38 Game-Based Learning

Sigmund Tobias, J. Dexter Fletcher, and Alexander P. Wind

Abstract

This chapter reviews a rapidly growing body of empirical evidence on the effectiveness of using video and computer games to provide instruction. Evidence of their effectiveness is drawn from existing results and data. The topics covered here are transfer from computer games to external tasks, enhancing cognitive processes, guidance and animated agents, playing time and integration with curricular objectives, effects on game players, attitudes toward games, cost-effectiveness, and, finally, the use of games for evaluation. Areas where the evidence base is particularly weak are identified in the discussion section. Findings and recommendations for the design of games used in instruction are summarized in a table. The chapter concludes with a call for development of tools and technology for integrating the motivating aspects of games with good instructional design. People do learn from games. Missing are generally effective design processes that ensure that learners will acquire the specific knowledge and skills the games are intended to impart.

Keywords

Video games • Computer games • Serious games • Transfer of learning • Cognitive processes • Evaluation

Introduction

The popularity of computer games[1] has been evident for some time. McGonigal (2011) estimated that more than 180 million people in the United States report playing these games for more than 13 h per week. The Entertainment Software Association (ESA, 2009) reported that computer game sales in America grew 22.9 % in 2008 to $11.7 billion—more than quadrupling industry sales since 1996. The mean age of gamers was found to be 35, and 40 % were female. Relatively new is the increasing program time allocated to computer games at professional and scientific meetings and the development of programs of study dealing with computer games at academic institutions around the world (Tobias & Fletcher, 2011a). Few instructional methods engage similar levels of interest among learners or induce them to persist on tasks for as long as games do. Because of the evident motivational qualities of games, educators and trainers alike seek to use them for instruction.

This chapter examines existing research evidence in a number of areas covering the use of computer games for instruction. Topics where the evidence base is weak, such

S. Tobias, Ph.D. (✉) • A.P. Wind
University at Albany, State University of New York, 1400 Washington Avenue, Albany, NY 12222, USA
e-mail: SigTobias@gmail.com

J.D. Fletcher
Institute for Defense Analyses, 4850 Mark Center Drive, Alexandria, VA 22311-1882, USA
e-mail: fletcher@ida.org

[1] These may also be called video games or video and computer games. All refer to games with an interactive user interface and visual feedback. We use "computer games" in this chapter—or just "games" to keep it short—unless we are quoting from someone who uses "video game."

J.M. Spector et al. (eds.), *Handbook of Research on Educational Communications and Technology*,
DOI 10.1007/978-1-4614-3185-5_38,

as the effect of learner characteristics, are identified in the discussion section.

The studies included here were all conducted after the publication of the games research review by Randel, Morris, Wetzle, and Whitehead (1992). There has been a sharp increase in the number of studies dealing with computer games, since we started to monitor this literature (Fletcher & Tobias, 2006). It is, therefore, impossible to list every study in the area, even in a review of research running to 95 printed pages (Tobias, Fletcher, Dai, & Wind, 2011). We have tried to abstract the most representative research studies and those we considered most important for review.

Review of Empirical Evidence

Our perspective is empirical. It concerns studies that compare computer games to other instructional delivery systems. Of course there are other approaches (Barab, Gresalfi, & Ingramp-Noble, 2010; Gee, 2003, 2011; Squire, 2005, 2006) influenced by linguistics which could be called experiential, or perhaps constructivist. Learning from computer games—as in all learning—is mediated by engaging appropriate cognitive processes, irrespective of whether knowledge is acquired by playing games, by participating in game-related communities, or by using worked examples in the games. As suggested elsewhere (Tobias, 2009) we believe that an empirical approach helps identify the cognitive processes controlling learning.

Areas reviewed here are transfer from computer games to external tasks, enhancing cognitive processes, playing time and integration with curricular objectives, effects on participants, cost-effectiveness, guidance and animated agents, the use of games for evaluation, and, finally, recommendations for game design. Details (e.g., Ns, treatments, results) of primary studies are summarized in Table 38.1; a more complete table describing primary studies may be found elsewhere (Tobias et al., 2011).

Transfer from Games to External Tasks

A critical question about using games for instruction is whether cognitive or psychomotor capabilities or attitudes acquired during game play generalize to nongame contexts, such as school, work, or everyday life, i.e., do they transfer? Of course, if there is no transfer, games would be of little use for instruction. Contrasting findings of two studies from the 1990s illustrate the transfer issue clearly.

Gopher, Weil, and Bareket (1994) used the *Space Fortress II* computer game, modified by Donchin (1989) from the original (Mane & Donchin, 1989), to simulate a complex and dynamic aircraft flight environment. Game groups performed significantly better than the control group in piloting real aircraft. The superiority of the game groups was attributed to similarities in cognitive load and attention demands of the game with actual flight conditions.

