Chapter I
A Qualitative Meta-Analysis of Computer Games as Learning Tools

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ABSTRACT

Drawing on grounded theory approach and a qualitative meta-analysis, this chapter intends to systematically review and synthesize the theories, methods, and findings of both qualitative and quantitative inquiries on computer-based instructional games. A major purpose of this literature review and meta-analysis is to inform policy and practice based on existing studies. Four major recurring themes concerning the effectiveness of computer-based instructional games have emerged from a comparative analysis with 89 instructional gaming studies and are discussed with the support of exemplar research. The chapter will assist practitioners and policymakers in understanding the "best practices" and key factors of a computer game-based learning program.

INTRODUCTION

Recently computer games have been anticipated as a potential learning tool with great motivational appeal and represent an interesting development in the field of education. The literature surrounding computer games and education is vast. For more than two decades, educationalists (e.g., Betz, 1996; Gee, 2003; Gredler, 1996; Kafai, 1995; Malone, 1981; Prensky, 2001; Rieber, 1996; Squire, 2003) have been investigating the potential that exists for the application of computer games to learning. Given the broad nature of computer games, a substantial question exists as to what basic insights the literature provides on the design and application of computer-based games for learning.

As a recent search shows, there are currently more than 600 research/report articles within the category of computer games in the literature. These articles fall into generalized categories with a great deal of variance within the categories. These categories include theoretical speculation (e.g., Garris, Ahlers, & Driskell, 2002; Gee, 2003), experimental or descriptive clinical study (e.g., Ke, 2007; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Squire, 2003), and review of existing research (e.g., Dempsey, Rasmussen, & Lucassen, 1996; Randel, Morris, Wetzel, & Whitehill, 1992). Even within the same general category, games studies vary in theoretical framework, research purpose, methodology of data collection and analysis, and game genre adopted. Further, the findings of these games studies are conflicting (Dempsey et al., 1996; Emes, 1997; Randel et al., 1992).

Given this multi-vocal data pool, a systematic review with rigorous qualitative meta-analysis is warranted to generate a clearer profile of computer games. The review should indicate what meta conjectures or recurring themes we can form from the huge quantity of often disassociated studies on the learning effectiveness of computer games. It should also illustrate what are the best models or best practices of designing and applying computer games for education.

This proposed chapter is an attempt to systematically review and synthesize the literature on the subject of computer-based instructional games. Specifically, the chapter addresses the following questions: (1) What is the cumulative qualitative and quantitative evidence for using computer games for learning, and (2) What are the factors, if any, that weigh in an effective application of instructional gaming?

BACKGROUND

Definition of Terms

Computer Game

Scholars (Dempsey et al., 1996; Malone, 1981) defined a game as "usually a contest of physical or mental skills and strengths, requiring the participant(s) to follow a specific set of rules in order to attain a goal" (Hogle, 1996, p. 5). More specifically, Prensky (2001) defined a game as organized play including six key structural elements: rules, goals and objectives, outcomes and feedback, conflict/competition/challenge/opposition, interaction, and representation or story.

There is a wide category of games under Prensky's game conceptualization. For the purpose of this research, a computer game is:

- Operated on a variety of personal computer platforms
- Developed for formal learning or adapted for informal learning
- Comprising rules, goals and objectives, outcomes and feedback, conflict/competition/challenge/opposition, interaction, and representation or story (Prensky, 2001)

In addition, a game is defined as being separate from a simulation in that a game involves competition. According to Dempsey et al. (1996), a competitive format does not necessarily require two or more participants. If a simulation enables a learner to compete against him or herself by comparing scores over successive attempts at the simulation, or has a game structure imposed on the system, it is regarded as a game mode. If the focus of a simulation involves the completion of an event only, the simulation will not be considered a game.

Multiple categories of computer games have been identified in this review, including but not limited to adventure games, simulation games, board games, puzzle games, business simulation games, action games, and strategy games.

Learning

In this study, learning is conceptualized as a multidimensional construct comprising all three components: "skill, metaskill, and will," or in other terms, cognitive learning achievement, metacognition, and motivation (Mayer, 1998, p. 51). Gagne (1985) defined *cognitive learning achievements* as comprising declarative, procedural, and strategic knowledge. *Metacognition* in this study refers to knowledge or awareness of cognitive processes and the ability to use self-regulatory mechanisms to control these processes (Eggen & Kauchak, 1997). This study adopts an expectancy-value model of *motivation.* Specifically, the model proposes that there are three motivational components: (a) an *expectancy* (or perceived competence) component, which includes students' beliefs about their ability to accomplish certain tasks; (b) a *value* component, which includes students' goals and beliefs about the importance and interest of the task; and (c) an *affective* component, which includes students' emotional reactions to the task (Pintrich & De Groot, 1990, p. 33).

Computer Games for Learning

Theoretical Perspectives on Computer Games for Learning

Several theoretical perspectives, such as Piaget's Theory of Intellectual Development, Situated Learning, and Information Processing Theory, may underlie the surging interest in deploying computer games for learning. Piaget (1951) considered play and imitation as two crucial functions in a child's intellectual development process: play as an assimilation strategy and imitation as an accommodation strategy. Extensive research on play with children and adults in anthropology, psychology, and education indicates that play is an important mediator for learning and socialization throughout life (Csikszentmihalyi, 1990; Provost, 1990). Given the natural role that play and simulation serve to intellectual development, computer games as a vehicle for both play and simulation are not just a diversion to children, but an integral part of their learning and social lives.

Researchers have stressed the importance of anchoring or "situating" learning in authentic situations (Brown, Collins, & Duguid, 1989; Choi & Hannafin, 1995; Cognition and Technology Group at Vanderbilt, 1990). One benefit is making learners become engaged by the material, thus invoking a state of "mindfulness" in which learners employ effortful and metacognitively guided processes (Salomon, Perkins, & Globerson, 1991). Learning in a mindful way results in knowledge that is considered meaningful and useful, as compared to the inert knowledge that results from decontextualized learning strategies (such as traditional classroom worksheets). With simulated visualization, authentic problem solving, and instant feedback, computer games afford a realistic framework for experimentation and *situated understanding,* hence can act as rich *primers* for active learning (Laurel, 1991; Gee, 2003).

Information processing theory (Miller, 1956), along with aspects of dual coding theory (Clark & Paivio, 1991) and cognitive load theory (Sweller, 1988), also sheds light on computer games' potential to facilitate learning. Information processing theory states that novel information must be processed in working memory in order to construct schemata in long-term memory. Multi-sensory information representation in a computer game will facilitate schema construction by offering a learner a "ready-made" explicit representation of the complicated concept, providing just the type of external support that would be required for the construction of a internal mental model. This external support, as stated by Gredler (1996, p. 597), "reduces the cognitive load and allows students to use their precious working memory for higher-order tasks." Furthermore, the multi-sensory representation in computer games also helps the schema indexed in memory in multiple formats, thus making the schema accessible in more than one way.

Findings of Previous Gaming Reviews/ Meta-Analysis

A discussion of previous gaming reviews offers an overview of the literature. It also highlights the limitations of previous reviews and illuminates how this current review will expand the previous research using a grounded meta-analysis method.

According to Garris et al. (2002), the following are tangible reasons for using computer games for learning purposes:

- Computer games can invoke an intensity of engagement in learners.
- There are empirical studies in the literature showing that computer-based instructional games have a wide spectrum of utility for learning (Dempsey et al., 1996; Randel et al., 1992). The learning outcomes measured include attitudes, cognitive strategies, problem solving, rules, and corporate concepts. Computer games have been applied in diverse environments from school education to training in military, healthcare, and management.

Six recent literature reviews (Dempsey et al., 1996; Emes, 1997; Hays, 2005; Randel et al., 1992; Vogel et al., 2006b; Wolfe, 1996b) were identified as being undertaken in areas associated with the use of computer games for learning purpose. The following section summarizes the results of these review articles. Other review reports (e.g., VanSickle, 1986; Hogel, 1996; Leemkuil, de Jong, & Ootes, 2000) have not been summarized but used to locate original computer game articles.

