACADEMIC ASAP	490	15
Emerald	474	5
IEEE/CSDL	675	12
ECGBL conferences 2007 and 2008	19	12
Total	7392	129

5.3. Quality ratings

As described in 4.3, each of the 129 papers was given a quality score and Fig. 1 shows a histogram of the number of papers rated at each score. The mean rating for the 129 papers was 8.56 and the modal rating for the papers was 9. Consequently papers rated 9 or over were considered as providing methodologically stronger evidence of the impact of games in that area. 70 papers were rated over 9 and these papers are summarized in Appendices A–G, showing the names of the authors, date that the study was reported, the aims and objectives of the study, methods used and the main findings and conclusions of the study as described in Section 4.2.1. The papers are organized with respect to the learning or behavioural outcomes or impacts.

5.4. Study design used in papers

Table 2 shows the numbers of papers which used each study design. Results are shown both for all 129 papers with the 70 higher quality papers in brackets and this way of reporting the data is adopted in all tables. The vast majority 121 (84%) of the included papers reported quantitative data with only 8 (6%) reporting qualitative data. Of the 121 studies which reported quantitative data, 65 (54%) utilized quasi-experimental designs, 43 (36%) survey designs, 12 (10%) used RCT designs, and one study used a correlational design. Of the quasi-experimental designs, 45 (69%) used between-group designs with no randomization and 20 (31%) used a within-group design with no control group. The 8 studies reporting only qualitative data utilized case study methodologies, protocol analysis and analysis of perspectives. There was no significant effect of study design upon study quality (RCT versus quasi-experimental versus other quantitative (survey and correlational) versus qualitative) with respect to higher versus lower weight of evidence, ($\chi^2_{(3)} = 2.72$, $p = .437$, two-tailed test, n.s.) as a result of a preponderance of quasi-experimental and survey designs, which were evenly split across weight of evidence.

Initially a meta-analysis of the evidence concerning the impacts and outcomes of playing games was planned. However papers identified in the review were very diverse with respect to the phenomena researched, underlying theoretical models and methodological approaches

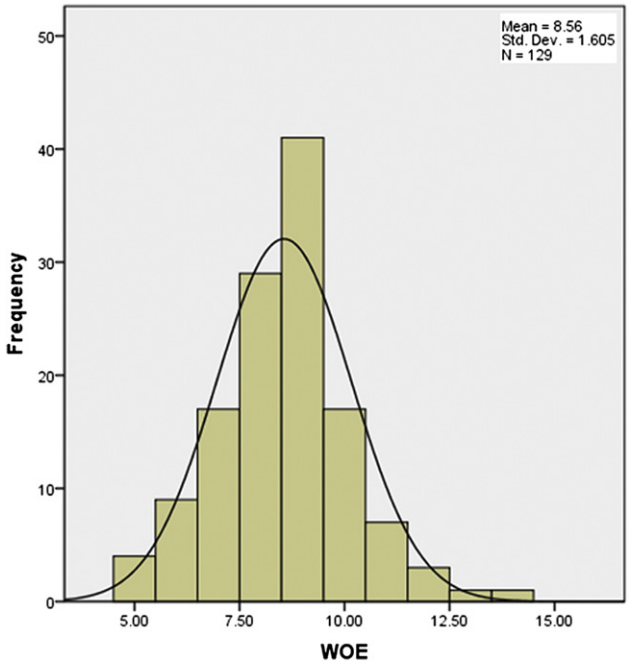

Fig. 1. Histogram of weight of evidence (WOE) quality scores for included papers.

Table 2
Primary purpose of game by study design for all papers (higher quality papers in brackets).

Study design	Purpose of game			Total
	Entertainment	Game for learning	Serious game	
Qualitative study	1 (0)	4 (2)	3 (3)	8 (5)
Correlational	0 (0)	1 (0)	0 (0)	1 (0)
Quasi-experimental	32 (16)	28 (14)	5 (4)	65 (34)
RCT	4 (4)	6 (4)	2 (1)	12 (9)
Survey	31 (16)	10 (6)	2 (0)	43 (22)
Total	68 (36)	49 (26)	12 (8)	129 (70)

adopted and, even amongst the higher quality papers, a minority of papers reported RCTs, the design of choice in evaluating impacts and outcomes of games (Connolly et al., 2008). In view of this methodological heterogeneity a meta-analysis was discounted and a narrative review was held to be most appropriate to capture the diversity of the papers.

5.5. Game variables

5.5.1. The primary purpose of the game: entertainment, game for learning, serious games

Table 2 also shows the number of papers which focused on entertainment games, games for learning and serious games for all papers and for high quality papers. 68 papers looked at entertainment games and 49 at games for learning. Only 12 papers in the current study described serious games and, of those, most could have been categorised as games for learning.

Table 2 also shows that different designs tended to be used in studies of entertainment games and games for learning. 28 studies of games for learning using a quasi-experimental design, with 10 surveys and 6 RCTs. Quasi-experiments (32) were also the design most frequently used in studies of entertainment games but surveys were also very popular (31) with only 4 RCTs.

5.5.2. Digital/non-digital

While the focus of the current study was on digital games, the search identified 3 high quality papers about non-digital games. Halpern and Wai (2007) compared the cognitive and perceptual abilities and strategies displayed by expert and novice Scrabble players. Vahed (2008) found that a non-digital board game could help dental students in learning about tooth morphology and Mayer, Carton, de Jong, Leijten and Dammers (2004) described how a complex, non-digital game helped students to understand the complex issues involved in planning urban networks. Consideration of how non-digital games support learning might also help in analysing digital games.

5.5.3. Game genre

Table 3 shows the number of papers reporting studies using each of the game genre both for all papers and for higher quality papers. Simulations were by far the most popular genre (43) followed by action games (14), puzzles (11), role-playing (8), strategy (6) and adventure (5) games. 22 studies examined the impact of games generally, while 4 addressed the effects of generic online games.

Table 3 also shows game genre split by the intention of the game. Simulations were the most frequently reported games in studies of games for learning, with puzzle games the second most popular and overall 80% of games for learning were either simulations or puzzles. The majority of serious games (10 out of 12) were also simulations. Only 10 papers about games for learning and 2 on serious games used any of the other game genre such as action games, adventure games and strategy games. The most frequently occurring studies of entertainment games looked at the of impact of games generally (22), but there were also studies on all of the different game genre, with action games (11) the most popular followed by role-playing games (7) but also including fighting, strategy, adventure and sports games.

Table 4 shows which designs were used in studies using different game genre. Looking at the relationship between study design and game genre reveals considerable heterogeneity in regard to the methodology used for evaluation. For example, the outcomes of almost 60% of the simulation games, the most frequently represented in the data set, were evaluated by quasi-experimental designs. In contrast, nearly 70% of studies of generic and generic online games in the data set were evaluated by surveys. The proportion of high quality to total games was fairly similar across genre, although papers about action games (71%) and role-playing games (75%) seemed to be over-represented and papers about puzzle games (27%) under-represented in the higher quality papers.

5.5.4. Platform/delivery

Table 5 shows that the most popular platform for delivery of games was the PC (73), followed by video console (28) and online games (19), with three papers looking at mobile games and one at a virtual world game. Entertainment games were distributed fairly evenly across PCs (24) and video consoles (26) with 13 games online, while the majority of games for learning were developed for the PC (38) with 6 games online. 11 of the 12 serious games were delivered by PC while one was a non-digital game.

5.5.5. Subject discipline/curricular areas

Table 6 shows the different subject disciplines that the games described in the papers address. Apart from a few cases, subject discipline was not relevant to entertainment games. The results confirmed that games for learning are being used across a wide range of subject disciplines with health (21) the most popular followed by games about social issues (14), science (11) and business (8). Games about mathematics and statistics (e.g. Nte & Stephens, 2008; Wijers, Jonker & Kerstens, 2008), engineering and computing (e.g. Papastergiou, 2009), language (e.g. Miller & Hegelheimer, 2006; Yip & Kwan, 2006) and history (e.g. Akkerman, Admiraal & Huizenga, 2008) were also found.

Table 3
Game genre split by the intention of the game (higher quality papers in brackets).

	Intention of game			Total
	Entertainment	Game for learning	Serious game	
Action	11 (8)	3 (2)	0 (0)	14 (10)
Adventure	3 (2)	2 (1)	0 (0)	5 (3)
Animated tutorial	0 (0)	1 (0)	0 (0)	1 (0)
Board game	1 (1)	1 (1)	0 (0)	2 (2)
Fighting	4 (2)	0 (0)	0 (0)	4 (2)
Generic games	22 (11)	0 (0)	0 (0)	22 (11)
Generic online games	4 (1)	0 (0)	0 (0)	4 (1)
Mobile device	1 (1)	0 (0)	0 (0)	2 (1)
N/A	1 (0)	0 (0)	0 (0)	1 (0)
Platform	1 (0)	0 (0)	1 (0)	1 (0)
Puzzle	2 (0)	9 (3)	0 (0)	11 (3)
Racing game	1 (1)	0 (0)	0 (0)	1 (1)
Role-playing	7 (5)	1 (1)	0 (0)	8 (6)
Simulation	3 (2)	30 (18)	10 (7)	43 (27)
Sports	2 (1)	1 (0)	0 (0)	3 (1)
Strategy	4 (0)	1 (0)	1 (1)	6 (1)
Virtual reality	1 (1)	0 (0)	0 (0)	1 (1)
Total	68 (36)	49 (26)	12 (8)	129 (70)

5.6. Outcomes and impacts of playing games

The outcomes and impacts of playing games were analysed in terms of the following variables.

5.6.1. Learning and behavioural outcomes of games

A key aim of the current review was to develop a workable classification of outcomes and impacts of playing games with respect to engagement and learning. Table 7 shows the numbers of papers that addressed the different learning and behavioural outcomes and impacts. The most frequently occurring outcomes reported were affective and motivational (33) and knowledge acquisition/content understanding (32) followed by perceptual and cognitive skills (20), behaviour change (13), physiological outcomes (11) and social/soft skills outcomes (11). Higher quality papers were spread fairly evenly across the different outcome categories, although there were slightly more higher quality papers on perceptual and cognitive outcomes and slightly fewer on social and soft skills outcomes than would be expected.

5.6.1.1. Learning and behavioural outcomes of games by study design. Table 7 shows that the quasi-experiment was the design of choice in studying knowledge acquisition, motor skills, perceptual and cognitive skills and physiological outcomes although a few studies on knowledge acquisition also used RCTs, surveys and qualitative designs. Surveys were the design used most frequently in studying affective and motivational and social outcomes of games although a few studies used a quasi-experimental design and RCT. Methods used in studying behaviour change outcomes were varied and included quasi-experimental, surveys, qualitative and RCTS. There were few qualitative studies overall and no study had a primarily qualitative approach to studying affective and emotional, motor or physiological aspects of games.

Table 4
Study design by game genre (higher quality papers in brackets).