In contrast, Hart and Battiste (1992) found no transfer effects for an off-the-shelf computer game (*Apache Strike Force*). The diverging results are probably attributable to the modifications of *Space Fortress* to simulate the cognitive demands of aircraft cockpits, whereas no similar attempts were made to *Apache Strike Force*. Tobias and Fletcher (2007) and Tobias et al. (2011) concluded that near or far transfer (e.g., Barnet & Ceci, 2002) from computer games may be expected when similar cognitive processes are engaged by the game and external task. When there is little overlap, transfer seems unlikely.

More recent transfer results have also been reported. Brown et al. (1997) found that young diabetic patients playing a computer game dealing with diabetes content gained more on various diabetes self-care behaviors than a comparison group playing a game without this content. Kato, Cole, Bradlyn, and Pollock (2008) found improved behaviors, knowledge, and efficacy attributable to a game among young cancer patients. Greitemeyer and Oswald (2010) demonstrated that playing a pro-social computer game, compared to one that was neutral, increased helping behaviors. Similar transfer findings have been reported elsewhere (Cannon-Bowers, Bowers, & Procci, 2011; Mayer, 2011; Sitzmann & Ely, 2009; Tobias et al., 2011).

Summary and Discussion

A number of studies have found that near and far transfer from computer games to external tasks occurs if they engage comparable cognitive processes. These findings further indicate that if transfer to external tasks is the objective, cognitive task analyses (Crandall, Klein, & Hoffman, 2006; Schraagen, Chipman, & Shalin, 2000) of both the game and the task need to be conducted to assess overlap in the processes engaged by both. If transfer from games to external tasks is desired, overlap must exist in the cognitive processes engaged by both, a finding consistent with research on transfer generally (Mestre, 2005). If such overlap is minimal, transfer is unlikely. Of course, transfer cannot be assumed on the basis of the task analyses alone, but must be determined independently by research.

While some findings suggest that computer games hold promise for transfer, current evidence for transfer is much weaker than the enthusiasm for using computer games in instruction. Substantial further research is needed, and specific suggestions were made (Tobias & Fletcher, 2011b; Tobias et al., 2011) to confirm these tentative conclusions, extend the supporting evidence, and specify game features likely to increase transfer.

Table 38.1 Research on games and learning

Reference SS characteristics	*n* per group	Treatment and duration	Metrics	Results
Adams (1998)		60 % of geography, planning, or urban study majors liked *SimCity* without reservations, 89 % of other majors like it without reservation. SS with prior topic knowledge more likely to recognize the program to be unrealistic and evaluated it more critically than less knowledgeable SS.		
Introductory urban geography class of 46 (11♀)	No groups	SS instructed to use *SimCity* software to complete 3 tasks	SS turned in an essay on game enjoyment, task, learning, and ideologies	0 % of ♀ and 60 % of ♂ SS had prior experience with game, 89 % non-majors and 60 % majors liked program
Anderson et al. (2010)		Meta-analytic procedures were used to test the effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, empathy/desensitization, and pro-social behavior. Meta-analyses yielded significant effects for all six outcomes Variables suggesting that exposure to violent video games is a causal risk factor for increased aggressive behavior, aggressive cognition, and aggressive affect and for decreased empathy and pro-social behavior		
138 papers $K=136$, $N=130{,}296$ drawn from Western and Japanese sources		Studies were identified and coded	Effect size ($r+$), research design, SS' ages, culture (West or Japan)	Exposure to violent games led to higher aggressive behavior ($r+=0.21$) and aggressive cognition ($r+=0.217$). Too few experimental/long studies for effect on pro-social behavior, empathy/desensitiza-tion, or arousal
Bailey et al. (2010)		Participants with high and low video game experience performed the Stroop task while brain activities were recorded. Results suggest that video game experience has a negative influence on proactive, but not reactive, cognitive control		
51 ♂ college students 18–33 years old	26 low gamers (1.76 h play/week), 25 high (43.4 h play/week)	SS selected based on prior question-naire, Study given again, SS given computerized Stroop task	Usage questionnaire, EEG activity (68 sensors), eye movement tracking, Stroop performance, and speed	No difference between groups time or accuracy on Stroop. No difference for reactive control. High gamers showed significant change on proactive reaction, low gamers no significant change
Baylor (2002)		Agents affected SS' self-reports, but not performance		
135 preservice teachers enrolled in Intro Educational Technology Course	2×2 design ± instructivist agent, ± constructivist agent	SS developed an instructional plan within computer-based environment	Meta-cognitive awareness and attitude	Presence of constructivist agent SS reported a change in planning, decreased reflection, and increased use of constructivist ideas. Presence of instructivist agent SS was more negative to instructional planning
Betz (1995–1996)		Simulation group, plus coordinated readings, had more knowledge, understanding, & application of concepts learned than reading group alone		
Freshmen engineering tech. SS enrolled in Materials & Methods of Construction	Not indicated	SS in game group played *SimCity 2000* game and did reading, SS in control only read	20 multiple choice and true false item exam and follow-up survey	Only 24 SS took exam, but experimental group outperformed control. Experimental group enjoyed computer simulation more than reading
Brown et al. (1997)		Improved diabetes self-care skills, communicating with parents, & decreased urgent care visits after playing game with diabetic content compared to controls playing an entertaining game		
59 diabetes patients, ages 8–16	Experimental: Educational game treatment group ($n=31$), entertainment game control group ($n=28$)	Experimental: A game with diabetes content. Control: Entertainment game with no diabetes information. 6 months	Self-care behaviors	Game groups superior in diabetes-related self-efficiency ($p<0.07$); communication with parents about diabetes ($p<0.025$); self-care behaviors ($p<0.003$); fewer unscheduled doctor visits ($p<0.08$)
Coller and Shernoff (2009)		Engagement of SS playing game to teach mechanical engineering assessed by self-report. SS who played game as part of homework showed more engagement than in other engineering courses		