Recently, Vogel et al. (2006b) conducted a quantitative meta-analysis with 32 studies on computer games and interactive simulation. They reported strong, positive effect sizes of interactive simulations and games vs. traditional teaching methods for both cognitive gains and attitude. Their analysis also indicated that the effects of games and interactive simulations sustained across people (in terms of gender and age) and situations (in terms of learner control, level of realism, and individual/group usage). However, Vogel et al. (2006b) noted that the effect size analysis of computer games, different from that of interactive simulations, yielded a low reliability and hence should be considered with caution.

Randel et al.'s (1992) review on video games, examining 68 early studies up to 1991, compared the effect of games and simulations with that of traditional classroom instruction on student performance. It produced the following results: of the 68 studies, 38 (56% of the studies) found no difference, 22 (32%) found differences favoring simulations/games in student performance, 7% favored simulations/games but their controls were questionable, and 5% found differences favoring conventional instruction. The authors concluded that the beneficial effects of games were most likely to be found when specific content was targeted and objectives precisely defined. In many studies students reported more interest in game activities than in conventional classroom instruction. Business games were *not* included in Randel et al.'s review.

Wolfe (1997), conversely, reviewed only studies regarding computer-based business games used in strategic management coursework. These studies all used comparative design with at least one treatment and one control group. He found evidence for the effectiveness of business games. In every study citied in the article, game application produced significant knowledge-level increases and was superior to conventional case-based teaching in producing knowledge gains.

Dempsey et al. (1996) examined 99 studies for common threads in the instructional game literature. They found the preponderance of games intending to promote higher-level intellectual skills and attitudes learning as opposed to verbal knowledge outcomes. They also found that games served many functions such as tutoring, amusing, helping to explore new skills, promoting self-esteem, practicing existing skills, drilling existing skills, automatizing, and seeking to change an attitude. Practicing existing skills (n = 22) was the highest frequency, and learning new skills (n = 21) was a close second. From the studies reviewed, they delineated a list of assertions for using and designing instructional games, such as using intrinsically motivating games, employing instructional support features (e.g., debriefing, flexible scoring, progression of complexity), and selecting game genres based on learning objectives.

Another review on instructional games (Emes, 1997) examined games' use with children and found no clear causal relationship between academic performance and the use of computer games. Although Emes' (1997) finding was based on three studies, his conclusion was confirmed by Hays (2005), who examined 105 instructional gaming articles. Hays' review (2005) reported:

There is no evidence to indicate that games are the preferred instructional method in all situations" and "although some games can provide effective learning for a variety of learning for several different tasks (e.g., math, attitudes, electronics, and economics), this does not tell us whether to use a game for our specific instructional task. (p. 6)

These past analyses/reviews highlighted six major themes:

- The literature base is sparse. Although many articles discussed the use of instructional computer games, most of the literature was based on the authors' opinions on the *potential* of instructional games or propositions on how games would be developed to be instructionally sound. Far fewer articles documented the empirical data on the effectiveness of instructional games (Hays, 2005; Dempsey, et al. 1996).
- Empirical studies' findings conflict (Dempsey et al., 1996; Randel et al., 1992; Vogel et al., 2006b). It appears that few firm conclusions can be drawn from the studies and there is no evidence that games can provide effective learning in all situations.
- The empirical research on instructional games is fragmented. Prior studies focused on different clusters of factors when evaluating the effects of an instructional game - administrative variables (game environment), learner variables (e.g., gender or academic ability), procedural variables (game-based activity, such as game-facilitated cooperative learning), and game variables (e.g., game genre and media) (Dempsey et al., 1996; Williams, 1980).
- Much of the work on the evaluation of games has been anecdotal, descriptive, or judgmental (Dempsey et al., 1996).
- Longitudinal studies are needed (Emes, 1997).
- A breakdown of the available studies by subject matter reveals that some knowledge domains are particularly suited to gaming, such as math, physics, and language arts (Randel et al., 1992; Hays, 2005).

On the other hand, the prior reviews of instructional computer games had the following limitations:

- Some existing reviews excluded qualitative studies. For example, Vogel et al. (2006b), Randel et al. (1992), Wolfe (1997), and VanSickle (1986) examined all quantitative studies in their reviews.
- Most of the existing reviews (e.g., Dempsey et al., 1996; Hays, 2005; Hogel, 1996; Leemkuil et al., 2000) were narrative literature reviews that did not reveal the decision rules used to synthesize findings from various studies, hence a lack of analytic rigor and objectivity (Hossler & Scalese-Love, 1989).
- Some existing reviews included low-quality studies or non-empirical reports that plagued the analysis result (Slavin, 1986).

MAIN FOCUS OF THE CHAPTER

Method

Drawing on grounded theory approach, the author conducted a qualitative meta-analysis to synthesize the theories, methods, and findings of both qualitative and quantitative inquiries of computer-based instructional games. Qualitative meta-analysis basically followed the same, replicable procedure of a quantitative meta-analysis, but was more interpretative than aggregative. Instead of a statistical data analysis, the researcher analyzed textual reports, creating new interpretations in the analysis process.

This study has utilized qualitative rather than quantitative meta-analysis, not because numbers are non-existent. The qualitative variant has been used specifically because it is an approach towards formulating a complete depiction of the subject and because a quantitative meta-analysis will exclude qualitative evaluation that is a major grouping in the literature. As Michelsen, Zaff, and Hair (2002) have stated, "…not every intervention strategy lends itself to an experimental evaluation." This statement is especially true in the case of instructional games research. In the current review, descriptive and case studies comprised almost 50% of the literature. In agreement with this discovery, Dempsey et al. (1996) have argued that although experimental studies have an important place in the instructional games literature, "there is a budding movement" to look at incidental learning using process-oriented inquiry. Because the instructional games literature itself comprises both qualitative and quantitative data, the integration of both qualitative and quantitative information is essential for a thorough synthesis of the literature for a complete state-of-the-art understanding of the domain.

Although some researchers regarded qualitative review methods as appropriate for interpreting qualitative data only, others (e.g., Noblitt & Hare, 1988; Light & Pillemer, 1982) proposed the possibility of qualitatively synthesizing both qualitative and quantitative information. Specifically, Hossler and Scalese-Love (1989) developed the grounded meta-analysis using Glaser and Strauss's grounded theory approach. Following their example, the study adopted qualitative meta-analysis and a thematic synthesis approach associated with grounded theory.

Trustworthiness of findings was achieved by using multiple coders for peer examination (Creswell, 1994). The actual procedure of research synthesis abided by the proposition of Hossler and Scalese-Love (1989) and is presented in the following sections.

Data Collection

A set of criteria was specified to select appropriate research for this study (Slavin, 1986). Preliminary criteria included:

- Content relevance - research focused on the design or application of computer-based games for learning purpose.
- Year of publication was 1985-2007
- English-language publications

The data search was systematic and exhaustive within the data pool consisting of computerized bibliographic databases (i.e., ERIC, PsycInfo, Educational Research Complete, Dissertation Abstracts, ACM), major education and technology journals, conference proceedings, and the reference lists of several reviews. A total of 256 studies were reviewed in the course of this analysis.

Data Coding and Analysis

When conducting the literature search, the author paid special attention to the studies that established components to be used in creating frameworks for analysis. An initial open-ended coding matrix was developed to delineate each study's stated purpose, method, intervention, learner, sample size, investigated factor, timeframe, learning settings, learning task and environment, outcome and measurement, game information, findings, specified/inferred implications and recommendations, and overall quality of the study. This coding matrix was constantly refined as synthesis proceeded. Both quantitative and qualitative information was coded using the same coding matrix to permit comparison of findings across studies.