Game genre	Study design					Total
	Qualitative	Correlational	Quasi-experimental	RCT	Survey	
Action	0 (0)	0 (0)	10 (7)	3 (3)	1 (0)	14 (10)
Adventure	1 (0)	0 (0)	2 (1)	1 (1)	1 (1)	5 (3)
Animated tutorial	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)
Board game	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	2 (2)
Fighting	0 (0)	0 (0)	2 (1)	0 (0)	2 (1)	4 (2)
Generic	0 (0)	0 (0)	6 (3)	1 (1)	15 (7)	22 (11)
Generic online	1 (0)	0 (0)	0 (0)	0 (0)	3 (1)	4 (1)
Mobile device	0 (0)	0 (0)	1 (1)	0 (0)	1 (0)	2 (1)
N/A	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)
Platform	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)
Puzzle	0 (0)	0 (0)	7 (3)	2 (0)	2 (0)	11 (3)
Racing game	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)
Role-playing	0 (0)	0 (0)	3 (2)	0 (0)	5 (4)	8 (6)
Simulation	5 (4)	0 (0)	25 (14)	5 (4)	8 (5)	43 (27)
Sports	0 (0)	0 (0)	2 (0)	0 (0)	1(1)	3 (1)
Strategy	1 (1)	1 (0)	3 (0)	0 (0)	1 (0)	6 (1)
Virtual reality	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)
Total	8 (5)	1 (0)	65 (34)	12 (9)	43 (22)	129 (70)

Table 5
Primary purpose of the game by platform (higher quality papers in brackets).

Platform	Entertainment game	Games for learning	Serious game	Total
All	3 (2)	0 (0)	0 (0)	3 (2)
Mobile	1 (1)	2 (2)	0 (0)	3 (3)
Non-digital game	1 (1)	0 (0)	1 (1)	2 (2)
Online	13 (6)	6 (3)	0 (0)	19 (9)
PC	24 (12)	38 (18)	11 (7)	73 (37)
Video console	26 (14)	2 (2)	0 (0)	28 (16)
Virtual world	0 (0)	1 (1)	0 (0)	1 (1)
Grand total	68 (36)	49 (26)	12 (8)	129 (70)

5.6.1.2. Learning and behavioural outcomes by primary purpose of games. Table 8 shows the number of papers which addressed the different outcomes in terms of the primary purpose of game. It is evident that papers about entertainment games and games for learning focused on different kinds of outcome. The most frequently occurring outcome with games for learning was knowledge acquisition/content understanding (26), followed by perceptual and cognitive skills (7). In contrast, the most frequently occurring outcomes for entertainment games were affective and motivational outcomes (26), although several studies also looked at the acquisition of perceptual and cognitive skills (13) in entertainment games. Physiological outcomes were only studied in entertainment games. Serious games were fairly evenly split across outcome categories, but with no studies of perceptual and cognitive or physiological outcomes.

5.6.2. Discussion of the learning and behavioural outcomes and impacts of the higher quality papers

In this section the 70 higher quality papers described in Appendices A–G are discussed in more detail.

5.6.2.1. Knowledge acquisition/content understanding. 17 higher quality papers reported on games involving knowledge acquisition/content understanding. Games were developed to support the acquisition of knowledge across a range of curricular areas largely in tertiary education but also in high school. There were few RCTs and the evidence they provided about the impact of games was mixed. Papastergiou (2009) showed improvement in performance on computer memory concepts and Beale, Kato, Marin-Bowling, Guthrie, and Cole (2007) found better perfomance on cancer knowledge for a game playing group compared with a control group. In contrast however Sward, Richardson, Kendrick, and Maloney (2008) found no difference in performance between students using an online game and students using computerised flash cards in their mastery of paediatric knowledge, although students preferred learning with the game and enjoyed it more. Miller & Hegelheimer (2006) and Rossiou and Papadakis (2008) and Yip and Kwan (2006) found better performance in a game group compared with a control, but these studies did not include pre-tests of the groups. Nte and Stephens (2008) found that students self-reported that a game-based approach was effective in teaching the basic properties of the normal distribution.

Several studies considered pedagogical aspects of how games were incorporated into learning. For example Cameron and Dwyer (2005) found that introducing a competitive game-based approach into a knowledge acquisition game about the physiology and functions of the human heart did not in itself lead to improved performance, but including feedback about the accuracy of response did. Yaman, Nerdel, & Bayrhuber (2008) found that instructional support, especially in the form of worked out examples, was of particular benefit to students learning about the difficult content area of mitochondrial membranes.

Most knowledge acquisition games were learning games designed specifically to address curricular goals in the classroom, although Miller and Hegelheimer (2006) used a COTS games, the SIMS, to teach language. Games have also proved effective in informal learning environments. For example, Beale et al's game for young people recovering from cancer proved to be an effective vehicle for health

Table 6
Summary of subject discipline/curricular areas addressed by the games (higher quality papers in brackets).

Subject discipline	Total
Business	8 (3)
Computing	1 (1)
Engineering	4 (1)
Entertainment	47 (24)
General knowledge	3 (0)
Generic games	1 (0)
Geography	3 (2)
Health	21 (12)
History	2 (2)
Language	4 (3)
Mathematics	4 (3)
Military/War game	3 (2)
N/A	1 (0)
Science	11 (6)
Social issues	14 (9)
Statistics	1 (1)
Variety	1 (1)
Grand total	129 (70)

Table 7
Study design by learning and behavioural outcomes of games (higher quality papers in brackets).

Learning outcome	Study design					Total
	Qualitative	Correlational	Quasi-experimental	RCT	Survey	
Affective and motivational	0 (0)	0 (0)	10 (6)	2 (2)	21 (10)	33 (18)
Behaviour change	2 (2)	0 (0)	6 (3)	1 (1)	4 (2)	13 (8)
Knowledge acquisition/Content understanding	3 (2)	0 (0)	17 (8)	6 (3)	6 (4)	32 (17)
Motor skills	0 (0)	0 (0)	8 (4)	0 (0)	0 (0)	8 (4)
Perceptual & cognitive	2 (0)	1 (0)	12 (8)	1 (1)	4 (4)	20 (13)
Physiological	0 (0)	0 (0)	10 (5)	1 (1)	0 (0)	11 (6)
Social/soft skill outcomes	1 (1)	0 (0)	2 (0)	1 (1)	7 (2)	11 (4)
Various	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)
Total	8 (5)	1 (0)	65 (34)	12 (9)	43 (22)	129 (70)

education in adolescents and young adults with chronic illnesses. While knowledge acquisition was the main focus of these studies, many papers also reported that students enjoyed the game-based approach or found it motivating.

5.6.2.2. Perceptual and cognitive skills. 13 higher quality papers were identified which looked at the impact of games on perceptual and cognitive skills. The majority of these papers (9) focused on entertainment games, with several adding weight to the growing evidence that players of digital entertainment games display a range of attentional and visual perceptual advantages compared with non-game players. Green and Bavelier (2006) found that game players could numerate and simultaneously track two more items than non-game-players. Terlecki and Newcombe (2005) found that the use of computers including computer games mediated gender differences in mental rotation ability, while Feng, Spence, & Pratt (2007) found that giving females experience in playing an action video game reduced gender differences in attentional and spatial skills.

Boot, Kramer, Simons, Fabiani & Gratton (2008) were interested in whether the benefits of playing games extended to a broader range of cognitive abilities, such as memory and problem solving. They found mixed results, some supportive of previous research and others not, and suggested that more research is required to find out exactly which perceptual and cognitive skills game playing supports. Barlett, Vowels, Shanteau, Crow, & Miller's (2009) RCT did find support for the impact of games on a broader range of cognitive skills. They found that playing video games for even a short time led to improvements in performance on working memory, addition, auditory perception and selective attention tasks. Evidence that games can support higher level thinking came from Mayer, Carton, de Jong, Leijten, & Dammers (2004) who demonstrated that games can provide complex scenarios which support real world real decision-making and Steinkuehler and Duncan (2008) who showed that players' contributions to discussion fora in the online game World of Warcraft demonstrated an impressive variety of higher order scientific reasoning skills, such as using data and argument, building on others' ideas and using system-based reasoning. However these were both qualitative studies and did not compare performance against a non-game control.

5.6.2.3. Motor skills. 4 papers, all using quasi-experimental designs, examined the impact of playing games on the acquisition of motor skills. Hogle, Widmann, Ude, Hardy, & Fowler (2008) compared a group who practiced laparoscopic skills using a simulator with a group who did not. They found mixed results with improvements in performance on depth perception and operative performance but no difference on four other measures. They also found that students with experience of playing video games learned faster but did not perform better than non-video game players. The researchers questioned whether the time and effort involved in developing the simulator was worth the return. Stefanidis, Scerbo, Sechrist, Mostafavi, and Heniford (2008) found improvements in students' performance with a simulator but that achieving automaticity on a secondary task required a long training period. Orvis, Horn, and Belanish (2008) found that inexperienced players did not benefit as much on a marksmanship task when task difficulty was continuously increased compared with other strategies for modifying task difficulty.

5.6.2.4. Behaviour change. The 8 high quality papers categorised under behaviour change were more varied in their focus and methodology than those in other categories. Jouriles et al. (2008) used a RCT to test their innovative virtual reality, role-playing game designed to train young women to develop behavioural strategies for resisting untoward sexual advances and concluded that a VR approach could be useful in this respect. Lavender (2008) developed a game "Homeless: It's No Game" to determine whether people could be persuaded to

Table 8
Primary purpose of game by learning and behavioural outcomes (higher quality papers in brackets).

Outcomes of playing game	Entertainment game	Game for learning	Serious game	Total
Affective and motivational outcomes	26 (14)	5 (4)	2 (0)	33 (18)
Behaviour change	7 (3)	4 (3)	2 (2)	13 (8)
Knowledge acquisition/content understanding	3 (3)	26 (12)	3 (2)	32 (17)
Motor skills	1 (0)	5 (2)	2 (2)	8 (4)
Perceptual and cognitive skills	13 (9)	7 (4)	0 (0)	20 (13)
Physiological outcomes	11 (6)	0 (0)	0 (0)	11 (6)
Social/soft skill outcomes	6 (1)	2 (1)	3 (2)	11 (4)
Various	1 (0)	0 (0)	0 (0)	1 (0)
Grand total	68 (36)	49 (26)	12 (8)	129 (70)

become more sympathetic to the plight of the homeless by playing the role of a homeless woman. Results were mixed, with some indicators showing an increase in sympathy towards the homeless and others showing no significant effect. Gentile and Gentile (2008) argued that violent video games systematically incorporate many important features of modern theories of successful learning and consequently teach players to think and behave more aggressively. Gentile & Gentile found support for this claim showing that students who play multiple violent video games have more aggressive cognitions and behaviours than students who play fewer or no violent video games.

Other papers categorised as having behaviour change outcomes included those by Schneider and Cornwell (2005) who looked at the effects of advertising in games, Eastin (2006) who looked at the impact of gender representation on feelings of presence and aggressive thoughts and Lee et al. (2007) who examined the impact of different kinds of game in technological addictions to games and the Internet. Davidovitch, Parush and Shtub (2008) found that students performed better when they could use a history recording mechanism to help them remember events in a complex project management game.