(continued)

Table 38.1 (continued)

Reference				
SS characteristics	*n* per group	Treatment and duration	Metrics	Results
51 university students in dynamic systems and controls course		SS wore watches for three 1-week periods over semester which reminded to take self-inventory 20 times/week	Recorded what doing and perception of activity	SS used game related to the course. They were more involved and felt better using game than studying for other no-game courses
Costabile et al. (2003)		Lecture group outperformed game group. In later study after the game group was informed that teachers would monitor game performance carefully, no differences between lecture and game groups		
Experiment 1: 54 primary SS scoring below 7/10 on baseline logic test. Experiment 2: 40 primary SS	Experiment 1: The control group teacher assisted (TA), experimental group *Logiocando*. Experiment 2: Control and experimental ea $n=20$	Experiment 1: Control got two lectures from teacher; experimental used *Logiocando* tutoring software. Experiment 2: Same but more motivation training	Experiment 1 and 2: Pre- and posttests on set operations and diagrams	Experiment 1: All SS improved pre–post ($p<0.001$). Group effect was significant ($p<0.01$) favoring lecture. Experiment 2: All subjects improved pre–post ($p<0.001$). Group effect not significant
Din and Calao (2001)		SS improved spelling and reading, but not math, scores on standardized test compared to controls		
From 2 kindergarten classes, 5–6-year-olds, Black low SES families, most w 1 parent	$n=24$ in experimental class, $n=23$ in the control class	SS in the experimental received educational game consoles and used in class for 11 weeks	WRAT-R3 test of spelling, math and reading	Both groups improved pre to post. Experimental showed significantly greater imp. on spelling ($p<0.05$) and reading ($p<0.001$), but not math
Ferguson (2007)		Meta-analysis of 17 (1995–2007) studies found an average correlation of .14 between video game playing and aggressive behavior; 0.04 when corrected for publication bias		
Articles published between 1995 and 2007 with specific keywords	17 studies total sample size of 3,602	Meta-analysis	Pooled *r*	Effect of video game exposure on aggression $r^2=0.14$, publication bias is very prevalent, effect of violent game exposure on visuospatial cognition $r+=0.49$
Ferguson and Rueda (2010)		SS given a frustration task then played no game, a nonviolent game, a violent game with good versus evil theme, or a violent game in which they played as a "bad guy." Results do not support a link between violent video games and aggressive behavior, but do suggest that violent games reduce depression and hostile feelings in players through mood management		
103 undergrads (62♂) (98 Hispanic)	Antisocial violent game $n=26$, pro-social violent $n=26$, nonviolent game $n=25$, no game $n=26$	SS played violent, nonviolent, or no game then given computer frustration task	Video game use, aggression measure, post-game affects	No significant difference between groups on aggression, hostile feelings, depression
Ferguson et al. (2008)		Study 1 found that neither randomized exposure to violent video games nor prior real-life exposure to violence had any effect on aggressive behavior in the lab. Study 2 indicated that trait aggression, family violence, and male gender were predictive of violent crime but exposure to video game was not		
Study 1: 101 undergrads (46 ♂) Study 2: 428 undergrads (173 ♂)	Study 1: 1 group played violent games, 1 group played nonviolent, 1 group given choice of either. Study 2: no groups	Study 1: SS played games condition specific Study 2: SS given questionnaire	Study 1: Trait aggression video game habits. Study 2: demographics, trait aggression, video game habits, crime history	Study 1: No group differed on lab aggression $p>0.05$, no effects of past game exposure on lab aggression $p>0.05$. Study 2: Game violence is related to trait aggression $r=0.21$, not aggression or violent crime
Fontana and Beckerman (2004)		Students playing a violence prevention video game increased knowledge of conflict and anger management strategies		
204 second graders in 14 classes	90 in experimental, 114 in control	Experimental had access to interactive antiviolence video game and instruction, control engaged in no formal violence prevention program	Pre- and posttest on concepts of violence prevention and conflict resolution	Experimental group increased scores, control decreased, significant difference $p<0.05$