It was an overlapping process of collecting studies, coding information, and analyzing data. Specifically, constant comparative method (Slavin, 1986) was employed. The author and peer investigators constantly compared the data collected/coded to revise the coding categories, reanalyze studies, and gain new insights. Both quantitative data (sample size, methodology, etc.) and qualitative information (learning context, conclusion, etc.) from each study were recorded in coding sheets for further analysis and eventual summarization. A research team of three peer coders was used to assure the consistency and rigorousness of analysis and results (Hossler & Scalese-Love, 1989).

During data analysis, low-quality studies were excluded from the synthesis. In the current analysis, a quantitative study was labeled low quality if it did not explain its methodological design features (such as sample size and study procedure). A qualitative study was excluded when it failed to provide a rich description of the learning context and outcomes or it appeared to be written based on the author's bias rather than field observation. For example, quite a few articles announced the effectiveness of a specific game based on purely design assumptions rather than empirical data from field testing.

Results

A total of 256 documents on the design, use, and evaluation of computer-based games were reviewed. Of these, 167 could not be included in the analysis:

- 20 articles focused on the effects of games on non-learning-oriented outcomes, such as the effect of an action game on children's aggression and violent behaviors, and the effect of computer video game on body movements of children with ADHD.
- 13 articles were computer-based instruction studies where gaming was only a contextual element but not the research focus.
- 45 were either *development* articles that described the design and development of a specific instructional game, or *discussion* articles that described opinions on an instructional game without empirical or systematically presented evidence (Dempsey et al., 1996).
- 45 articles presented only theoretical proposition or conceptual analysis on instructional game design principles or potential game-based learning processes.
- 18 articles were research reviews - synthesis of articles concerning games in general.
- 6 articles presented only propositions on future game application and research.
- 20 articles documented studies that were labeled as low quality.

Eighty-nine research articles that provided empirical data on the application and effectiveness of computer-based instructional games were included in the current analysis. Qualitative outlines of empirical studies coded were synthesized and are presented in Table 1. The table also revealed the coding rules used to synthesize findings from various studies and illuminated the potential factors that might weigh in an effective application of instructional gaming.

Discussion

Four major recurring themes concerning the effectiveness and key influence factors of computer-based instructional gaming have emerged from a comparative analysis with 89 computer