5.6.2.5. Soft skills and social skills. Although authors such as Dondlinger (2007) and Dede (2000) have suggested that games have the potential to support soft skills, in the current review only one paper was found which addressed soft skills. This paper by Backlund, Engström, Johannesson, Lebram, and Sjödén (2008) found that a driving simulator increased self-efficacy in driving compared with a control condition. Soft skills overlap to some extent with social skills and 3 higher quality papers examined social skills, although none of these papers compared performance in game and non-game conditions. Assmann and Gallenkamp (2009) found that perceptions of leadership trustworthiness were affected by culture, high self-disclosure and intensive use of communication media. Hämäläinen, Oksanen and Hakkinen (2008) carried out a qualitative analysis of the functions of utterances between game players in a virtual 3D online serious game while they worked together in a team to solve problems about work safety in construction work. This paper was interesting in showing how structured support can be used in games to prompt players about what to do next at different phases in the game. It also demonstrated the use of games in an activity which would not have been possible in a traditional classroom setting.

5.6.2.6. Affective and motivational outcomes. 18 higher quality papers addressed affective and motivational outcomes, with 14 of these focussing on entertainment games and 4 on games for learning. There were two good RCTs which investigated subjective experiences of players playing games. Jennett et al. (2008) provided a detailed analysis of the nature of immersion in entertainment games. They developed and tested a subjective questionnaire measure of immersion based on cognitive involvement, emotional involvement, real world dissociation, challenge and control as well as objective measures based on real world dissociation and eye movements. These measures distinguished immersive and non-immersive games. Russell and Newton (2008) compared positive and negative affect while exercising on a bike, using a game plus bike and game alone conditions. They found that introducing a game element into an exercise bike did not improve players' mood over and above the beneficial impact of the exercise bike alone. Weibel, Wissmath, Habegger, Steiner, and Groner (2008) also examined the nature of subjective experiences in playing games, investigating the links between flow, presence and enjoyment for players playing the online game Neverwinter Nights. They found that flow mediated the link between presence and enjoyment. A difficulty in using RCTs in this area is that entertainment games frequently offer new leisure experiences for which there is no obvious non-game-based control.

Several surveys examined players' reasons for playing entertainment games (Chou & Tsai, 2007; Connolly, Boyle, & Hainey, 2007; Karakus, Inal, & Cagiltay, 2008). A variety of reasons was found with pleasure/fun and challenge coming out as key reasons. Using the Uses and Gratifications framework, Lucas and Sherry (2004) identified six main reasons why people play computer games: competition, challenge, social interaction, diversion, fantasy and arousal. Lucas and Sherry also found that males gave higher ratings to all reasons for playing games than females. Using the Technology Acceptance Model, Hsu and Lu (2004) found that social norms (i. e. players' perceptions of other people's views of the technology), critical mass (the number of people using the technology) and flow were good predictors of attitudes to and use of online entertainment games.

With respect to motivational aspects of games in learning, Fu, Su, & Yu (2009) found that, with the addition of a learning subscale, Sweetser and Wyeth's gameflow model applied well to evaluating motivational features of educational games. Wijers et al. (2008) found that students found a game motivating for learning maths, but surprisingly Huizenga, Admiraal, Akkerman & Dam (2008) found that students did not find a mobile game motivating for learning history.

5.6.2.7. Physiological outcomes. Papers on physiological outcomes examined the physiological correlates of emotions felt while playing entertainment games. Six higher quality papers were identified and the effects that were examined were varied and included electroencephalographic (EEG) oscillatory responses evoked by violent events in the game (Salminen & Ravaja, 2008), facial EMG activity in response to violent game events (Ravaja, Turpeinen, Saari, Puttonen & Keltikangas-Jarvinen, 2008) and changes in skin conductance (Ivory & Kalyanaraman, 2007). van Reekum, Johnstone, Banse, Etter, Wehrle & Scherer (2004) assessed players' cardiac activity, skin conductance, skin temperature and muscle activity as well as emotion self-report in responses to emotional events while playing games. The RCT by Baldaro et al. (2004) compared the short-term effects of playing violent or non-violent computer games. They found increases in systolic blood pressure during the game and increases in state anxiety at the end of the game only for those who played violent games.

5.6.3. Intended and unintended outcomes

While the majority of papers (76) reported outcomes which were intentionally designed into the game, a sizeable proportion of papers (48) reported unintended outcomes of playing games and 5 papers reported both intended and unintended outcomes. Clearly with games for learning and serious games, outcomes are usually intended since the explicit aim of the game is to teach the player. With entertainment games, more outcomes were classified as unintended than intended. The capacity of MMOGs to support scientific reasoning skills (Steinkuehler & Duncan, 2008) is an example of an entertainment game having a beneficial but unintended outcome.

5.6.4. General and specific effects

Overall many more papers looked at the effects of specific games (87) than the effects of playing games generally (42). Papers looking at effects of playing specific games included both learning games and entertainment games, while papers on the effects of games generally tended to look at entertainment games.

6. Discussion

It seems that, despite the overwhelming publicity given to the negative impact of games, like most technologies before them, computer games can have both positive and negative impacts. The current review focused on positive impacts of playing games, looking at how entertainment games, games for learning and serious games can engage players and support learning and skill acquisition.

The large number of papers (7392) identified using our search terms confirmed that there has been a surge of interest in digital entertainment games, games for learning and serious games. The vast majority of these papers speculated about the potential of games in learning, described how a game was designed or discussed theoretical issues underlying the design of games but since they did not include empirical evidence concerning positive impacts and outcomes of games with respect to learning and engagement they were excluded from our review. Also excluded were papers which could not be coded in terms of our variables. Our inclusion criteria identified 129 papers providing empirical evidence concerning impacts and outcomes of playing computer games, suggesting that concerns about the lack of empirical evidence in this area are starting to be addressed. 70 of these papers provided higher quality evidence, although few differences were found between the higher quality papers and all the papers.

Papers selected for this review were very diverse in terms of the aims of the research, the underlying theoretical frameworks and methodologies used, reflecting the interdisciplinarity of the area, the varied backgrounds of the researchers and their wide ranging interests in digital games. The multi-component analysis developed in the current study, looking at the main purpose of the game, game genre, subject discipline and learning and behavioural outcomes, has helped to provide a framework for organizing and understanding games and their outcomes which allows comparisons between the different variables.

Empirical evidence was identified concerning all the learning and behavioural outcomes including knowledge acquisition, perceptual and cognitive, behavioural, affective, motivational, physiological and social outcomes, but with the exception of soft skills. The most frequently occurring outcomes were knowledge acquisition/content understanding, which were typically examined in games for learning and affective and motivational outcomes which were typically examined in entertainment games. This reflects the parallel interests in the engaging features of games as an entertainment medium but increasingly also their use for learning. While motivational features in GBL were studied, these were typically of secondary interest to the primary focus on performance. Relatively few papers in the review were classified as serious games. All of these had educational intent and could have been categorized as games for learning. These games were varied with respect to content area and included games about health, business and social issues.

The results show that studies of games for learning and serious games tended to use quasi-experimental designs with surveys less common, while studies of entertainment games used quasi-experiments and surveys. RCTs and qualitative designs were relatively uncommon. While studies using quasi-experimental designs and surveys have added to our understanding of the outcomes and impacts of playing games, RCTs clearly provide more rigorous evidence about the impacts of games and a recommendation of this review would be that more RCTs should be carried out. Given the problems in identifying a suitable control condition in looking at affective and motivational outcomes, the relative dearth of RCTs was not surprising, but Jennett et al's (2008) detailed study of immersion in games stood out in this respect.

Given the negative publicity frequently attached to digital entertainment games, it was possibly surprising that more papers were identified that looked at positive outcomes of entertainment games than games for learning. Several papers on entertainment games used surveys to identify the varied features which contribute to engagement in games. Given the experiential nature of motives and emotions, it was surprising that there were no qualitative studies of these outcomes, although our coding of design focused on the main aim of the study and may have underestimated the use of qualitative approaches. A recommendation of this review would be to extend the methods used to study affective and motivational outcomes of playing entertainment games beyond the survey to adopt more rigorous experimental approaches and also to carry out more qualitative studies of affective and motivational outcomes.

Studies of entertainment games also provided further evidence that playing entertainment games informally leads to improvements in attentional and visual perceptual skills (Green & Bavelier, 2006). Given how difficult it can be to design a game to improve learning intentionally, it is somewhat surprising that games which were not explicitly designed to support the acquisition of these skills do exactly that. The visual perceptual skills that playing these games supports are generic or transversal competences which underpin success in Science, Technology, Engineering and Mathematics (STEM) subjects. Since boys are the most frequent players of these entertainment games, there has been concern that playing computer games may provide boys with enduring advantages in these disciplines compared to girls (Terlecki & Newcombe, 2005).

Consistent with Kirriemuir and McFarlane (2004), few examples of entertainment games being explicitly used in the classroom were found, mainly due to difficulties in matching the affordances of entertainment games to specific curricular outcomes. An exception was Miller and Hegelheimer (2006) who found that the SIMS game could be usefully adapted for language learning, although the design of this study could be criticized for using very small numbers.

The study confirmed that a games-based approach to learning is being used across many different curricular areas, most notably in health, business and social issues. Players seem to like the game-based approach to learning and find it motivating and enjoyable, although it would be useful to examine the motivational features of GBL and serious games in more detail. Evidence that games leads to more effective learning was not strong. Only 3 higher quality RCTs were found looking at knowledge acquisition. Cameron and Dwyer (2005), Davidovitch et al. (2008) and Orvis et al. (2008) and Yaman et al. (2008) addressed different features relating to how games are integrated into the

learning experience (feedback, strategies for varying difficulty level and availability of support for memory) and showed that this is key to the success of the games-based approach.

Despite the optimism that games might be especially useful in promoting higher order thinking and soft and social skills (Dondlinger, 2007), the few papers which provided high quality evidence to support these claims presented qualitative rather than quantitative analysis (Mayer et al, 2004; Steinkuehler & Duncan, 2008). While it is not always clear what a suitable control comparison would be, there is clearly scope for more well-designed quantitative studies of games in developing higher order thinking skills and soft skills. The lack of papers coded as serious games and the observation that most could have been categorized as games for learning suggests that there is still confusion concerning the characterization of a serious game.

In the current review papers looking at entertainment games reported a variety of genre. However with GBL and serious games, simulations were by far the most frequently occurring genre, possibly because their use in education is already established. Puzzles were also used in GBL, again because their educational relevance is clear. It may be that the relative lack of other genre in GBL is because educators are unclear about how to utilize the distinctive features of these genre in teaching. If a wider variety of game genre is to be used in learning, better guidance needs to be provided about how the affordances of different kinds of games can support learning in different ways, in terms of detailed accounts of the tasks and activities offered in different kinds of games. O'Brien (2011) provides an analysis of games that might be useful in this respect. He distinguishes game genre in terms of linear, competitive, strategic and role-playing games where the different categories specify increasingly sophisticated actions required in the games. This classification might be more useful for classifying games for learning than the traditional classification of genre, although for our purposes it would have to be modified to include simulations.