Gentile (2009)		A national survey of 1,178 US youths found that among those aged 8-18 pathological play patterns by 8.5 % who exhibited at least 6 of 11 symptoms listed in DSM. Pathological gamers played mean of 24.6 h/week, compared to a mean of 11.8 for non-pathological players		
1,178 nationally representative (US) sample 8–18-year-olds	NA	SS invited via e-mail and given 20-min survey online	SS asked about video game habits and pathological gaming based on DSM-IV path-gambling criteria	Data were weighted. 88 % of US youths play some video games. ♂ played more often and for longer ea session. As many as 19.8 % of the sample exhibited pathological gaming
Gopher et al. (1994)		After playing game dealing with flight (modified for similarity to cockpit processing demands), two experimental groups scored higher than controls in flying aircraft		
$n=59$ Israeli Air Force Cadets	16 full-time training, 17 in emphasis-only, 25 in control	Experiment: Ten 1-h sessions playing flight game modified to resemble cockpit processing demands; Control: No game experience	Flight instructor ratings from 8 training flights of 45–60 min	Game groups received higher instructor ratings than controls ($p<0.05$)
Green and Bavelier (2003)		In 4 experiments SS playing action game had superior performance on indices of visual attention compared to controls		
Male game players aged 18–23 played action games for 4 h/week	Varied	SS' game experience was ascertained, then tested	Performance on tests of visual attention and spatial distribution	Game players and those trained in games did significantly better on measures of visual attention than control
Greitemeyer and Oswald (2010)		In 4 experiments. playing pro-social video game increased pro-social behaviors		
German University students aged 18–56	Randomly assigned to conditions	Experiment 1: SS played pro-social, neutral, or aggressive games. Experiments 2–4: SS played pro-social or neutral	Pro-social behavior (actual and reported)	Showed that playing video games with pro-social content is positively related to increases in different kinds of pro-social behavior
Gremmen and Potters (1997)		Lectures supplemented with a game were more effective for teaching economics principles than lectures alone		
Three economics classes, 47 students total	Ea. class split into half	All SES played economics game, *SIER*, once, experimental played more and control received lectures only	Tests of SS' knowledge of international economics model	Both groups improved, but experimental improved more (p at least <0.1 for each test)
Harris and Williams (1985)		For SS playing mean of 240.8 min per week, English grades correlated −0.28 with game playing time and −0.20 with money spent on video games		
152 high school SS (80 ♂)	No groups	SS filled out questionnaire during class	1 page questionnaire with demographic and video game usage inquiries	All but 3 had played games, 23 did not currently play. SS played average 241 min/week. English grades correlated −.28 with time and −.20 with money spent on video games
Hart and Battiste (1992)		No transfer effects after playing game dealing with flight		
Student aviators who were about to enter flight school	2×3 design (33 warrant officer candidates, 37 officers)×(14 Space Fortress, 14 Apache Strike, 14 control)	SS in control did nothing, SS in experimental played either *Space Fortress* or *Apache Strike* in 10 daily 1-h sessions	*Space Fortress* yielded 15 measures of success, *Apache* yielded measures of success. Performance of all SS on Common Core flight training were assessed by SS and instructors	Performance on games improved from first to last session for both experimental groups ($p<0.0001$). Fewer in the Space Fortress failed at least 1 check ride than others. They did better on some components than other groups
Karle et al. (2010)		Video game players demonstrated a task-switching benefit compared to non-players. However, this benefit disappeared when proactive interference between tasks was increased, with substantial stimulus and response overlap in task set rules		

(continued)

Table 38.1 (continued)