Table 1. A summary of empirical studies reviewed

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Abbey (1993)	Evaluate the effectiveness of game and explore game-based learning activity/ pedagogy	Quantitative (experimental)	86	1 lab session	Simulation game (as stand-alone or complementary pedagogical instrument)	College students	Non-content-related problem-solving strategy	General learning	Cognitive strategy near and far transfer	Gaming promoted far transfer significantly more than the conventional instruction, but not near transfer; there was no difference between the two gaming groups; and conventional instruction group solved significantly more levels.
Alkan & Cagiltay (2007)	Explore game-based cognitive process	Mixed-method	15	1 lab session	Puzzle game	College students	Non-content-related problem solving	Informal learning	Cognitive strategy	Trial-and-error strategies were mostly used.
Anderson (2005)	Explore game-based learning activity	Quantitative (correlational - causal)	172	4 weeks	Business simulation game	College students	Business management	Higher education course work	Student affect toward game-based learning	Team dynamics (e.g., cohesiveness and heterogeneity) influenced students' game playing performance and their affect toward game.
Bahr & Rieth (1989)	Explore game-based learning activity	Quantitative (experimental)	46	4 weeks (with 10 minutes per day and 3 days per week)	Other (drill-and-practice game)	Mildly handicapped junior high students	Math	School education course work	Test-based cognitive learning achievement	Students gained math learning achievement during gaming, but there was no significant effect of goal conditions (cooperative, competitive, and individualistic condition).
Barab, Sadler, Heiselt, Hickey, & Zuiker (2007)	Evaluate the effectiveness of game	Mixed-method (quasi-experimental & case study)	28	10 days	Massive multiplayer online game	4th graders (gifted students)	Science education	School education course work	Conceptual knowledge and problem solving	Statistically significant gains in near-transfer performance test but not in far-transfer standards-based academic achievement.
Barker, Brinkman, & Deardorff (1995)	Evaluate the effectiveness of game	Mixed-method (quasi-experimental with qualitative interviewing)	26	1 lab session	Role-playing/ simulation game	Pair of a child (mean age 14) and a biological parent (mean age 44) who had not been divorced for more than 3 years	Divorce adjustment	Informal learning	Rule learning and self-reported behavior change	There was no significant improvement in knowledge, but subjects reported positive behavior change for divorce adjustment.
Bartholomew et al. (2000)	Evaluate the effectiveness of game	Quantitative (experimental)	171	40-minute gaming session	Adventure game	Children with asthma, ages 7-17	Asthma self-management skills	Health education	Descriptive knowledge and behavior change	Gaming increased knowledge for older children and for those who scored higher at pre-test, and gaming intervention was associated with less hospitalizations.
Ben-Zvi (2007)	Evaluate the effectiveness of game	Quantitative (descriptive)	90	1 semester	Business simulation game	Graduate students	Business functions	Higher education course work	Student affect toward game-based learning	Affective reaction was favorable.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Cahill (1994)	Evaluate the effectiveness of game	Quantitative (descriptive)	3,829	n/a	Simulation game	5-8th graders	AIDS education	Informal health education	Game-based learning process/ experience	Learning experience was enhanced, and positive attitudes toward subject were developed.
Cameron & Dwyer (2005)	Evaluate the effectiveness of game and the influence of learner's cognitive style, and explore instructional game design	Quantitative (experimental)	422	45-minute gaming session	Other (drill-and-practice game)	College students	Knowledge about heart	Higher education course work	Descriptive and conceptual knowledge	Simple gaming was not more effective than the conventional instruction in promoting achievement; gaming with questions and elaborative feedback was significantly more effective than the simple gaming and conventional instruction; there was no significant intervention between learners' cognitive style (FD/FI) and gaming.
Cauzinille-Marmeche & Mathieu (1989)	Explore game-based cognitive process	Qualitative (cognitive task analysis)	120	1 lab session	Puzzle game	Children ages 7-15	Non-content-related problem solving	General learning	Cognitive strategy	A deductive model was used predominantly by 11- through 15-year-olds, a rule-based model was used predominantly by the youngest subjects, a development trend was observed from rule-based model to deductive model.
Chang, Yang, Chan, & Yu (2003)	Evaluate the effectiveness of game	Mixed-method (case study)	78	1 lab session	Board games	College students	Multiple subject topics	Higher education course work	Student affect toward game-based learning	Affective reaction was favorable.
Chen, Shen, Ou, & Liu (1998)	Evaluate the effectiveness of game	Quantitative (descriptive)	n/a (6 classes)	One 2-hour lab session	Multi-user game	College students	Web navigation skills	Online learning	Motivation	Game promoted student motivation (esp. low achievement students) to learning.
Christensen & Gerber (1990)	Evaluate the effectiveness of game and the influence of learner characteristics	Quantitative (experimental)	60	n/a	Arcade drill-and-practice game	Elementary-level students (learning-disabled and non-disabled)	Math	School education course work	Factual/ descriptive knowledge	Straightforward drill was more effective than the game format for learning-disabled students.
Conati & Zhao (2004)	Explore instructional game design	Quantitative (experimental)	20	One 20-minute gaming session	Puzzle game	7th graders	Math	School education course work	Conceptual knowledge	Game (with pedagogical agent) promoted more learning (marginally significant) than game only. Students learned little from game without any external guidance.
De Jean, Upitis, Koch, & Young (1999)	Explore the interaction between learner characteristics and instructional game	Qualitative (case study)	104	6 months	Massive multiplayer online game	Students ages 12-13	Math	School education course work	Game-based learning experience	Most girls lacked awareness of math content embedded in the game.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Dempsey, Haynes, Lucassen, & Casey (2002)	Explore instructional game design	Qualitative	40	1 lab session	A variety of game genres for educational purposes	Adults ages 18-52	Multiple subject topics	General learning	Affect toward game-based learning	All game genres had potential for educational use and different learning outcomes.
Doyle & Brown (2000)	Evaluate effectiveness of game	Mixed-method (case study)	30	6 weeks	Business simulation game	College students	Business management	Higher education course work	Game-based learning experience	80% surveyees had positive simulation-based learning experience.
Forsyth (1986)	Explore instructional game design and the influence of learner characteristics (gender)	Quantitative (experimental)	120	40-minute gaming session	Adventure game	4th and 5th graders	Place location learning	School education course work	Cognitive recall and retention, and affect toward game-based learning	Game-with-map groups outperformed the no-map group in instant recall test; labels-with-game groups outperformed the other groups; all groups showed high level of retention of knowledge after 2 weeks; there was no influence of gender on learning or attitude.
Foss & Eikaas (2006)	Evaluate the effectiveness of game	Quantitative (descriptive)	1,200	n/a	Simulation game	College students	Engineering	Higher education course work	Affect toward game-based learning	Affective feedback to game use was favorable.
Goldsworthy, Barab, & Goldsworthy (2000)	Evaluate the effectiveness of game	Quantitative (experimental)	59	Twice (30-50 minutes each session) a week for 4 weeks	Simulation game	Adolescents ages 10-16 with ADHD	Non-content-related social problem solving	Informal learning	Social problem solving, social behavioral rating, and level of engagement	The group using game performed significantly better than the control group and comparably to a therapist-directed group on measures of problem solving and engagement, but there was no significant effect of game on (far transfer) social behavioral rating scale.
Goodman, Bradley, Paras, Williamson, & Bizzochi (2006)	Evaluate the effectiveness of game	Quantitative (experimental)	169	One 3-minute gaming session	Puzzle game	Hockey players ages 11-17	Health education	Informal learning	Conceptual knowledge	Game improved learning gains and increased the speed of test performance.
Gopher, Weil, & Bareket (1994)	Evaluate the effectiveness of game	Quantitative (experimental)	58	10 1-hour sessions	Flight simulation game	Cadets ages 18-20	Flight training	Flight training for cadets	Problem solving and motor skills in actual flight performance	Game group was significantly better in flight performance than the control group.
Grabe & Dosmann (1988)	Evaluate the effectiveness of game	Quantitative (descriptive)	70	n/a	Adventure game	6th graders	Reading	School education course work	Cognitive text-processing and metacognitive skill	There was evidence for game's effect on text-processing and metacognitive skill development.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Greenfield, Camaioni, Ercolani, & Weiss (1994)	Evaluate the effectiveness of game	Quantitative (correlational-causal)	200	n/a	Entertaining action game	College students	Scientific-technical discovery	Informal education	Cognitive strategy	Knowledge of the game was developed as a result of inductive discovery process and subjects' gaming performance correlated with their test performance with scientific-technical discovery.
Gremmen & Potters (1997)	Evaluate the effectiveness of game	Quantitative (experimental)	47	1 semester	Economic simulation game	College students	Economic education	Higher education course work	Conceptual knowledge	Game was more effective (than lectures) in promoting post-test performance.
Halttunen & Sormunen (2000)	Evaluate the effectiveness of game	Qualitative (case study)	n/a (1 class)	1 tutoring session	Simulation/ modeling game	College students	Information search strategy	General learning	Rule learning	Game enhanced learning.
Haynes (2000)	Explore the interaction between learner characteristics and game, and instructional game design	Mixed-method (quasi-experimental and qualitative interviewing)	5 classes	1 lab session	n/a (educational game)	9th graders	Math	School education course work	Test-based cognitive learning achievement, attitude (value) toward subject	There was no effect of gender on game-based math learning achievement, but females gave more evidence of using metacognitive, cognitive, and cooperative strategies. Females showed higher motivation through relevance, while males were more motivated by challenge in terms of self-esteem.
Henderson, Klemes, & Eshet (2000)	Evaluate the effectiveness of game	Mixed-method	20	45-minute session daily for 6 weeks	Microworld simulation game	2nd graders	Science education	School education course work	Descriptive knowledge, conceptual knowledge, problem solving, and transfer	Game facilitated the improvement in multiple cognitive outcomes, from basic recall to higher-level thinking (classification and inference), as well as in usage of scientific language. Transfer was not significant.
Horn, Jones, & Hamlett (1991)	Evaluate the effectiveness of game	Qualitative (case study)	3	n/a	Action game	Non-vocal students (ages 5-8) with severe physical handicaps	Basic motor skills	Special education	Scanning and selection motor skills	Subjects demonstrated substantial skill development and maintenance.
Inal & Cagiltay (2007)	Evaluate the interaction between gender and game	Mixed-method (case study)	33	1 hour per week for 6 weeks	A variety of game genres	Children ages 7-9	Social skill development	General learning	Game-based experience	Gender and challenge level in game influenced students' flow experiences and game-playing behaviors. Girls had more tendency playing mind games, boys enjoyed the game playing and forming group more than girls; ludology had more effect than the narratology of games on flow of boys, while girls were the opposite.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Inkpen, Booth, Klawe, & Upitis (1995)	Explore game-based learning activity and the influence of learner characteristics	Mixed-method (experimental and qualitative observation)	435	40-minute gaming session	Puzzle game	School children ages 6-12	Non-content-related problem solving	Informal learning	Cognitive problem-solving tasks and motivation	Playing configuration (playing together or not) had a significant effect on motivation; grouping children around one computer did not negatively affect performance and in the case of female/female groupings, it had a positive effect.
Johnson (1993)	Evaluate the effectiveness of game	Quantitative (descriptive)	446	6-minute gaming session	Puzzle game	General public: from preadolescent to senior citizen	Health education	Informal learning	Descriptive knowledge gain and motivation	Game promoted statistically significant gain in knowledge and self-efficacy.
Ju & Wagner (1997)	Evaluate the effectiveness of game and explore instructional game design	Quantitative (descriptive)	12	1-hour gaming session	Adventure games	College students (from senior to PhD level), most were female	General cognitive outcomes	Training	Cognitive problem solving, conceptual knowledge, and affect toward game	Games endeared least information retention and problem solving and most conceptual knowledge. Ludology, role-playing, appropriate complexity level made a game appealing.
Kafai & Ching (1996)	Evaluate the effectiveness of game (as construction kit)	Qualitative (case study)	4	1 hour a day for 3 days	Game design	5th graders	Math	After-school learning	Conceptual knowledge	There was evidence of improved learning.
Kambouri, Thomas, & Mellar (2006)	Evaluate the effectiveness of game	Qualitative (case study)	n/a (3 UK learning centers)	n/a	Adventure game	Young adults	Literacy learning	Formal adult education	Literacy gains	The game was engaging and learners made significant literacy gains beyond expectation.
Kashibuchi & Sakamoto (2001)	Evaluate the effectiveness of game and the influence of learner characteristics	Quantitative (experimental)	279	50-minute gaming session	Simulation and board games	2nd- and 3rd-year high school students in Japan, ages 16-18	Sex education	School education course work	Conceptual knowledge and motivation	Gaming with a reversal role-playing facilitated conceptual knowledge most, and there were no effects of experimental situations on attitudes/motivation.
Ke & Grabowski (2007)	Explore game-based learning activity and the influence of learner characteristics	Quantitative (quasi-experimental)	125	Twice a week (40 minutes each session) for 4 weeks	Puzzle games	5th graders	Math	School education course work	Cognitive learning achievement and attitude toward subject	All gaming groups outperformed control group in cognitive learning achievement. Cooperative gaming group outperformed all other groups (competitive and control) in attitudes scale. SES-disadvantaged students benefited from cooperative gaming most. There was no effect of gender.
Kiili (2005)	Explore instructional game design	Mixed-method (case study)	18	n/a	Role-playing/ simulation game	College students	General motivation	Informal learning	Motivation (flow)	Content creation was the main activity causing flow; bad usability and low gameness were cited as obstacles.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Kiili (2007)	Explore instructional game design	Qualitative	12	5-hour gaming session	Business simulation game	College students ages 20-30, all male	Business functions	Higher education course work	Game-based learning experience	Authenticity, group dynamic, and learning by doing were found to be most effective elements for effective instructional game application.
Ko (2002)	Evaluate the effectiveness of game	Quantitative (experimental)	87	1 lab session	Board game	Children ages 6-10	Basic cognitive skill development	General learning	Cognitive skill development (decision making, choice behavior, and use of logical reasoning); affect toward game-based learning	Children's developed cognitive skills over the practice of games; children reported high satisfaction and joy; there was no difference between computer game and traditional game on learning.
Leger (2006)	Evaluate the effectiveness of game	Mixed-method (case study)		7 weeks	Business simulation game	College students	Business functions	Higher education course work	Conceptual knowledge, technical skills, and affect toward game-based learning	Affective feedback on using game was favorable.
Leutner (1993)	Explore instructional game design	Quantitative (experimental)	182	n/a (1 lab session)	Simulation game	7th and 8th graders and college students	Economic education	School and higher education	Conceptual knowledge	Learners without instructional support in game learned to play game rather than domain-specific concepts; the opposite occurred with the learners given advice. Instructional support is essential for instructional games.
Lim, Nonis, & Hedberg (2006)	Evaluate the effectiveness of game	Mixed-method (case study)	8	Longitudinal	Massive multi-user game	4th graders	Science education	School education course work	Engagement level and conceptual knowledge	There was a significant knowledge gain but the level of engagement of students was low.
Malouf (1987)	Evaluate the effectiveness of game	Quantitative (experimental)	25	20-minute gaming session	Puzzle game	6-8th graders identified as learning disabled	Vocabulary skill	School education course work	Motivation and descriptive knowledge	Game produced significantly higher continuing motivation and quicker question response, but there was no difference in descriptive knowledge learning in comparison to computer program (with no game feature).
Mandinch (1987)	Explore instructional game design, evaluate game effectiveness and the influence of learner characteristics	Quantitative (correlational-causal)	48	n/a	Strategy game	7th and 8th graders	Non-content-related strategic planning skill	School education	Cognitive problem solving	Students with successful game performance performed better on problem-solving transfer tasks than unsuccessful students; low-ability students appeared to perform better at gaming with instructional support.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Martens, Gulikers, & Bastiaens (2004)	Explore the intervention between learner characteristics and gaming	Quantitative (descriptive)	33	Maximum was 3 hours	Simulation game	College students (20 years old)	Game content learning	Higher education	Descriptive knowledge	Students with high intrinsic motivation did not do more but demonstrated more explorative study behavior; however the learning outcomes of students with high intrinsic motivation were not better.
McMullen (1987)	Evaluate the effectiveness of game	Quantitative (experimental)	37	1 lab session	n/a	6th graders	Science education	School education	Cognitive learning achievement, retention, and attitude toward learning materials	There was no significant effect of gaming on instant or delayed learning achievement test; gaming promoted significantly more positive attitudes than the other groups (CAI and conventional instruction).
Miller, Lehman, & Koedinger (1999)	Explore instructional game design	Quantitative (experimental)	24	30-minute gaming session	Microworld simulation game	College students	Physics: electrical interaction	Higher education course work	Conceptual knowledge	Students in the standard-goal gaming condition learned less qualitative physics than did those in the two alternative conditions (no-goal and specific-path).
Moreno & Mayer (2002)	Explore instructional game design	Quantitative (experimental)	164	1 lab session	Simulation game	College students	Natural science	Higher education course work	Descriptive knowledge, problem solving, and affect toward learning materials	Students scored higher on retention, transfer, and program rating in narration condition than in text conditions. The media□desktop displays or head-mounted displays□did not affect performance on measures retention, transfer, or program rating.
Moreno (2004)	Explore instructional game design	Quantitative (experimental)	104	1 lab session	Simulation game	College students (with a mean age of 18) who are novice in subject knowledge	Natural science	Higher education course work	Descriptive knowledge, problem solving, and affect toward learning materials	Agent-based elaborative feedback in the game facilitated learning achievements more than agent-based corrective feedback in the game, due to reductions in cognitive load.
Moreno & Mayer (2004)	Explore instructional game design	Quantitative (experimental)	48	1 lab session	Simulation game	College students	Natural science	Higher education course work	Descriptive knowledge, problem solving, and affect toward learning materials	Students learned more deeply from games when agent speaks in personalized speech rather than a non-personalized style. Presentation via head-mounted display (high immersion) did not lead to better performance on descriptive knowledge or problem solving than presentation via desktop computer (low immersion).