While the current study has extended our understanding of the categorisation of learning and behavioural outcomes and impacts, it also highlighted some problems. The categorising and naming of skills and learning outcomes in a useful way presents a tricky problem that has been well recognised by those who have tried to identify distinct employability skills, learning skills and core skills (QAA, 2006). It is important to ask whether our classification was the most useful way of characterising the different outcomes. Our categorization was inclusive in that all reported outcomes could be allocated to one of our categories. However there was some ambiguity about which category an outcome should be coded under. For example knowledge acquisition outcomes and perceptual and cognitive outcomes tend to overlap and how they were viewed depends upon whether they were being considered from the perspective of educational theory or cognitive theory. Knowledge acquisition outcomes are grounded in models of learning, while perceptual and cognitive outcomes are rooted in cognitive theories which tend to offer more detailed explanations of underlying skills. A related difficulty concerns the granularity of analysis, i. e. the categorisation of skills at appropriate levels of generality/specificity. For example, arguably our behaviour change category could include all other outcomes. At the other end of the scale, "tracking mulitiple objects simultaneously" (Green & Bavelier, 2006) is a very specific perceptual skill.

It may be useful to refine our working classification of outcomes and propose a higher level classification distinguishing (a) knowledge acquisition (b) skill acquisition (c) affective, motivational and physiological outcomes and (d) behaviour change outcomes, where these categories could be further split into sub-categories as required. For example skills could be further decomposed into perceptual and cognitive skills, motor skills and soft/social skills, and each of these categories could be further decomposed where relevant. Any definitive classification of outcomes would have to be fairly flexible and to some extent would depend on what the game is being used for and who is using it. Generally teachers would be more interested in how games support learning outcomes at a more general level, while researchers and game designers would require a finer grained analysis.

6.1. Limitations

The current review has a number of limitations. As with all reviews it was limited by the search terms used, the journals included and the time period of papers published. However the papers discussed in this literature review provide a snapshot of empirical research on outcomes and impacts of digital games which is representative of the state of the art at the time. The review excluded speculative and theoretical papers because it was important to ground our understanding of outcomes and impacts of playing games in research evidence rather than speculation. While many aspects of engagement and learning discussed here are also relevant to children, there may be other outcomes which are important for children. In the current study we coded each study with respect to one main outcome or impact, although we did discuss other impacts where they were relevant.

6.2. Conclusion

The most notable point about the current review was the diversity of research on positive impacts and outcomes associated with playing digital games. The multi-component analysis of games proposed in the current study has helped to provide a framework for organizing these diverse outcomes and impacts of games, but has also highlighted the persistent difficulties associated with classifying learning outcomes. While empirical evidence concerning the effectiveness of games-based learning was found in the current review, there is a need for more RCTs to provide more rigorous evidence of their effectiveness. More qualitative studies would also help to extend our understanding of the nature of engagement in games. To encourage the use of games in learning beyond simulations and puzzles, it is essential to develop a better understanding of the tasks, activities, skills and operations that different kinds of game can offer and examine how these might match desired learning outcomes. As with other educational interventions, it will also be important to consider the detail of how games are integrated into the student's learning experience.

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Appendix A. Affective and motivational outcomes.

Author(s)	Aims/Objectives of study	Methods	Results and conclusions
Lucas and Sherry (2004)	To examine gender differences in uses and gratifications of video games and video game use (amount of time spent playing games)	544/593 participants; mean age = 19.71 years; age range = 18 to 24. 57.5% young women ($n = 313$) and 42.5% young men ($n = 231$); participants completed a uses and gratifications instrument looking at game preferences, number of hours played per week and uses & gratifications of video games (23 item scale)	Females played for fewer hours per week (4.25) than males (11); males rated all six reasons for playing games (competition, challenge, social interaction, diversion, fantasy & arousal) as more important than females. Challenge was rated top by both males & females; need for arousal & excitement in top 3 most important reasons for playing games for both males & females. Males rated social interaction as second most important of six reasons for playing games; females rated it least important. Female players preferred traditional games to physical enactment & imagination games while males rated physical enactment and imagination games higher than traditional games.
Kim and Ross (2006)	To develop and validate an instrument for measuring motives for playing sports video games (svgs) developed using the uses and gratifications perspectives.	**Focus group:** 36 participants; **exploratory factor analysis:** 207 undergraduates: 167 males and 40 females; validation study: 214 respondents, age range = 18–30; 68.7% male; 69.2% single; **confirmatory factor analysis:** 214 participants; 68.7% male.	**Focus group** identified principal reasons for playing svgs and generated 32 items for questionnaire; **exploratory factor analysis** revealed a seven factor, 20-item solution (entertainment, identification with sport, knowledge application, fantasy, competition, social interaction and diversion); **confirmatory factor analysis** indicated that the seven factor model provided a good fit to the data (GFI = .90) with reliabilities over. 7 for all seven factors; seven factors are sufficiently distinct from each other.
Fu et al. (2009)	To develop and validate eGameFlow – a scale to measure learners' enjoyment of e-learning games with four different games for learning	Pre-test validation of instrument: 52 valid samples from 85 students. Main study: 166 valid samples from 502 students (65% female). The eGameflow scale for evaluating enjoyment of games for learning was developed using item analysis and factor analysis. Four games were used to collect data on player experience.	Following tests for reliability and validity, 42 of the 57 items were retained across the eight factors and validity and reliability were acceptable. Correlation between overall score and enjoyment was .52 suggesting that the measure is an effective tool for evaluating players' level of enjoyment of games.
Riegelsberger, Counts, Farnham, and Philips (2006)	To identify how matching player characteristics for one-off gaming encounters in an online game (Mechassault) could be improved with a view to reducing the occurrence of perceived 'bad' behaviour.	6 Mechassault players helped identify implicit player attributes; 267 participants, 96% male, 4% female rated 50 user profiles with respect to how much they would like to play with them and also described which information they used when picking up game partners.	Preference profiles worked out for each participant and cluster analysis of these profiles established 3 main player types: socially-oriented players (46.4%), skill-oriented players (44.2%) and extreme players who prefer aggressive partners (9.4%). These player types differed on explicit and implicit attributes of players. Players with different player types also differ in self described profile attributes. Results suggest that matchmaking is a more promising way to reduce 'bad' behaviour in one-off gaming encounters than imposing uniform standards.
Connolly et al. (2007)	To examine motivations for playing computer games, amount of time spent playing etc. as well as acceptability of games in Higher Education.	551 respondents (328 female and 220 male) to online survey of game playing habits, motives for playing computer games, kinds of games played & perceptions of acceptability of games in Higher Education.	Males played for more than twice as long as females and nearly four times more males than females played for more than 5–10 h per week. Men were significantly more likely than women to take part in online gaming. Pleasure, relaxation, leisure and challenge were top rated reasons for playing games. Males played shooting, strategy & role-playing games most frequently; females played strategy, role-playing & adventure games most frequently. Computer games are seen as an acceptable form of supplementary learning in Higher Education.
Chou and Tsai (2007)	To explore gender differences in adolescents who play computer games.	1150 questionnaires distributed in 30 classes in 15, randomly selected high schools in 4 geographic areas in Taiwan; 1000 valid samples; 535 played computer games; mean age = 16.88; 372 males and 163 females.	Males spend more time playing games than females, they enjoyed playing games significantly more and they consistently gave higher ratings to positive motives for playing than females did, but they also gave higher ratings to negative impacts of games on studies and relationships with parents and teachers. Entertainment, seeking information, filling time and use of games as a social device were the four most important predictors of enjoyment of games for both males and females.
Wan and Chiou (2007)	To examine the motivations of Taiwanese adolescents who are addicted to online games with those who are not addicted.	**Study 1:** 416 adolescents (age = 17–24) participated in the survey of intrinsic and extrinsic motives for playing games. **Study 2:** 222 undergraduates who were frequent players of MMORPGs; experimental study examined 4 factors, expectancy, relevance, tangibility, and contingency.	**Study 1:** addicts' intrinsic motivation was significantly higher than their extrinsic motivation; non-addicts showed opposite effect. Further, addicts' intrinsic motivation was significantly higher than the non-addicts. **Study 2:** expectancy, relevance, tangibility, and contingency moderated extrinsic motivators (such as reward) to undermine intrinsic motivation and function as predicted from the cognitive perspective of human motivation.
Karakus et al. (2008)	To explore the preferences, playing habits, expectations, and thoughts concerning computer games of Turkish high school students.	1224 vocational high school students, studying at 8 different schools in 6 cities within 4 different regions in Turkey completed a questionnaire about game playing habits and preferences and use of games in education.	Half of students (with no gender differences) agreed that games could be used in education, especially in Mathematics or History courses and to improve mental skills. Female students expect games to have instructive elements, while males want games to be entertaining, competitive, and multi-player. Females complained about negative aspects of computer games, such as causing laziness and leading to aggressive behavior, more than males.