Reference				
SS characteristics	*n* per group	Treatment and duration	Metrics	Results
Experiment 1: 56 undergrads all ♂ Experiment 2: 40 undergrads all ♂	Experiment 1: 30 action game players, 26 non-VG players. Experiment 2: 20 action game players, 20 non-VG players	Experiment 1: SS given computerized perception test. Experiment 2: SS given computerized task-switching test	Experiment 1: Perception test performance. Experiment 2: Task-switching performance	Experiment 1: Players showed significantly decreased reaction times on more complicated trials. Experiment 2: Players showed significantly decreased reaction times ($p<0.05$), no significant difference in accuracy
Kato et al. (2008)		*Re*-Mission, a cancer education game, or a commercial adventure game, taught adolescents and young adult cancer patients adherence to cancer-related prescribed behaviors. Adherence to medication was greater in the intervention group. Self-efficacy and knowledge also increased in the intervention group compared with the control group, but did not affect self-report measures of adherence, stress, control, or quality of life		
Patients who were aged 13–29 years w/ malignancy diagnosis undergoing treatment	Intervention *Re-Mission* game $n=197$, control commercial game $n=178$	All SS received computer asked to play game (either *Re-Mission*, a cancer education game, or a commercial adventure game) 1 h/week over 3-month period	Game usage was recorded, self-reported treatment adherence, antibiotic adherence, cancer knowledge, quality of life instrument	22 % of control and 33 of experimental played game at least 1 h/week. No significant difference between groups on treatment adherence. Experimental took 62 % of prescribed meds versus 53 % control. Intervention showed greater increase in cancer knowledge ($p=.035$) and no significant difference between groups on quality of life
Ke (2008)		A math computer game improved attitudes to math learning but not math performance and metacognitive awareness		
487 SS from 18 fifth-grade classes in 4 rural PA districts, 49 % ♀, 38 % low SES, 23 % below basic math ability, 34 % proficient, and 23 % advanced	Computer games $n=177$ (individualistic $n=57$, competitive $n=51$, cooperative $n=69$) Pen-and-paper drills $n=181$ (individualistic $n=58$, competitive $n=63$, cooperative $n=60$)	SS played *ASTRA EAGLE* edu games or pen and paper equivalents	Math skills, attitude test, and metacognitive scale	Experimental SS significant main effect for learning, and classroom goal structures
Laffey et al. (2003)		Children using math games gained more on math posttest than controls; "at-risk" children gained more than others		
187 pre-K-first grade low SES SS	22 at-risk with interactive computer tech (ICT), 19 at-risk with no ICT, 10 no-risk with ICT, 10 no-risk with no ICT	SS of high/low problem behavior had 16 sessions with interactive computer technology	Tests of mathematics behavior measures	Kids in ICT group had significantly more gain in math, $p<0.00$, no difference between at-risk and no risk in ICT group. No significant Δ in behavior
Leutner (1993)		SS without instructional support learned to play the game, but learned little about domain-specific concepts. SS given advice learned more domain-specific concepts, but learned to play the game only to a limited degree		
Study 1: 64 German seventh graders. Study 2: 38 University students. Study 3: 80 seventh and eighth graders	Study 1: 16/condition. Study 2: 19/group. Study 3: 20/group	Study 1: 2×2 design with ± pretutorial information and ± adaptive advice. Study 2: 2 groups ± adaptive advice. Study 3: 2×2 with ± background information ± adaptive advice	Study 1: Test of domain geology and game knowledge. Study 2: Functional knowledge, residual game, and domain knowledge. Study 3: Same	Study 1: Pretutorial—adaptive advice group did best on domain knowledge. Study 2: Presence of adaptive advice was significantly associated with increased scores. Study 3: Main effect of background information ($p=0.012$)
Moreno et al. (2001)		Animated agent facilitated transfer, recall, and interest ratings but not retention. Retention and transfer to problem solving improved with speech not text		
Study 1: Undergrads from psych pool. Study 2: 7[th] graders in urban middle school	Study 1: n=24 in no-pedagogical agent group, 20 in pedagogical agent group. Study 2: 24 in no-pedagogical agent group, 24 in the pedagogical agent	Computer tutorial either had a pedagogical agent or not. Study 1 took ~1 hr. Study 2 took ~90 min	Retention and transfer tests	Study 1: No significant group difference on retention. Agent significantly better on transfer than no agent ($p<0.005$). Study 2: No significant difference on retention between groups. Agent significantly better on transfer than no agent ($p<0.005$)