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Noble, Best, Sidwell, & Strang (2000)	Evaluate the effectiveness of game	Mixed-method (case study)	101	1 lab session	Arcade-style motorcycle action/racing game	Children ages 10-11	Drug education	School education	Expectancy and value	Game increased students' awareness toward illegal drug and their self-efficacy.
Okolo (1990)	Evaluate the effectiveness of game	Quantitative (experimental)	18	7-hour gaming session	Other (drill-and-practice game)	Learning-disabled high school students	Keyboarding motor skill	Special education	Basic motor skills, attitudes toward subject, and continuing motivation	There were no significant differential effects between drill-and-practice and game on skill acquisition and attitudes, but the game format had a detrimental effect on continuing motivation.
Okolo (1992)	Evaluate the effectiveness of game	Quantitative (experimental)	41	4 gaming sessions	Other (drill-and-practice game)	Intermediate-level students with learning disabilities	Math	Special education	Descriptive knowledge and continuing motivation	There were no significant differential effects between drill-and-practice and game on knowledge acquisition, but the game had a facilitative effect on continuing motivation of students with low initial attitudes toward math.
Ota & DuPaul (2002)	Evaluate the effectiveness of game	Quantitative (experimental-multiple baseline design)	3	60-80 minutes in total (4 times a week)	n/a (educational game)	4-6th graders with ADHD	Math	Special education	Cognitive math performance and task engagement	Gaming led to increases in active engaged time and decreases in off-task behaviors in all subjects; all subjects also showed some improvement in math performance, but improvement was modest in comparison to conventional instruction condition.
Oyen & Bebko (1996)	Evaluate the effectiveness of game	Quantitative (experimental)	120	1 lab session	Puzzle game (with endogenous or exogenous gaming element)	Children ages 4-7	Memory-enhancing strategy	Preschool education	Memory rehearsal strategy and recall performance	Games increased overt rehearsal strategy use, yet no greater memory recall (in comparison to traditional), and there is no effect of game type.
Padgett, Strickland, & Coles (2006)	Evaluate the effectiveness of game	Quantitative (pre-/post-case series design)	5	1 lab session	Massive multi-user game	Children diagnosed with fetal alcohol syndrome, ages 4-7, low or average intellectual functioning	Fire safety skill	Informal learning and special education	Procedural knowledge gain and retention	Game helped all participants develop procedural knowledge gain and helped knowledge retention (in one-week follow up test).
Pannese & Carlesi (2007)	Evaluate the effectiveness of game	Quantitative (descriptive)	n/a	n/a	Business simulation game	College students and company employees	Business functions	Higher education course work and workforce training	Affect toward game-based learning	Affective feedback to game use was very high.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Paperny & Starn (1989)	Evaluate the effectiveness of game and the influence of learner characteristics	Quantitative (experimental)	718	30- to 40-minute session	Action games	High school students ages 13-18	Health education	Informal learning	Descriptive, conceptual knowledge, and attitude (value)	Games produced significant knowledge gain and attitude change (as opposed to traditional instruction); students with low SES enjoyed and learned from games especially.
Perzov & Kozminsky (1989)	Evaluate the effectiveness of game	Quantitative (experimental)	68	110 minutes total (10 minutes/day for 11 days)	A variety of games with or without elements requiring visual perception	Kindergarten children in Israel age 5	Non-content-related visual perception skill	Preschool education	Basic motor skill	No significant effect of games (with or without elements requiring visual perception) was found.
Pillay (2002)	Evaluate the effectiveness of game	Mixed-method (quasi-experimental & qualitative cognitive task analysis)	36	15-minute gaming session	2D puzzle recreational game and 3D strategy recreational game	School children ages 14-16	Environmental education	School education course work	Time on task, cognitive task performance, and cognitive/ meta-cognitive process	3D game promoted successful subsequent performance on 3D computer-based instructional tasks (as opposed to 2D game), suggesting the extent of recreational game influence depends on how closely the game type matches the design of the tasks in the educational software.
Pillay, Brownlee, & Wilss (1999)	Explore game-based cognitive process	Qualitative (cognitive task analysis)	21	n/a	Puzzle and strategy entertainment games	High school students ages 14-18	General problem solving	General learning	Cognitive strategies	Game players demonstrated complex cognitive processes (e.g., general search heuristics, use of game tools, and a combined approach, metacognitive monitoring, maintaining temporal information for multitasking).
Piper, O'Brien, Morris, & Winograd (2006)	Evaluate the effectiveness of game	Qualitative (case study)	8	5 gaming episodes	Board game	Children from social cognitive therapy class	Social skill development	Informal learning	Social skill development	The game provided an engaging experience for participants to work with others.
Rai, Wong, & Cole (2006)	Evaluate the effectiveness of game (as construction kit)	Qualitative	n/a	1 semester	Game design	College students	Computer science (programming)	Higher education course work	Affect to game-based learning	Game construction promoted active engagement with the content and increased enthusiasm level.
Ravenscroft & Matheson (2002)	Evaluate the effectiveness of game	Quantitative (experimental)	36	20- to 30-minute gaming session	Other (dialogue games)	Secondary school students ages 15-16	Physics	School education course work	Conceptual knowledge	Games promoted significant improvement in conceptual knowledge gain and retention (in comparison to conventional learning).