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Author(s)	Aims/Objectives of study	Methods	Results and conclusions
Huizenga et al. (2008)	To compare knowledge acquisition and affective effects of Frequency 1550, a mobile city game about medieval city of Amsterdam, with regular History classes.	458 pupils from 20 classes across 5 schools. Age range = 12–16; mean age = 13. Quasi-experimental design with pupils from 10 classes playing the mobile history game and pupils in the control condition followed regular project-based lessons.	Pupils playing the game gained higher scores on the knowledge tests about medieval Amsterdam than control group. However, there was no effect on narrative knowledge of medieval Amsterdam nor significant affective effects of playing the game. It might be that playing this game for only one day is not enough to have motivational effects.
Wijers et al. (2008)	To test usability of MobileMath, a collaborative mobile game to support students' engagement in learning mathematics	Pilot with 5 teachers. 60 students, 54 completed questionnaire on usability of game; age range = 13–14; 32 males and 24 females.	Pilot with teachers found that game play was engaging, technology worked and rules and goals were clear. Pupil questionnaire found that Mobile Maths games can motivate, engage and be fun at this level. Collaboration in the teams was good and students could easily understand the goal of the game.
Nelson, Yaros, and Keum (2006)	To examine the effects of playing versus watching a game, real or fictitious brands and telepresence on recall, game liking and perceived brand attitudes.	62 participants; 45 men, 14 women, 4 no gender identified (age range = 18–30+). Compared players and watchers of games, real and fictitious brands and telepresence. Telepresence was measured according to a published 8-item telepresence scale	Game players recalled significantly fewer brands than did watchers, whether these were real and fictitious. Both players and watchers recalled more real than fictitious brands. Game play had no direct effect on game liking or perceived brand attitudes. No direct effects of telepresence on recall were found beyond the play versus watch condition. However telepresence did positively influence perceived persuasion. The arrival factor of telepresence was positively related to perceived persuasion effects for embedded real and fictitious brands.
Russell and Newton (2008)	To establish whether game plus exercise cycle leads to enhanced affective benefits (more positive mood, less negative mood) compared with cycle only and game only conditions.	168 college students: 78 males and 90 females; mean age = 21.51. Participants were randomly assigned to (a) exercise control condition, (b) interactive video game exercise condition or (c) video game control condition. Positive and negative mood (PANAS) was assessed before, immediately after and 10 min post.	Participants in video game control had higher post-activity negative affect immediately and 10-minutes post-activity than either exercise group. Also, exercise condition participants had higher positive mood at 10-minutes post-activity compared to the video game control participants. Results support immediate affective benefits of exercise compared to sedentary activity, but do not show that interactive video games technology further benefits mood over other forms of exercise.
Hsu et al. (2004)	To identify variables which impact on attitude to and intention to use online games	233 usable responses, 80% male, 20% female; participants recruited via online message boards of popular game–related websites. Field survey of online game users looked at social norms, critical mass, perceived ease of use, perceived usefulness, flow, intention to use and attitudes to games.	Structural equation modelling showed that social norms, attitudes to games and flow experience impacted directly on intention to play games, while perceived ease of use, perceived usefulness and critical mass impacted on attitudes. Flow experience was not related to intention to play games but was related to attitude to games. The model predicted 80% of the variance in intentions to play online games.
Jennett et al. (2008)	To develop a better understanding of immersion: to develop subjective (questionnaire) and objective measures of immersion and study links between these.	**Study 1:** 40 university students; mean age = 21, range = 18–36. 10 males & 30 females. Randomly assigned to immersive game (half-life) or non-immersive task; measured subjective and objective (time to re-engage in real world) immersion. **Study 2:** 41 subjects, 21 in non-immersive condition & 20 in immersive condition. 22 males and 19 females. Mean age = 25.39, range = 18–39; measured subjective and objective (eye movements) immersion. **Study 3:** 36 subjects, 19 females & 17 males. Mean age = 24.6; age range17–42; participants randomly assigned to one of four speed conditions; effects on state anxiety, positive and negative affect (measured by PANAS) and subjective ratings of immersion.	**Study 1:** subjective immersion scores higher for immersive game than non-immersive task; significant positive correlation between subjective measures of immersion and the difference in time to complete the real world (Tangram) task before and after immersive task. Suggests good objective measure of immersion. **Study 2:** subjective immersion scores higher for immersive game than non-immersive task; significant increase in eye movements over time in non-immersive group, but significant decrease in immersive group; positive correlations between subjective and objective measures of immersion. Suggests good objective measure of immersion. **Study 3:** Non parametric comparisons found increasing state anxiety and negative affect from slow to self paced to increasing to fast pace conditions; effects not significant for immersion or positive affect; only positive affect correlated with overall immersion.
Weibel et al. (2008)	To examine links between presence, flow and enjoyment in an online game; to examine whether playing online games against other users leads to more flow, presence and enjoyment than playing against computer-controlled opponents.	70 university students; 37 females; 33 males; mean age = 23.9). Random assignation to type of opponent (computer versus human opponent) and dependent variables were participants' feelings of presence, flow and enjoyment.	Participants who played against a human-controlled opponent reported stronger experiences of presence (strongest effect), flow, and enjoyment. Positive correlation found between presence, flow and enjoyment and in a regression analysis, flow mediated the relationship between presence and enjoyment. Participants playing against a human-controlled opponent reported stronger experiences of presence, flow, and enjoyment.
Schwabe, Goth and Frohberg (2005)	To establish whether team size has an impact on fun, immersion, activity, team building and learning in a mobile game used for student induction.	149 university students on an introductory computer science course: 58% were computer science students, 42% were science students; mean age = 23 years. Students take part in the "orientation rally" play individually or in small teams (1–4 persons) against each other or against other teams. Measures of fun, immersion, activity, team building and learning are collected.	Teams of two (i.e. dyads) had more fun, were more immersed, more active and had better team building than students working alone or working in larger teams. Team sizes of 4 had significantly reduced fun and immersion. Results on learning were more mixed.

Chiang, Cheng and Lin (2008)	To investigate and compare the effects of violent and non-violent digital entertainment games on undergraduate players' flow experiences and affect.	30 undergraduates (11 male; 19 female). Two groups; one played violent and non-violent games and the other group played non-violent and then violent games. Measures of emotion taken before and flow, playfulness of game, positive affect and aggression after playing the games	Both violent and non-violent digital games evoke undergraduate players' flow experiences and positive affect but participants reported higher scores in flow experiences and positive affect after playing the target non-violent game than after playing the target violent game.
Houtkamp, Schuurink and Toet (2008)	To examine the effects of adding dynamic visual elements and sounds to a levee patroller training game on the appraisal of the environment and weather conditions and the engagement and performance of users.	55 Dutch residents, 27 males, 28 females. Mean age = 44.7 years, sd = 18.5.	The addition of visual dynamics and sounds together increased the perceived fidelity, validity and convincingness of the virtual environment showing that sounds and visual dynamic features can enhance the validity of 3D-models. The effects of the visual dynamics and sounds on the appreciation of the game and engagement of the participants were less clear cut. Arousal decreased over the duration of the experiment but was not influenced consistently by the addition of sound and light, although the dynamic version had higher levels of involvement than the static version of the game.

Appendix B. Behavioural change outcomes.

Author(s)	Aims/Objectives of study	Methods	Conclusions
Mayer et al. (2004)	To explore the future of development planning on the level of an urban network by combining gaming and scenario techniques.	Around 50 representatives of all relevant administrative, private and social parties participated in each session and played similar to their positions in real life in teams of 2–4. Game was played twice in two full-day sessions within two different long-term scenarios.	The gaming-scenario approach was an effective method that generated new and critical insights on future of development planning and urban networks. The future scenarios proved very effective as contexts for the game and gave the game a long-term future orientation and enhanced creativity.
Schneider and Cornwell (2005)	To test the effects of advertising in games.	46 male participants self-selected through advertisements at a university. Participants completed a questionnaire about gaming habits and experience, before playing 5 laps of *Rallisport Challenge* and completing a post-test questionnaire testing recall and recognition of brands in the game and flow experienced while playing the game.	Prominent placements in in game advertising were found to have higher recall and recognition than subtle placements. Qualitative analysis showed that banner characteristics, direct interaction and brand familiarity impacted on recall. Flow level had no effect on recall or recognition. Contrary to predictions, novices experienced more flow than experts.
Kiili, Ketamo, and Lainema (2007)	To develop a framework to enhance reflection in problem-based gaming.	**Study 1:** 92 students played a business simulation. 12 volunteers were interviewed after game. **Study 2:** 24 pre-school pupils; 15 boys and 9 girls from 3 kindergartens; 6 years old. Played a teaching game. Participants were interviewed during and after game. **Study 3:** 58 elementary school pupils; 30 boys and 28 girls; age range = 11–15. Participants were interviewed during and after game.	**Study 1:** Several triggers of reflection were found: conflicts, competition, visualisation of performance, communication with other players and challenging comments of game characters. **Study 2:** 14 gained knowledge; 10 had little gain. **Study 3:** Both computer-generated and teacher-generated messages stimulated players to think about relevant things during gaming. Results indicated that reflection is a vital process in learning.
Jouriles et al. (2008)	To evaluate whether virtual reality (VR) enhances presence in role plays (RP) designed to help college women develop behavioural strategies for resisting untoward sexual advances.	Participants were 62 female undergraduate psychology college students (aged 18–30 years) randomly assigned to RP group ($N = 31$) or virtual RP group ($N = 31$) conditions. There were no differences across the two groups on any of the measured demographic variables or prior experiences of sexual coercion or assault.	VR can enhance presence in role plays designed to help college women resist sexual attacks. In role plays in which a male actor made verbal threats and sexual advances, women in the virtual RP condition perceived the role plays to be more realistic than did women in the RP condition. They reported more negative affect after the role plays and expressed more verbal negative affect during the role plays than women in the RP condition. VR appears to be a promising tool in this area.
Lavender (2008)	To evaluate the persuasive video game "Homeless: It's No Game" to see whether a game-based approach could persuade players to become more sympathetic to the plight of the homeless.	82 participants; 52% under 40; 48% over 40. Group 1 played Homeless: It's No Game, Group 2 read a short story based on the homeless character in the game and Group 3 acted as a control. Of the 120 initial volunteers, 82 completed the experiment. pre-test/post-test.	No significant changes were noted in knowledge of homelessness or interest in homelessness. A significant increase in sympathy for homeless people was found for the game playing group but a decrease for the narrative group. A significant increase was found in acceptance of games for learning for game playing group.
Davidovitch et al. (2008)	To evaluate the effectiveness and efficiency of the learning–forgetting–relearning process in a dynamic project management simulation environment.	66 graduate engineering students; age range = 25–50. Students used a project management trainer that simulates a generic dynamic, stochastic project management environment. Students were assigned to manual or automatic history recording mechanisms or a control group which did not use any history recording mechanism.	Students using both history recording mechanisms performed better (showed significantly higher profit and better learning processes) than the control group. Students using the manual history recording mechanism performed better than the automatic recording group after a two week break but not after a four week break.
Gentile and Gentile (2008)	To examine whether students who play multiple violent video games are more likely to learn aggressive cognitions and behaviours and whether students who play violent video games more frequently are more likely to learn aggressive cognitions and behaviours.	430 elementary students: 51% male, age range = 7 to 11. 607 young adolescents: 52% male, mean age = 14; years, with 52% males. Late adolescent college sample: 1441 older adolescents, 45% male, mean age = 19.4 years. Participants completed three confidential surveys on game playing habits and aggressive attitudes and behaviours.	Playing multiple violent games, even after controlling for total amount of time playing all games, leads to better transfer of aggressive cognitions and behaviours; controlling for amount of violence in video games, playing more frequently during a given week over multiple years was correlated with greater hostile attribution bias and arguments with teachers.
Eastin (2006)	To examine how gender representation of self and opponent in a first-person perspective game influences presence and aggressive thoughts.	**Study 1:** 76 female university students. Examined relations of players' gender and same gender or different gender avatar to presence and aggressive thoughts. **Study 2:** 75 female university students. Examined relations of players' gender playing against a human or a computer that is controlling the opponent on presence and aggressive thoughts. **Study 3:** 81 female university students. Focus on opponent gender effects on presence and aggressive thoughts.	**Studies 1 and 2** suggest that females experience greater presence and more aggressive thoughts from game play when a gender match between self and game character exists. **Studies 2 and 3** indicate that playing against a human rather than a computer opponent increases aggressive thoughts. Finally, although all studies indicate that playing as a female against a male opponent increases aggressive thoughts, **Studies 1 and 2** suggest playing as a male against a female opponent consistently and significantly decreases aggressive thoughts.

Appendix C. Knowledge acquisition/Content understanding outcomes.