Rodrigo et al. (2008)		Compared intelligent tutoring system in mathematics and entertaining general problem-solving game and found observational ratings of frustration and boredom to be higher for the game and SS spent more time on task conversations in the game		
TIM study: 176 students in 6 Philippines high schools aged 12–19 (76♀)	36 students played The Incredible Machine game, 140 used *Aplusix* math tutoring software	SS in game condition played for 10 min in groups of 9, SS in tutoring used software for 45 min in groups of 10	Observed affect and behavior during session	SS in both groups mostly in flow state, but significantly more so in game ($p = 0.1$), frustration more common in game ($p = 0.001$), boredom more common with tutoring ($p = 0.0001$)
Roe and Muijs (1998)		Frequent European gamers also frequent television viewers, users of VCRs, film viewers, listeners to music and radio; they read less than others, spent less time with friends, scored lower on all indices of achievement, and had lower self-concepts and self-esteem		
Stratified random sample of 1,001 Flemish fourth graders from 51 schools	No groups	2 waves of questionnaires and concurrent parent questionnaire	Computer usage, self-concept, parent variables	9.2 % heavy computer game users. These were more likely to have working-class parents with lower education, watched more TV, and saw more movies
Ronen and Eliahu (1999)		Students liked using simulation for homework and found it more interesting and effective than other homework activities		
71 ninth graders (30♂) who completed computer literacy course	No groups	SS learned about electricity with open-environment software and workbook	Questionnaire, interviews, and grades	SS liked simulation (especially frequent users and higher scorers), most SS relied on simulation for feedback over other sources ($p < 0.001$)
Rosser et al. (2007)		Physicians' skill on 3 video games correlated with laparoscopic skill and suturing ability; past game experience predicted laparoscopic proficiency; players with no prior video game experience took more time to complete laparoscopic surgery drills and made more errors on them than those who played more than 3 h a week		
33 surgeons—21 residents, 12 attending	No groups	SS completed questionnaire on past videogame usage. Then they completed Top Gun virtual endoscopic training over 1.5 days. Finally SS played 3 commercial video games	Video game usage was self-reported, Top Gun success measures were time to completion and errors, video game scores were a composite of 3 game scores	Surgeons who never played video games took more time to complete and committed more errors in Top Gun drills than those who played >3 h a week (both $p = 0.03$)
Sims and Mayer (2002)		Skilled players outperformed less skilled on mental rotation tasks with stimuli similar to shapes used in game		
Study 1: Undergrads from psych pool. Study 2: Female grad students w/o *Tetris* experience	Study 1: 53 in low-skill group. Study 2: 8 experienced group, 8 no experience	Study 1: SS divided based on *Tetris* ability 2 sessions of ~40 and 60 min. Study 2: SS in experimental group played *Tetris* for fourteen 1-h sessions, non-experimental group played nothing	Both studies, performance on mental rotation tasks	Study 1: SS in high-skill group quicker on rotation tasks. Significant difference on rotation of *Tetris* shapes ($p < 0.01$). Study 2: No significant difference on pre- to posttest or between groups
Spicer and Stratford (2001)		SS using a virtual hypermedia-based field trip emphasizing televised images, with some opportunity for interaction, were unanimous that it was not a substitute for real field course. Result contrasted with findings that attitudes to virtual trip were positive and that student test scores re learning from trip did not differ from actual field trip		
Second-year students in zoology	No groups	SS participated in a "Virtual Field Trip"	Likert-type and open-ended rating of program	SS indicated "field notebook" feature as best feature (73 % of SS), and text to voice-over ratio as worst (37 %), SS liked the activity, but did not view it as replacement for real field trips
Sung et al. (2008)		Preschoolers playing a game designed to improve classification skills had improved skills in making distinctions between thematic and taxonomic relationships and hierarchical taxonomic concepts in comparison to other groups		
60 Taipei preschoolers aged 3.5–5.5	20/condition (10 each/age group)	SS took pretest, participated in 1 of the 2 games or a non-software activity, and then took posttest	SS took geometric tile test, thematic/taxonomic concept test, and hierarchical taxonomic concept test	SS in the sort software program outgained other 2 on pre- to posttest

(continued)

Table 38.1 (continued)