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Renaud & Suissa (1989)	Evaluate the effectiveness of game and explore instructional game design	Quantitative (experimental)	136	One 3-hour gaming session	Simulation games (with or without attitude-triggering elements)	5-year-old children in school	Traffic safety education	Preschool/ general education	Attitude (value), behavior change, and transfer of learning	All gaming interventions promoted three learning achievements more than the control condition; attitude-triggering elements (role-playing and group) was necessary and sufficient to modify behavior.
Ricci, Salas, & Cannon-Bowers (1996)	Evaluate the effectiveness of game	Quantitative (experimental)	60 (most are male)	45-minute gaming session	Puzzle game	Military students with a median age of 20	Military rules	Military training	Descriptive knowledge gain and retention, and attitude (value) toward subject	Gaming promoted knowledge gain and retention significantly more than text situation, but not different from test situation; participants in gaming demonstrated significantly higher attitudes than the other two situations.
Rosas et al. (2003)	Evaluate the effectiveness of game	Mixed-method (experimental and case study)	1,274	30 hours over a 3-month period	n/a	1st and 2nd graders from socio-economic disadvantaged schools in Chile	Reading, math, and spelling	School education course work	Cognitive learning achievement and motivation to learn	Game use had positive impact on motivation and classroom dynamics. There was significant difference between gaming group and internal control group in relation to the external control group, but no significant difference between gaming and internal control groups on cognitive learning achievement.
Sandford, Ulicsak, Facer, & Rudd (2007)	Explore game-based learning activity/design	Survey research	924	n/a	n/a	Primary and secondary school teacher	n/a	School education course work	General school learning	Teacher played important role in effective use of instructional games in classroom.
Santos (2002)	Evaluate the effectiveness of game	Quantitative (descriptive)	41	3 weeks	Business simulation game	College students	Business education	Higher education course work	Affect toward game-based learning	Students' affective feedback toward game use was favorable.
Simms (1998)	Evaluate the effectiveness of game	Qualitative	4	5 weekly lessons	Other (educational game)	College piano students with motivation problem	Musical skills (note identification and note playing)	Musical education	Motivation	There was evidence of motivational effects of game.
Spivey (1985)	Evaluate the effectiveness of game	Quantitative (experimental)	29	20 days	Puzzle games	1st graders	Math	School education course work	Cognitive math learning achievement	No significant effects of the game (with conventional teaching) on math learning (in comparison to conventional teaching only) was found.
Squire & Barab (2004)	Evaluate the effectiveness of game	Qualitative (case study)	18	6 weeks (3 times per week, 45 minutes per session)	Massive multi-user entertainment game	High school students who were academically disadvantaged	History, geography, and political science	School education course work	Game-based learning experience	Failure to understand basic facts drove students to learn; the game can be a powerful tool for engaging learners.

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Table 1. continued

Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Squire, Barnett, Grant, & Higginbotham (2004)	Evaluate the effectiveness of game	Mixed-method (experimental & case study)	96	n/a	3D simulation game	8th graders	Electromagnetic	School education course work	Conceptual knowledge	Gaming group outperformed the conventional instruction.
Strommen (1993)	Explore game-based learning activity	Quantitative (experimental)	56	n/a	Other (educational game)	4th graders	General learning	School education	Game task performance	Cooperative environment resulted in better game-based learning performance than the competitive environment.
Stone (1995)	Evaluate the effectiveness of game	Quantitative (descriptive)	248	n/a	Business strategy game	College students	Business management	Higher education course work	Affect toward game-based learning	Affective feedback toward game use was favorable.
Taylor (1987)	Evaluate the effectiveness of game	Quantitative (experimental)	194	1 lab session	Simulation game	College students	Political science	Higher education course work	Cognitive academic achievement and attitudes toward subject	There was no significant effect of game with lecture in comparison to lecture only.
Thomas & Cahill (1997)	Evaluate the effectiveness of game	Quantitative (descriptive)	211	1 lab session	Adventure game	High-risk adolescents (ages 12-22)	Health education	School education	Self-efficacy	There was significant effect of the game on self-efficacy improvement.
Tuzun (2004)	Explore game-based motivation process	Qualitative (ethnography)	20	Longitudinal	Massive multi-user game	School children	Science education	General learning	Motivation	Thirteen categories of motivational elements to play the game emerged: identity presentation, social relations, playing, learning, achievement, rewards, immersive, context, fantasy, uniqueness, creativity, curiosity, control, and ownership.
Tuzun (2007)	Evaluate the effectiveness of game and explore game-based learning activity design	Qualitative (case study)	77	1 week	Massive multi-user game	4th and 5th graders, 9th graders, and college students	Science education	School/higher education course work	Game-based learning experience	Potential of using game in classroom setting and relative issues: school infrastructure, role of teacher, classroom culture, distraction in games.
Van Eck (2006)	Evaluate the effectiveness of game and explore instructional game design	Quantitative (experimental)	123	50-minute gaming session	Simulation/ modeling game (with pedagogical advice or competition scheme)	7th and 8th graders ages 12-15 in Catholic school	Math	School education coursework	Attitude (value) toward subject	The game with no competition but contextual advisement promoted most positive attitude; and there was no significant difference between gaming and the control condition.
Vogel, Greenwood-Ericksen, Cannon-Bowers, & Bowers (2006)	Evaluate the effectiveness of game	Quantitative (quasi-experimental)	44	2 weeks with 10 minutes per day	Other (virtual reality game)	Children ages 7-12 (some were hearing-impaired)	Math and language arts	School education course work	Descriptive and conceptual knowledge	Game did not promote learning, neither more than conventional CAI, deaf children improved learning in conventional tradition more than in gaming.