Author(s)	Aims/Objectives of Study	Methods	Conclusions
Cameron and Dwyer (2005)	To explore whether: (1) presenting material in a game format helps students to learn; (2) different instructional effects (embedded questions and feedback) help to make games more effective; (3) students with different learning styles (field dependent and field independent) learn differently.	422 college students; separated into field dependent and field independent learners using the Group Embedded Figures Test; students were randomly assigned to 4 instructional treatments (1: no game; 2: game; 3: game + response feedback; 4: game + elaborative feedback). 4 criterion tests measuring different educational objectives administered 2 weeks after instructional intervention.	There was no difference in performance between the game and no game condition, showing that introducing the instructional games was not sufficient to improve retention. Response feedback significantly improved performance on composite and terminology measures; elaborative feedback improved performance on all four measures: drawing, identification, terminology and comprehension. Without sustained elaborative feedback games are not an effective strategy for facilitating increased student achievement. Significant effects of cognitive style were found on all measures.
Yip and Kwan (2006)	To examine the usefulness of online games in vocabulary learning for undergraduate students.	100 freshmen engineering students. Experimental group learnt vocabulary from 2 carefully selected websites with games, while the control group learnt the same vocabulary through traditional activity-based lessons. Pre-test and post-tests were conducted in the first and ninth weeks.	Groups did not differ in performance on pre-test but game group performed significantly better following intervention than control group. Respondents generally held positive views about the games: over 70% found the games enjoyable; 75% found level of difficulty was just right; the majority found the instructions and game rules easy to follow and more than 70% regarded the games as effective in helping their vocabulary building. Drill and skill type online games have the potential to support vocabulary acquisition.
Miller and Hegelheimer (2006)	To determine whether the popular authentic simulation, the SIMs, can be adapted to enhance vocabulary learning through supporting materials.	18 intermediate adult ESL learners at a major U.S. research university. Pre-test/post-test with 3 experimental conditions: (a) participants received mandatory supplemental vocabulary and grammar activities (b) voluntary access to supplemental materials (c) no supplemental materials. Tested on overall linguistic gain; quizzes on vocabulary and grammar and questionnaires about the supplemental materials and the simulation in general	Students in group a outperformed the students in group b and group c on the total daily quiz scores, but there was no significant difference between groups b and c. Similar results were found for the vocabulary component of the quiz. 94% found vocabulary helpful, 82% for grammar and 88% for culture.
De Lucia, Francese, Passero, and Tortora (2009)	To evaluate a virtual environment in Second Life with regard to: presence, communication, awareness and social awareness, perceived socialability, virtual environment, productivity and general satisfaction.	26 students attending a computing course participated voluntarily. Student impressions were collected via using a questionnaire assessing presence, communication, awareness and social awareness, perceived sociability and views of the virtual enviroment.	Virtual environment successfully supports synchronous communication and social interaction. Tutors observed that students were highly motivated and most students' comments were enthusiastic. Many students also expressed high interest in using the environment to meet colleagues.
Felicia and Pitt (2007)	To examine whether learning outcomes of educational games could be improved if content was tailored to suit players' personalities and learning styles.	80 secondary school pupils from 1st and 2nd grade (aged 13–14). **Experiment 1:** participants selected for high levels of neurotocism. Control group: no time displayed; experimental group: time displayed. **Experiment 2:** participants selected for high levels of competitiveness; control group: no ranking displayed; experimental group: ranking displayed. Performance and time to solve measured.	**Experiment 1:** Contrary to predictions, displaying time in an educational game for pupils with high levels of neuroticism increased their proficiency in solving equations and decreased time to solve. **Experiment 2:** Displaying ranking in the game for subjects with high levels of competitiveness decreased time to solve but did not increase their proficiency in solving equations. Study showed importance of user-centred design for educational games.
Beale et al. (2007)	To investigate whether a video game, Re-Mission, can actively involve young people with cancer in their own treatment and increase self-care and illness knowledge	Multi-site, randomised, controlled study with 375 adolescent and young adult cancer patients (age range = 13–29). 179 participants received a regular commercial game (control) and 196 participants received both the regular game plus Re-Mission to play at home on a PC for an hour each week for 3 months. A test on cancer-related knowledge was given prior to game play (baseline) and again after 1 and 3 months. At 3 months the Re-Mission group also rated the acceptability and credibility of Re-Mission.	Knowledge test scores for both control and experimental groups improved significantly over the follow-up periods, but the scores of the experimental Re-Mission group improved significantly more. But the magnitude of knowledge gains following intervention is not associated either with recorded hours of Re- Mission play, or with the number of unique missions completed. The effect of Re-Mission play on cancer knowledge was not linked to players' expectations about the game. Video games can be an effective vehicle for health education in adolescents and young adults with chronic illnesses.
Huizenga, Admiraal, Akkerman, and ten Dam (2007)	To investigate the usability of Frequency 1550, a mobile city game to acquire historical knowledge of medieval city of Amsterdam.	Participants were 470 13–15 year old students in three secondary schools in Amsterdam. 10 classes in experimental condition played play Frequency 1550 and 10 classes in control condition received two regular lessons on medieval history of Amsterdam	The preliminary results showed that pupils were very enthusiastic about the game. Game group showed significant increase in motivation for history and control showed decrease in motivation. No significant increase in attitude towards collaboration in both conditions. Students enjoyed the game and said they learned a lot, but some pupils had difficulties differentiating between the fictional story elements and the real source material.

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Author(s)	Aims/Objectives of Study	Methods	Conclusions
Schrader and McCreery (2007)	To examine players' experiences in playing an MMOG; to examine age and expertise differences in these experiences.	1817 males, 309 females and 14 participants who did not report gender. Age range = 18–25. A 20-item, Likert-type instrument to measure aspects of players' gaming experiences was developed and tested.	Factor analysis of the questionnaire revealed five stable factors (1) Game Knowledge and Performance, (2) Technology Competence, (3) Collaboration, (4) Non-guild Collaboration, and (5) Status. Younger participants rated their level of expertise in online games as significantly higher than older adults did. Gaming expertise significantly impacted on all factors.
Halpern and Wai (2007)	**Study 1:** to compare Scrabble playing habits in experts and novices. **Study 2:** to identify the cognitive benefits of playing Scrabble by comparing competitive Scrabble players and high achieving college students who do not play Scrabble. **Study 3:** to investigate whether experts and novices differ in memory for scrabble boards manipulated in predetermined ways.	**Study 1:** 114 people in the competitive Scrabble group, 66% men (mean age = 41.89). Comparison group had 147 students, 55% men (mean age = 19.48). **Study 2:** 26 competitive scrabble players recruited (mean age = 49). **Study 3:** 48 in the competitive group (mean age = 44.25) and 48 in comparison group (range: 18–23).	**Study 1:** 113/114 Scrabble players but only 8/147 novices studied words from official list; only 7/104 experts claim to always learn word meanings. **Study 2:** Competitive players had significantly higher scores than novices on extended range vocabulary, shape memory and paper folding reaction time, but not on lexical decision, lexical decision reaction time, mental rotation or paper folding. **Study 3:** Scrabble players were much better than novices at recalling a real board (with no errors), a board with spelling errors, a spatially disconnected board and an extra blank letter tile board. Overall expert Scrabble players show superior performance on verbal and visuospatial tasks that reflect abilities implicated in competitive play.
Rossiou and Papadakis (2008)	To evaluate effectiveness of an online multi-player game to teach recursive algorithms.	16 students participated in tutor telemeetings and played the game; 10 students played the game but did not participate in tutoring; 16 students neither participated in the tutoring nor played the game.	Participants playing the recursive algorithm game performed better in final exam and on recursion problems than those who participated in tutoring but not game and both groups performed better than the control group who did not receive the game.
Lindh Hrastinski, Bruhn, and Mozgira (2008)	To explore the benefits, drawbacks and factors critical to the success of business simulation games for students and teachers.	13 teachers had used business simulation games, but only 6 teachers from 5 different universities were interviewed. A student questionnaire was sent to the 390 students with 67 students who had played the simulation game (PharmaSim), responded.	Students views were mixed: 88.1% of students did not perceive the simulation game to give a good representation of reality, 50% thought the simulation game was well suited to the course, 42% of the students agreed that the simulation game improved the course, 78% thought that it was not an important part of the course, 65.7% agreed that simulation games are an innovative approach to studying, 71.6% agreed that the game was somewhat exciting, 73.1% did not agree with simulation games being more effective than lectures and seminars.
Harr, Buch, and Hanghøj (2008)	To evaluate the game Global Conflicts: Palastine and examine the discrepancy between educational goals and educational game design	8 pupils from a 9th grade class (age range = 15–16) played Global Conflicts: Palestine (GC:P). Empirical findings comprised observations and post-game interviews with the teacher and pupils.	Pupils found that quotes in the article template were mutually incoherent, did not tie together and were stripped of context. Pupils wanted to express their own opinions rather than select from preset options. It seems unlikely that it is possible to teach and learn critical thinking merely by letting pupils interact with the game environment without actively producing meaningful utterances
Yaman et al. (2008)	To find out to what extent computer simulations incorporating different kinds of instructional support (worked examples or problem tasks) had positive effects on situational subject interest. To evaluate the interactions between learners' interests and the instructional support with regard to the learning results (factual knowledge and understanding).	A random sample of pupils at 4 secondary schools in Germany: 182 pupils in grades 11–13 (52.3% female, 46.7% male; 40%: grade 11, 35% grade 12, and 25% grade 13). Age range : 15–20. Data was collected in a pre/post-test design with an intermediary, computer-based intervention (worked examples or problem tasks)	Simulations incorporating worked out examples, but not problem solving tasks, positively influenced the learner's situational subject interest in highly complex subject matters. For learners with low individual subject interest, both kinds of instructional support (worked examples and problem tasks) were conducive to fostering gains in factual knowledge. When deeper understanding is concerned, worked out examples were of particular benefit for learners with a high individual subject interest.
Vahed (2008)	To examine whether a board game can improve performance in learning about Tooth Morphology.	32 first year Dental Technology students in 2006 and 20 in 2007. All had completed a module on Tooth Morphology. Students completed a 14 question anonymous questionnaire. Performance was compared for 2005 (no game) and 2006 and 2007 (game) cohorts.	Significantly better performance was found on test scores for student cohorts who used the games than for those who did not. The game impacted positively on students' knowledge of and attitudes to tooth morphology.
Sward et al. (2008)	To assess, using a Web-based format, third year medical students' paediatric knowledge and perceptions of game playing with faculty facilitation compared with self-study computerised flash cards.	The study used a repeated-measures experimental design with random assignment to a game group or self-study group. Paediatric knowledge was tested using multiple choice exams at baseline, week 6 of the clerkship following a 4 week intervention, and 6 weeks later. Perceptions about game playing and self-study were evaluated using a questionnaire in week 6.	Game and control groups did not differ on content mastery, perceptions about content, or time involved in game playing or self-study. Perceptions about game playing versus self-study as a pedagogical method appeared to favour game playing in understanding content, perceived help with learning, and enjoyment of learning and increased willingness to continue

			participating in the intervention. Games can be an enjoyable and motivating method for learning paediatric content, enhanced by group interactions, competition, and fun.
Nte and Stephens (2008)	To develop a computer game that explains the statistical concept of normal distribution.	55 first year undergraduate psychology students. A 10 item multiple choice questionnaire was employed.	The evaluation results were positive overall: 70% of students agree that game provided a useful method of learning about statistics; 54% agreed they learned about the normal distribution; 61% agreed that they had a better understanding of producing histograms from data. The game also seemed to reduce fear of statistics.
Papastergiou (2009)	To assess the learning effectiveness and motivational appeal of a computer game for learning computer memory concepts at high school compared to a similar application lacking the gaming aspect. To investigate gender differences in the game's learning effectiveness and motivational appeal.	88 Greek high school students (46 boys and 42 girls, aged 16–17 years); randomly assigned to two groups, one used the gaming application (Group A, $n = 47$) and the other one the non-gaming one (Group B, $n = 41$). A Computer Memory Knowledge Test (CMKT) was used as the pre-test and post-test. Students were also observed during the interventions and, following the intervention, students' views on the application were elicited through a questionnaire.	The game was more effective in promoting students' knowledge of computer memory concepts and more motivating than the non-gaming approach. The learning gains that boys and girls achieved through the use of the game did not differ significantly, despite boys' greater involvement with, liking of and experience in computer gaming outside school and significantly greater initial knowledge of the subject matter. No significant gender differences in students' views on the overall appeal, quality of user interface, and educational value of the game used.