Reference SS characteristics	*n* per group	Treatment and duration	Metrics	Results
Tompson and Dass (2000)		Undergraduate business majors in a simulation strategic management course had greater increase in self-efficacy than controls studying the same material using case studies		
252 fourth-year undergrads in strategic management course	Experimental group $n = 126$, control $n = 126$	Experimental enrolled in courses which used computer simulation, whereas control taught primarily w/ case studies	Pre- and post-measures of course content knowledge and self-efficacy	Simulation accounted for significantly more gains in self-efficacy pre to post ($p < 0.01$)
Virvou and Katsionis (2008)		Educational games were more likable than non-game software. Novice players wasted most time suggesting a useful role for training and guidance in games		
Vos et al. (2011)		Compared students creating their own memory game versus those who played a premade memory game. Creating group showed greater motivation and deep strategy use		
113 fifth graders and 122 sixth-grade students from 9 Dutch classes	5 classes ($n = 128$) in construction condition, 4 classes ($n = 107$) in play condition	SS told about Dutch proverb. SS in construction condition instructed to create own drag-and-drop game about proverbs, SS in play played an existing drag-and-drop game on proverbs	Pre- and posttests on student use of deep strategy use and intrinsic motivation	Students in the construction condition showed greater motivation on all subscales, perceived competence ($p = 0.004$), interest ($p < 0.001$), and effort ($p < 0.001$). SS in construction condition showed more deep strategy use ($p < 0.001$)
50 children, 11–12 years old	15 novice, 20 intermediate, and 15 expert game players	SS played virtual and then non-virtual game. Later were given virtual game and then commercial game to take home	Computer monitoring, self-report use	Novice players did not use all game features. SS preferred virtual game to non-virtual. Advanced users preferred commercial game, no difference in preference for novices

Enhancing Cognitive Processes

Enhancing cognitive processes is an important outcome. Some research has found evidence for improvement in such processes from computer game playing. These findings may transcend issues of near or far transfer since, as indicated above, overlap in the cognitive processes engaged by games and external tasks is the basis for both types of transfer.

Green and Bavelier (2003) conducted five experiments comparing the visual abilities of those who played action games to non-players. They found improvements in different indices of visual attention for the players. Anderson and Bavelier (2011) reviewed a program of research and found that fast action games improved processes dealing with perception, attention, and cognition. They suggest that the results from many of their experiments may be attributable to increases in speed of processing, sensitivity to inputs in the environment, or flexibility in allocating cognitive and perceptual resources. They expected that such improvements would enhance performance in tasks like reading fine print or driving. Karle, Watter, and Shedden (2010) found that computer game players had significantly shorter reaction times on complicated perceptual tasks. However, they observed no group differences in time or accuracy in the ability to switch from one task to another.

Bailey, West, and Anderson (2010) compared the performance of groups playing an average of 43.4 h per week to those playing only 1.76 h per week on the Stroop (1935), considered to be a measure of selective attention, interference, cognitive flexibility, and/or processing speed. There was no difference between the players on test accuracy, but EEG activity indicated greater proactive reaction to changes for the high playing group suggesting enhanced cognitive processing activity. Sung, Chang, and Lee (2008) evaluated a multimedia computer game involving sorting designed to improve children's classification skills. Tests examined the children's ability to grasp simple and complex taxonomic concepts. They found improved classification skills for the group playing the classification skills game compared to participants in a non-software activity or others playing a game not designed to improve classification schemes.

Sims and Mayer (2002) found that undergraduates who were already skilled *Tetris* players outperformed less skilled players only on mental rotation tasks that presented stimuli similar to shapes used in the game. In a second experiment, female graduate students who played Tetris for fourteen 1-h sessions showed no improvement on mental rotation tasks. These results suggest that improvements in cognitive processes may be very specific to processes and stimuli used in the game, i.e., they lead to near but not far transfer.

Rosser et al. (2007) reported that game-playing surgeons made fewer errors and worked more rapidly during laparoscopic surgery (where a tiny camera and instruments are controlled by joysticks outside the body) than non-players, presumably because they engaged similar cognitive and psychomotor processes. Further evidence of improvements in processes underlying game performance was reviewed by Tobias et al. (2011).

Summary and Discussion

The findings suggest that computer games may lead to improvements in some cognitive and psychomotor processes. Results from Bavelier's research program (Anderson & Bavelier, 2011) and other studies suggest that the ability to flexibly alternate between tasks could lead to improvements in the skills of pilots, as also suggested by the Gopher et al. (1994) results. While the research in Bavelier's laboratory, and by others, is carefully designed and executed, the findings should be replicated and extended. These results offer the intriguing possibility of investigating the use of computer games to train cognitive processes in specific populations of interest (Tobias & Fletcher, 2011b). For example, while performance decrements due to aging are unlikely to be reversed by training, perhaps the pace of the decline in older groups could be reduced by games. Also, could games be used to improve the cognitive processes contributing to the difficulties of individuals with dyslexia or attention deficit disorders? The implications of Bavelier's results for effects on players' aggression are discussed later in this chapter.

Guidance and Animated Agents

Computer games often provide assistance or guidance to help players navigate in the game. Virvou and Katsionis (2008) found that such guidance was needed by novices to help them use the game effectively. Similarly, Leutner (1993) compared system-initiated advice and student-requested background information. Students who requested background information learned to play the game, but acquired minimal domain-specific concepts. The opposite occurred with system-initiated advice, i.e., students acquired more domain-specific concepts, but only learned to play the game to a limited degree.