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Study	Purpose	Method	Sample Size	Timeframe	Game Used	Learner	Learning Task	Learning Environment	Learning Outcome	Findings
Walters & Others (1997)	Explore the interaction between learner characteristics and game	Quantitative (descriptive and correlational-causal)	80	Half semester	Strategy simulation game	College students	Business functions	Higher education course work	Affect toward game-based learning	Students whose psychological profiles exhibited significant deviation from that required to function effectively in a team were less satisfied with game use.
Washbush & Gosen (2001)	Evaluate the effectiveness of game	Quantitative (correlational-causal)	474	1992-1997	Business enterprise simulation game	College students	Business management	Higher education course work	Cognitive learning achievement	Learning took place as a result of simulation participation, but there was no relationship between learning and simulation performance.
Wellington, Faria, & Nulsen (1996)	Evaluate the effectiveness of game	Quantitative (experimental)	130	A semester	Business simulation game	College students	Business marketing	Higher education course work	Cognitive process/strategy	Simulation play results primarily in behavioral learning, with cognitive learning playing a secondary role.
Wiebe & Martin (1994)	Evaluate the effectiveness of game	Quantitative (experimental)	109	1 lab session	Adventure game	5th and 6th graders	Geography	School education course work	Descriptive knowledge and attitudes toward subject	No significant effect of computer games in comparison to non-computer games.
Wildman & Reeves (1996)	Evaluate the effectiveness of game	Quantitative (descriptive)	557	n/a	Simulation game	Nursing students	Nursing education	Higher education course work	Game-based learning experience	Affective feedback was favorable and games encouraged teamwork.
Whitehill & McDonald (1993)	Evaluate the effectiveness of game and explore instructional game design	Quantitative (experimental)		1 lab session	Simulation game	Military personnel	Electric repairs	Military training	Problem solving and persistence	There was no significant effect of gaming, but game with variable payoff resulted in increased persistence.
Yip & Kwan (2006)	Evaluate the effectiveness of game	Quantitative (quasi-experimental)	100	9 weeks	Other (online educational game)	Engineering students	English vocabulary	Higher education	Descriptive knowledge and affect toward game-based learning	There was significant effect of games with lecture in comparison to lecture only, and the affective feedback was favorable.

game studies and are discussed with the support of exemplar studies.

Game Research Purpose and Methodology

The empirical studies coded can be classified into five major research purposes[1]: (1) evaluating the effects of computer-based game on learning (65 out of 89 studies), (2) exploring effective instructional game design (17 out of 89), (3) exploring game-based learning activity or pedagogy (9 out of 89), (4) evaluating the influence of learner characteristics on game-based learning process (10 out of 89), and (5) investigating cognitive or motivational processes during game playing (4 out of 89).

Studies on the Effects of Instructional Gaming

Studies that evaluated the effectiveness of computer-based games for learning purposes are predominant. Among these studies, 69% used quantitative design-experimental, quasi-experimental, correlational-causal, or descriptive. For example, Gopher, Weil, and Bareket (1994) investigated the effect of a flight simulation game on cadets' flight performance by randomly assigning 58 participants into two experimental conditions (gaming vs. conventional instruction). The experiment lasted 10 hours (one hour each session) and the results favored simulation game. Vogel, Greenwood-Ericksen, Cannon-Bowers, and Bowers (2006a) examined the difference between virtual reality games and conventional computer-assisted instruction in promoting math and language arts learning. They assigned 44 primary school students (in intact class unit) to two experimental conditions (lasting two weeks with 10 minute/day) and reported that there was no significant effect of games. Greenfield, Camaioni, Ercolani, and Weiss (1994) used one-group design in their game study and discovered that there was no significant correlation between college students' successful game performance and their achievement in scientific-technical discovery. Johnson (1993) surveyed 446 instructional game players after a six-minute gaming session and reported that game promoted significant self-efficacy.

Among the studies examining the effects of games, about 15% employed mixed-method design and another 15% were qualitative ethnography or case study. For example, Barab et al. (2007) evaluated the effects of a massive multiplayer online game on 28 fourth graders with both quantitative pre- and post-tests and qualitative in-field observation. Conversely, Piper, O'Brien, Morris, and Winograd (2006) reported a positive effect of a cooperative tabletop computer game for social skills development only with a thick, qualitative description.

In terms of results, 34 out of the 65 game effectiveness studies reported significant positive effects of computer-based game, 17 reported mixed results (instructional games facilitated certain learning outcomes but not the others), 12 reported no difference between computer games and conventional instruction, and only one study (Christensen & Gerber, 1990) reported conventional instruction as more effective than computer games.

It should be noted that in these 65 studies, computer games were compared with conventional instructions either as a stand-alone pedagogical instrument (e.g., Abbey, 1993; Bahr & Rieth, 1989; Cameron & Dwyer, 2005; Goldsworthy, Barab, & Goldsworthy, 2000) or as a drilling tool complementing the conventional instruction (e.g., Taylor, 1987; Gremmen & Potters, 1997; Yip & Kwan, 2006). In addition, less than 50% of the game evaluation studies were longitudinal; most of them lasted no more than two hours. This finding is in agreement with the claim by Emes (1997) that more longitudinal studies were still needed for game effectiveness evaluation. Another notable pattern is that qualitative studies tend to report positive effects of instructional games; few of them describe games' negative aspects.

Studies on Instructional Game Design

Among the 17 studies on game design, 10 are quantitative, three are qualitative, and the remainder are mixed-method. The examined game design features include pedagogical agent within a game, game playing group dynamics, games' goal condition (having specified goal or not), games' interface format (verbal narration, text, personalized speech or not), feedback type (elaborative or not), alignment of game-play and learning task, attitudes-triggering elements (grouping and competition), reward mechanism (at fixed or variable interval), complexity and authenticity level, richness of storyline, and the sort.

Most game design studies indicate significant results. A common finding extracted from these design studies is that instructional support features are a necessary part of instructional computer games. The studies generally conclude that learners without instructional support in game will learn to play the game rather than learn domain-specific knowledge embedded in the game (Leutner, 1993; Mandinch, 1987).

Studies on Game-Based Pedagogy

In this category of game studies, the researchers generally explore how game-based learning activities should be organized or administered, or how a game-based *external* learning environment should be constructed. For instance, Anderson (2005) examined how team dynamics, such as cohesiveness and heterogeneity, influenced team playing in a business enterprise simulation game and hence individuals' performance and attitudes toward game use. Bahr and Reith (1989), Ke and Grabowski (2006), and Strommen (1993) investigated whether the game-based learning goal structures-cooperative, competitive, and individualistic-influenced learning outcomes. Sandford, Ulicsak, Facer, and Rudd (2007) reported that teachers' facilitation played an important role in an effective use of instructional games in the classroom. These studies assert that the investigation on computer games for learning should focus on how games can be carefully aligned with sound pedagogical strategies or learning conditions to be beneficial.

Studies on Learner Characteristics

Only 10 out of 89 game studies examine the variable of learner characteristics; this confirms the finding by Dempsey et al. (1996) that studies on the interaction of learner characteristics and instructional game usage are limited. Among the studies reviewed, gender is the most examined learner characteristic. Some research (e.g., De Jean, Upitis, Koch, & Young, 1999; Inal & Cagiltay, 2007) has reported gender difference in terms of game-based learning performance and game design preference, while other research (e.g., Forsyth, 1986; Haynes, 2000; Ke & Grabowski, 2007) has not. Interestingly, the studies reporting gender difference are qualitative in nature, while those failing to find gender difference are mostly experimental and comparative in nature. A potential proposition extracted may be that gender influences game-play and learning processes more than learning outcomes.

Learner psychological profile or cognitive style (Walters et al., 1997; Cameron & Dwyer, 2005) is another examined characteristic variable. Generally, prior studies have reported that individuals' cognitive styles influence their performance in game-based team playing, yet failed to indicate the effect of cognitive styles on game-based individual learning.

In addition, learners with a lower socio-economic status and lower ability have been reported as enjoying games most (Papernv & Starn, 1989; Ke & Grabowski, 2007). Conversely, there is evidence suggesting learners with lower ability have difficulty extracting target knowledge from games (Mandinch, 1987).