Appendix D. Motor skills outcomes.

Author(s)	Aims/Objectives of Study	Methods	Conclusions
Nomura et al. (2008)	To determine whether interviewing prior to an experiment can assist in predicting the results in laparosopic surgery simulation.	43 5th year medical students with no prior experience of laparoscopic surgery or simulation training completed a short questionnaire on factors thought to be predictive of laparoscopic skill. They were divided into 2 groups depending on their answers and perfomance measures of laparoscopic skill on simulator were compared for the two groups.	Favourableness to TV games, manual dexterity, and confidence about driving predicted laparoscopic skill. These activities require the same psychomotor, perceptual and visuospatial abilities as laparoscopic skill. Interview can be an effective measure to examine the aptitude of medical students.
Stefanidis et al. (2008)	To investigate whether novices improve their ability to develop multitasking (i.e. automaticity) with accumulating experience on a simulator for laparoscopic tasks.	Novices (12 premed students) trained for 4 months in laparoscopic suturing. At the same time, participants performed a secondary visual spatial processing task to assess their spare attentional capacity. Trainees were required to achieve expert levels in both suturing and the secondary task.	Participants demonstrated improvements in their suturing and secondary task performance compared with their baseline scores. Although novices achieved simulator proficiency after relatively short training durations, the attainment of automaticity required substantially longer training periods
Hogle et al. (2008)	To determine whether simulator (LapSim) training for novice PGY1 surgical residents had predictive validity for improvement in performance of laparoscopic cholecystectomy (LC).	21 PGY1 residents (9 female, 12 male) performed LCs in pigs after minimal training and their performance was evaluated. 10 residents trained to competency on the LapSim Basic Skills Programs and then their post training performance on LC was compared with control group.	A statistically significant improvement in depth perception, but not on the four other performance measures was found in the operative performance of the LapSim trained students compared with the control group. Fast learners were all video game players but VG players did not perform better than non-VG players. The time and effort spent training novice surgical residents on the basic LapSim training programs may not be justified.
Orvis et al. (2008)	To investigate how various strategies for modifying task difficulty in instructional videogames impact on learner performance and motivation. To examine the influence of prior video game experience on learning outcomes, as well as the role prior experience played in determining the optimal approach for adjusting task difficulty.	26 participants, mean age = 25.96, completed a 12-trial training game task under one of four task difficulty conditions (static, increasing, adaptive-low, and adaptive-high). Participants with both high and low prior video game experience were randomly assigned, counterbalancing for gender, to one of the four task difficulty conditions.	Both learner performance and motivation improved from the pre-training to final performance trial in all task difficulty conditions. A performance by experience by condition interaction showed that for experienced gamers, performance significantly improved in all conditions from the pre-training to final performance trial at a comparable rate but, for inexperienced players, performance in the increasing condition (where difficulty was increased incrementally for each level) did not increase as much as in the other three conditions. Learners with greater prior experience performed better overall compared to the inexperienced group, but the inexperienced group improved their personal performance level to a greater degree than the experienced group.

Appendix E. Perceptual and cognitive skills outcomes.

Author(s)	Aims/Objectives of study	Methods	Conclusions
Terlecki and Newcombe (2005)	To assess to what extent gender differences in computer and video game usage may mediate the gap between the sexes in spatial ability, namely mental rotation ability.	1278 undergraduates, 370 men, 908 women; age range = 17–44, on an Introductory Psychology course. Participants completed the Survey of Spatial Representation and Activities (SSRA). High and low scorers on spatial experience based on the SSRA were invited to return for testing on the Mental Rotation Test (MRT).	Spatial experience was shown to behave as a mediator of the observed gender difference in mental rotation ability, especially for women. In line with Digital Divide theories, if males continue to choose to be involved in computer experiences that foster spatial ability, and females do not, the gap in spatial performance may continue to grow.
Aylon, Glaser, Hall, Uribe, and Fried (2005)	To study the relationship between students' previously acquired skills and their performance on a sinus surgery simulator.	26 students participated based on an email invite to 540 second/third year medical students. After completing their trials on the sinus surgery simulator, students completed a 28-item questionnaire.	Students who played video games either weekly or daily had significantly better novice hazard avoidance scores, while those playing monthly had significantly poorer scores. Being right-handed also led to better hazard avoidance in novice mode. Both effects washed out at intermediate level suggesting that practice on the simulator plays a more important role in performance.
Green and Bavelier (2006)	To examine whether action video game (VG) play enhances subjects' ability in two tasks thought to indicate the number of items that can be apprehended.	**Study 1:** VG group: 13 males, mean age = 19.4; non-VG group: 13 males, mean age = 19.3; assessed on enumeration task. **Study 2:** 20 NVG players - experimental group: 5 males and 4 females, mean age = 20.4 played action game; control group: 4 males, 4 females, mean age = 19.7 played tetris. **Study 3:** VG group: 11 males; mean age = 19.1; non-VG group: 11 males, mean age = 20.3, assessed on multiple object tracking task.	**Study 1:** Enumeration accuracy is on average two more for video game players than non-video game players. **Study 2:** even 10 h game play with action video games increased accuracy breakpoint and overall accuracy compared with control game. **Study 3:** video game players could on average track two more items than non-video game players.
Anand (2007)	To analyse impact of video game play compared with other extracurricular activities.	245 college-age students from freshmen to seniors, randomly selected from 5 post-secondary institutions. Participants given questionnaire on time management as well as video game play habits. Scholastic Aptitude Test (SAT) and grade-point average (GPA) scores were used to gauge academic performance.	There was a significant negative relationship between amount of video game play and total SAT scores and between video game play and GPA. There was a significant relationship between amount of video game play and Maths SATs scores for males only. Those playing for more than 4.5 h per day were at particular risk
Lee and Faber (2007)	To explore the conditions under which product placement in an online game will get noticed and be remembered from a perspective of the limited-capacity model of attention.	155 volunteer students; 98% of respondents aged 18–25; mean age = 20; 67% females, 33% males; 2 incentives were offered: (1) extra course credit, and (2) a chance to win a gift card in a lottery. Effects of local/peripheral brand placement, expert/non-expert player and game involvement on recall of brands was examined.	The study showed low levels of brand memory with only 12% of the brand names correctly recalled. Recall of brands in focal placement was better than recall of brands in peripheral placement but this disappeared for expert players who had a high but not a low level of involvement in the games. There was no such interactive effect for inexperienced players.
Carvelho, Allison, Irving, and Herriot (2008)	To examine the use of computer games as a new delivery paradigm for vision therapy, specifically at how they can be used in the treatment of convergence insufficiency while at home.	7 subjects (age range = 11–34). A modified 3D version of the Pacman game was created and tested in a small scale clinical trial.	Objective tests found significant clinical improvements from pre-tests to post-tests across time on a range of measures of optical functioning including average and maximum convergence angles, NPC break and PFV break. Questionnaire responses indicated that all subjects found the training easy to understand and perform, highly motivating and amusing. Six of the seven subjects felt that their eye coordination had improved. Four subjects felt less eye strain when looking at near objects and five subjects felt that they benefited from the exercises.
Castelli, Corazzini, and Geminiani (2008)	To evaluate gender differences in route and survey knowledge carried out in virtual environments and their relationship with basic spatial abilities and specific self-report scale.	40 right-handed participants, 20 male (mean age = 24.5) and 20 female (mean age = 24.5). All the participants had an acuteness of vision within the norm or suitably corrected by the use of lenses. A range of route knowledge and survey knowledge tasks was used.	The results showed a significant difference favouring males in the survey tasks, as well as in the spatial abilities tests, but no gender differences were found in the route task. Moreover, a different pattern of correlations among the measures were found in the male and female sub-groups.
Boot et al. (2008)	To determine whether (1) perceptual benefits of playing video games are restricted to visual and attentional tasks or whether improvements might be broader and evident in spatial processing, spatial memory, executive control and reasoning tasks; (2) video games practice could produce these gains in non-gamers.	**Cross sectional study:** 11 expert video game players (7+ hours of video games per week for the past two years plus high levels of action video games) and 10 non-video game players were recruited. Participants were tested on a range of visual and attentional, spatial processing and spatial memory and executive control and reasoning tasks. **Longitudinal study:** 82 college students, all male and all non- gamers (less than 1 h of	In **cross sectional study** video game experts tracked moving objects at greater speeds, showed greater accuracy in visual short-term memory task, switched between tasks more quickly, were faster and more accurate on object rotation tasks but did not perform better on FFOV, attentional or enumeration blink as Green and Bavelier found, suggesting task differences between current tasks and those of Green and Bavelier. **Longitudinal**