Studies on Game-Based Cognitive or Motivation Processes

In the four studies that examined game-based cognitive processes (Alkan & Cagiltay, 2007; Cauzinille-Marmeche & Mathieu, 1989; Pillay, Brownlee, & Wilss, 1999; Pillay, 2002), game-based cognition is a graduate development from random trial-and-error strategy, general deductive reasoning, rule-based learning, purposeful tools usage, to a combined approach. There is also a record of game-based metacognitive self-planning and regulation processes, yet the evidence is descriptive and anecdotal. Tuzun (2004) explored game-based motivation process and found 13 core components of game-facilitated motivation: identity presentation, social relations, playing, learning, achievement, rewards, immersive, context, fantasy, uniqueness, creativity, curiosity, control, and ownership. Although the games used in these types of studies are not necessarily instructional in nature, the results on game-based cognitive or motivational processes address the question as to whether games are a potential anchor to activate learners' cognitive, metacognitive, and motivational processes.

Learning

As the analysis results indicate, game studies involve a variety of learning settings: informal learning, kindergarten/preschool education, elementary education, secondary education, adult education, business management, military, and healthcare. Business management education seems to be the one associated with the most prevalent positive outcomes.

Learning subject areas in game studies comprise science education, math, language arts, reading, physics, health, natural science, science, and non-content-related social skill and general problem-solving skill development. Although Randel et al. (1992) suggested that a breakdown of the available studies by subject matter reveals that some knowledge domains (i.e., math, physics, and language arts) are particularly suited to games, this pattern is not evident in the current analysis.

Cognitive learning outcomes in those reviewed studies consist of basic motor skill (e.g., Horn, Jones, & Hamlett, 1991), descriptive knowledge (e.g., Bartholomew et al., 2000), conceptual knowledge (e.g., Conati & Zhao, 2004), problem solving (e.g., Moreno, 2004), and general cognitive strategies (e.g., Cauzinille-Marmeche & Mathieu, 1989). An interesting pattern is that games seem to foster higher-order thinking (e.g., planning and reasoning) more than factual or verbal knowledge acquisition, which sustains the finding of Dempsey et al. (1996). Importantly, it should be noted that few game studies directly measured metacognitive process or outcome.

Affective learning outcomes, involving self-efficacy, value (or attitudes toward subject content learning), affective feedback toward game use, and continuing motivation (or persistence), are present in many game studies. Generally, instructional computer games seem to facilitate motivation across different learner groups and learning situations. This finding is in agreement with Vogel et al.'s (2006) quantitative meta-analysis conclusion that the effect size of games vs. traditional teaching methods is highly reliable for attitude outcomes.

Learners

In this analysis, school children and college students are predominant among the targeted learner groups. Fewer studies focus on adult learners, especially the elderly. Studies regarding games for learners with disabilities typically report significant positive effects of computer games on their learning performance (e.g., Horn et al., 1991; Inal & Cagiltay, 2007; Ota & DuPaul, 2002; Padgett, Strickland, & Coles, 2006). This finding suggests that computer games can be a powerful instructional intervention in special education.

Intervention: Game Genre and Features

Games used in these studies demonstrate a high heterogeneity and can be classified as simulations, puzzles, adventures, board games, action games, strategy games, and business simulation games. These games are different in terms of game genre, media format (2D or 3D), timeframe, game-play design, and instructional support features. Since all of these game features can potentially influence the effectiveness of a game for learning purposes, it is difficult to quantify and synthesize the impact of games across different studies to create a standard effect size, especially when certain gaming studies failed to clearly describe their gaming treatments.

FUTURE TRENDS

This grounded meta-analysis implicates a list of propositions on the future practice and research of instructional gaming. These propositions, with the support of synthesis findings, are discussed below.

Implications on Future Instructional Gaming Policy and Practice

As the analysis indicates, the learning outcomes achieved through computer games depend largely on how educationalists align learning (i.e., learning subject areas and learning purposes), learner characteristics, and game-based pedagogy with the design of an instructional game. Out of the 89 coded gaming studies, 36 (40%) have investigated the influential role of learning purposes, learner characteristics, game-based pedagogy, and instructional game features; they generally assert the significant effects of these mediating factors on game-based learning outcomes. Additionally, there is a trend that instructional gaming may serve certain levels of learning objectives (e.g., higher-order thinking and affective outcomes) better than the others (e.g., factual knowledge acquisition) or serve certain learners (e.g., learners with disabilities) better than others. Therefore, educationalists should more frequently ask *how* (as opposed to *whether*) games can be incorporated into learning environments. Rather than using games in a one-shot and decontextualized manner, educationalists should take a comprehensive diagnostic approach to identify and measure multiple influential factors in a game-based learning environment, thus deciding how to use games effectively or when to use games.

The analysis results also implicate a careful design of external and internal instructional support features for gaming application, especially when the games are used for factual knowledge development or learners who have lower prior ability and have difficulty extracting target knowledge from games. External instructional support can be provided using teacher facilitation, good team dynamics, or structured cooperative learning/playing (Anderson, 2005; Bahr & Reith, 1989; Ke & Grabowski, 2006; Sandford et al., 2007). Internal instructional support features, as the prior studies suggest, are a necessary part of instructional games and should be embedded within a game through elaborative feedback, pedagogical agent, and multimodal information presentation (Cameron & Dwyer, 2005; Conati & Zhao, 2004; Forsyth, 1986; Moreno & Mayer, 2002; Moreno, 2004).

The current analysis demonstrates that instructional gaming can be used in multiple educational settings that range from informal, community learning to school education. There is no evidence to suggest that gaming is favorable for certain educational settings but not others. Therefore, educational policymakers are encouraged to consider using games as a learning tool in situations both within and beyond the classroom.

Implications on Future Gaming Research

Consistent with the finding of previous gaming reviews, this analysis indicates that the empirical research on instructional gaming is fragmented by research variables (i.e., research purpose and methodology), administrative variables (i.e., learning setting), learner variables, procedural variables (i.e., game-based pedagogy), and game variables (e.g., game genre and media). It is proposed that instead of adopting one-shot, incoherent experiments, future gaming research should take a systematic, comprehensive approach to examine dynamics governing the relations among multiple influential variables in a game-based learning system.

In addition, it is found that the empirical research on instructional gaming tends to focus on traditional learner groups while ignoring adult learners, especially the elderly. Hence more evaluation studies should be conducted to measure the effects of games in adult education.

Finally, instructional gaming researchers should provide clear descriptions on games used and game application contexts when reporting their game evaluation results. Without knowing the specifics of every game application, the literature reviewers will have difficulty synthesizing the impact of games across different studies using explicit decision rules.

CONCLUSION

This chapter reports a grounded meta-analysis with 89 empirical studies on instructional gaming. Research features and findings of these empirical studies are synthesized qualitatively under standard coding rules. The four recurring themes (gaming research purpose and methodology, learning, learner, and instructional game intervention) have been extracted from the analysis to outline the four clusters of influential factors that weigh in the evaluation of instructional gaming. It is argued that the best models or best practices of designing and applying instructional gaming would form by carefully aligning and integrating the three clusters of key variables-learning, learner, and instructional game design.

NOTE

A single study may serve multiple research purposes.

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KEY TERMS

Effect Size: A name given to a family of indices that measure the magnitude of a treatment effect.

Game Genre: Computer games are categorized into genres based on their game-play. Due to a general lack of commonly agreed-upon criteria for the definition of genres, classification of games is not always consistent.

Game Play: In computer game terminology, used to describe the overall experience of playing the game. It refers to "*what player does.*"

Grounded Theory: A qualitative research method that uses a systematic set of procedures to develop an inductively derived theory about a phenomenon. The primary objective of grounded theory is to expand upon an explanation of a phenomenon by identifying the key elements of that phenomenon, and then categorizing the relationships of those elements to the context and process of the experiment.

Instructional Support Features: Instructional support, or "instructional overlay," is the component that serves to optimize learning and motivation within a multimedia learning environment, such as a simulation or game.

Simulation: A computer simulation is a computer program that attempts to simulate an abstract model of a particular system.

Simulation Game: A game that contains a mixture of skill, chance, and strategy to simulate an aspect of reality, or a simulation that has a game structure imposed on the system.