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Author(s)	Aims/Objectives of study	Methods	Conclusions
		video games a week over the past 2 years). Tested before and after 21 h of practice on a range of cognitive and perceptual tasks.	**study** found, apart from Tetris, no gains in non-VG players after 21 h of practice in any tasks except mental rotation. Suggests that more practice is required to achieve the benefits or that advantages for VG players are due to self selection.
Yalon-Chamovitz and Weiss (2008)	To explore the use of virtual reality (VR) technologies to broaden the repertoire of accessible leisure activities for adults with intellectual disabilities (ID).	33 men and women with moderate ID and severe cerebral palsy participated in the study; age range = 17–29. 17 participants in the experimental group took part in VR activity 2–3 times weekly for 12 weeks. Questionnaire asked about participants' enjoyment during the game, success at playing it, feeling of presence and control and discomfort they experienced while playing	Participants reported consistently high levels of success, enjoyment and presence throughout the tasks and these measures were higher than instructor's ratings of the students on these measures. No differences in self esteem before and after were found. VR appears to provide varied and motivating opportunities for leisure activities among young adults with intellectual and physical disabilities.
Steinkuehler and Duncan (2008)	To examine the scientific habits of mind and dispositions that characterise online discussion forums of the massively multi-player online game (MMOG) World of Warcraft.	Used a random sample of 1984 posts across 85 threads of 4656 threads total. The final sample included discussion posts made by 1087 unique WoW characters. National benchmarks were used to code the posts.	86% of forum discussions were posts engaged in "social knowledge construction" rather than social banter. Over half of the posts evidenced systems based reasoning, one in ten evidenced model-based reasoning and 65% displayed an evaluative epistemology in which knowledge is treated as an open-ended process of evaluation and argument. Such findings support the view of virtual worlds as learning contexts that stretch across both intra-game and extra-game spaces.
Barlett et al. (2009)	To determine the impact that computer games have on cognitive performance; to determine whether playing violent, non-violent or no computer games for short durations (18 min) has an impact on cognitive performance on SynWin.	**Study 1:** 37 students, 28 males, 7 females; mean age = 19.38. aimed to discover how many trials required to reach asymptote on SynWin tasks: working memory; adding three numbers; an auditory perception task and a selective attention task. **Study 2:** 37 students, 28 males, 7 females; mean age = 19.38, participants randomly assigned to 3 groups: control, violent game group non-violent game group and performance on SynWin measured.	**Study 1:** players reached asymptote on cognitive measure after 4 trials. **Study 2:** playing both violent and non-violent video games led to increased performance on SynWin compared with the control group. This finding supports the use of video game to cognitively "warm-up". The cognitive benefit from playing video games occurs independently of violent or non-violent game content.
Feng et al. (2007)	**Study 1:** to examine differences in spatial attention between males and females and video game players and non–players; **study 2**: to examine differences in spatial attention and cognition between males and females following 10hr practice with an action or non action game.	**Study 1:** 48 19–30 year old undergraduates. Useful field of view (UFOV) task. **Study 2:** 18–32 year old undergraduates; spatial attention and mental rotation compared in men and women before and after 10 h of playing non action game.	**Study 1:** game players performed better than non-game players on UFOV task; males performed better than females and this was especially true for non-game players. Science students performed better than arts students. **Study 2:** performance of game group improved substantially on UFOV task and mental rotation task with no difference in performance on control group from pre to post-test. Females benefitted more than males nearly eliminating initial male advantage on the tasks.
Stefanidis et al. (2005)	To explore whether laparoscopic skill retention is improved using Virtual Reality (VR) and Videotrainer (VT)	14 Surgery residents with no previous VR or VT experience practiced 12 Minimally Invasive Surgical Trainer-VR and 5 VT tasks until proficiency levels were achieved. VR (manipulate diathermy) and 1 VT (bean drop) tasks were selected for assessment at baseline, after training completion (post-test), and at retention.	After an early performance decrement post-test there was no skill loss in retention test. Although residents did not retain all acquired skills (more so for VR than for VT), proficiency-based training on simulators results in durable skills.

Appendix F. Physiological arousal outcomes.

Author(s)	Aims/Objectives of study	Methods	Conclusions
van Reekum et al. (2004)	To use computer games to study psychophysiological reactions to emotion-relevant events in a video game (xquest).	33 US high school pupils; 27 boys and 6 girls; age range = 13-15; the effects of intrinsic pleasantness & goal conduciveness were examined on physiological measures (muscle activity, cardiovascular activity – inter-beat interval, finger pulse, pulse transit time, respiration, skin conductance, finger temperature) and self-reports of emotions (interest, pride, joy, anger, tenderness, shame, helplessness, surprise).	Self-reports indicate that game events altered levels of pride, joy, anger, & surprise. Goal conduciveness had little effect on muscle activity but was associated with significant autonomic effects, including changes to inter-beat interval, pulse transit time, skin conductance and finger temp; goal conduciveness had significant main effects on pride, joy, anger, surprise with joy and pride higher in conducive conditions and anger, surprise and tenseness higher in obstructive conditions. Intrinsic pleasantness had little impact on physiological responses.
Baldaro et al. (2004)	To evaluate the effects of violent (unreal tournament) compared with non-violent (puzzle bobble) games on physiological and psychological measures	22 males, aged 20–29 year who have habitually played videogames for more than 5 years. Physiological measure were arterial pressure and heart rate and psychological measures were state anxiety and aggression.	Significant main effect of time on systolic blood pressure (BP) showed higher blood pressure while playing, but significant interaction between game type and systolic BP showed that this increase during play was true only for violent game group. Diastolic BP decreased post-game no matter what condition. Anxiety levels measured using the State Trait Anxiety Inventory were lower before game but increased after the game. A game type by time interaction indicated this was true for violent games only. No differences for pre and post measures of hostility.
Higuchi, Motohashi, Liu, and Maeda (2005)	To determine whether playing an exciting computer game using a bright display at night affects sleep variables if it alters presleep physiological variables.	7 male adults (24.7 ± 5.6 years old) played exciting computer games with a bright display and a dark display and performed simple tasks with low mental load as a control condition in front of a bright (control) and dark (control) between 23:00 and 1:45 h in randomised order and then went to bed at 2:00 h and slept until 8:00 h.	Researchers found playing video games before bed increased sleep latency, significantly increased heart rate and significantly decreased perceived sleepiness and the theta power of EEG, as well as a decrease in REM sleep.
Ivory and Kalyanaraman (2007)	To examine impact of technological advancement and violent/non-violent game content on video game players' presence, involvement, physiological and self-reported arousal and aggression measures	120 undergraduate students; mean age = 20.57, (sd = 4.41); 68% (n = 82) female. Participants were randomly assigned to one of 4 experimental conditions (older non-violent, newer non-violent, older violent and newer violent game). Data assessing presence, arousal, aggression, and other measures were collected with pre- and post-exposure questionnaires and physiological measures.	The results showed a significant main effect of technological advancement, confirming that more technologically advanced games led to increased feelings of engagement with the game, increased sense of presence, involvement and physiological and self-reported arousal for both violent and non-violent games. No main effect of violence nor a violence-by-advancement interaction on presence, involvement and arousal, suggesting that the level of engagement was similar for violent and non-violent games.
Salminen and Ravaja (2008)	To explore the (eeg) oscillatory responses evoked by two instantaneous violent events	25 participants; 16 male and 9 female; mean age = 23.8 years. Age range = 20–30; right-handed healthy young adults. Electroencephalographic (EEG) readings were recorded to two violent events: the player character (a) wounding and (b) killing an opponent character with a gun, in the digital game James Bond 007: NightFire.	Both kinds of emotional event evoked increased occipital theta (4–6 hz) responses as compared to pre-event baseline. The wounding event also evoked increased occipital high theta (6–8 hz) response & the killing event evoked low alpha (8–10 hz) asymmetry over the central electrodes, both relative to the pre-event baseline. Eeg responses may be attributable to affective processes related to violent games.
Ravaja et al. (2008)	To examine emotional valence and arousal-related phasic psychophysiological responses to different violent events in the first-person shooter video game "James bond 007: Nightfire" compared with responses to non-violent game "Super Monkey Ball 2"	36 Finnish undergraduates (25 male, 11 female, age range = 20–30). All players had played at least one video game once a month. Psychoticism: the psychoticism scale of the Eysenck Personality Questionnaire. Physiological data: Facial electromyographic (EMG) were used to assess participants' positive (zygomaticus major), negative emotions (corrugator supercilii) and "positively valenced high-arousal emotions" (orbicularis oculi). Electrodermal activity or skin conductance level (SCL) measures arousal.	Wounding and killing the opponent elicited an increase in SCL (Skin Conductance Level) and a decrease in zygomatic and orbicularis oculi EMG (Electromytographic) activity. The decrease in zygomatic and orbicularis oculi activity was less pronounced among high psychoticism scorers compared with low psychoticism scorers. The wounding and death of the player's own character (James Bond) elicited an increase in SCL and zygomatic and orbicularis oculi EMG activity and a decrease in corrugator activity. Instead of joy resulting from victory and success, wounding and killing the opponent may elicit high-arousal negative affect (anxiety), with high psychoticism scorers experiencing less anxiety than low psychoticism scorers. Although counterintuitive, the wounding and death of the player's own character may increase some aspect of positive emotion.

Appendix G. Soft skills and social outcomes.

Author(s)	Aims/Objectives of study	Methods	Conclusions
Backlund et al. (2008)	To investigate the effects of a driving simulator on self-efficacy for driving and driving skill	30 voluntary participants; 6 females and 24 males; age range = 18–37 years; not yet holders of a driving licence and inexperienced drivers. Participants completed a self-efficacy for driving measure and a reference test of driving skills before and after completing the driving practice session. Participants in the experimental group completed the driving practice with the simulator, those in the control group all played the original game version, with the level structure used in previous studies	Increases in self-efficacy for driving were found for the experimental group but not the control group following their use of the driving simulator. Driving skills increased in both conditions following participation in the driving simulator but there was no overall difference in skills between the experimental and control groups. The differing results for performance and self-efficacy illustrates that these do not always go hand-in-hand.
Hamalainen et al. (2008)	To develop a game environment to simulate issues of work safety in a vocational context; to examine what kind of activities the scripted game environment generated among the players; to examine how the least and the most successful groups differ in their activities.	16–18 year old vocational students ($n = 64$); 49 males, 15 females; divided into 16 groups of four. Data included observation notes on the game process, an electronic survey immediately after the game session, videotaping nine groups, logging chat conversations and logging all player activities during the game.	The scripted game environment provided opportunities that would not have been possible in traditional classroom settings (e.g. dealing with an authentic fire emergency situation). The scripted game environment helped players to know what to do next in the different phases of the game to solve the problem. The groups, especially highest and lowest scoring groups, differed in terms of results in the test, collaboration processes, and the type and quantity of discussion but the number of communications was not related to achievement in the final test.
Akkerman et al. (2008)	To carry out a case study analyzing how a mobile history game was applied in a narrative learning environment.	216 students, spread over 10 secondary school classes, in groups of four or five students, played the History game over one day. All information exchanged during the games was collected and the game play and introduction of the game was observed by team coaches and researchers.	The design of the game and gaming process was analysed with respect to how it evoked three types of storification: receiving (spectator), constructing (director) and participating (actor) in a story. Results show that the game was composed of a mixture of the three types of storification. Participating in the story evoked high activity in the game but less awareness of the whole story whereas constructing the story triggered awareness of the whole story. Compared to receiving the story, both these types positively affected the engagement of the students being active and motivated during the game.
Assmann and Gallenkamp (2009)	To examine the influence of culture, self-disclosure and communication media on perceptions of trustworthiness of the leadership of a virtual team using a massively multi-player online game (MMOG).	Sample comprised 2245 participants from 319 virtual teams.	The study showed that perceptions of leadership trustworthiness are affected by culture, high self-disclosure and intensive use of communication media. It was also found that the relationship between two dimensions of self-disclosure and trustworthiness as well as the usage of synchronous or asynchronous communication media and trustworthiness is moderated by culture. On the whole, this study contributes to the knowledge of the dynamics of trust building in a cooperative, ICT enabled relationship.

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