Guidance is often delivered by animated agents, usually cartoon-like characters resembling human or animal figures, to help players use the game. Research findings regarding the use of animated agents have been equivocal (Dehn & van Mulken, 2000; Tobias et al., 2011). For example, Moreno, Mayer, Spires, and Lester (2001; see also Mayer, 2011) used a guided discovery learning environment and found that having animated instructional agents facilitated transfer and interest ratings but not retention. Baylor (2002) used two types of agents and found that they affected students' self-reports of different processes, but had little effect on performance in an instructional planning task.

Summary and Discussion

Moreno (2005) reviewed research on animated agents and concluded that since no studies found that agents interfered with learning or transfer, there seems to be little reason, other than development costs, to avoid them. The issue of providing guidance is more complex. Research reviews (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003; Wittwer & Renkl, 2008) found that help offered in computer displays, not necessarily game based, is infrequently used and does not facilitate learning. Furthermore, Wise and O'Neil (2009) found that the term "guidance" is ambiguous, and used to cover explanations, feedback, help, modeling, scaffolding, and procedural direction, among other instructional alternatives. Perhaps the guidance issue should be reframed in terms of instructional support (Tobias, 1982, 2009), i.e., any type of assistance that helps students learn. The ambiguity of findings regarding help or guidance may be clarified by developing a hierarchy of different forms of instructional support and studying the types of support that facilitate game learning.

Playing Time and Relationship to Course of Study

Time on task in technology-based instruction is readily measured and may be used for assessment or to guide individualization. Although studies have shown that time in simulations and computer games may not always track student learning because of student excursions to explore and answer their "what-if" questions (Hoover & Fletcher, 2011), it has been found to be far more closely related to learning and transfer than seat time in classroom learning (e.g., Bickley, 1980; Orlansky & String, 1977; Suppes, Fletcher, & Zanotti, 1975, 1976). Research on time devoted to game playing and the relationship of games to curriculum are discussed below.

Time

Harris and Williams (1985) found that students, including some non-game players, were playing an average of 241 min per week. Students' English grades were negatively correlated with both time and money spent on games. Betz (1995–1996) reported that participants spent more time on a simulation than on a comparison reading task. Similarly, Laffey, Espinosa, Moore, and Lodree (2003) reported that students in game conditions received more instruction than did non-gaming controls.

Integration with Courses of Study

Coller and Shernoff (2009) found that students who played a computer game designed to teach mechanical engineering as part of their homework evaluated it more positively and were more engaged in the course than in other engineering courses. Din and Calao (2001) reported that learning increased when the games played were integrated into the curriculum. Similarly, Henderson, Klemes, and Eshet (2000) stressed the importance of curriculum integration, and Gremmen and Potters (1997) found that lectures supplemented by a computer game were more effective for teaching economics principles than lectures alone. Costabile, De Angeli, Roselli, Lanzilotti, and Plantamura (2003) found that learning from a game increased when students were informed that teachers would monitor their performance in an instructional game. Jackson and McNamara (2011) found that adding game elements improved student engagement and enjoyment in an intelligent tutoring system.

Finally, Sitzmann and Ely (2009) reported that students learned more from computer games supplemented by other instruction than from games alone. Their analysis of 55 studies (Sitzmann, 2011; Sitzmann & Ely, 2009) found that learners using computer-based simulation games outscored control groups on self-efficacy, declarative and procedural knowledge, and retention. Learning was found to increase if games conveyed content actively rather than passively and learners could access the game as often as desired. More learning occurred in the comparison instructional method if it engaged learners actively. Surprisingly, games receiving higher ratings for fun were no more likely to yield gains in motivation and affect than those receiving lower ratings.

Summary and Discussion

With regard to time, the evidence indicates that students spend more time on computer games and simulations than on comparison instructional methods. These findings raise the possibility (Tobias et al., 2011) that any gains from games may be attributable to the greater amounts of time spent playing them rather than any affordances of games. It is well known (Fisher & Berliner, 1985; Suppes et al., 1975, 1976) that the amount of time students are engaged with instructional material is positively related to learning. Research is needed in which time on task is systematically varied to determine whether learning from games is attributable to increased engaged time, or to other factors. If learning gains can be attributed to time spent playing, research might compare games to other ways of increasing students' time on task to assess their cost-effectiveness.

Playing computer games unrelated to curricula may be fun, but it is not likely to enhance progress toward targeted learning objectives unless the game is integrated with other instructional material (Tobias et al., 2011). Games can be integrated by including features requiring students to retrieve additional information from resources external to the game, such as printed matter, laboratory exercises, and Internet inline links ("hot links"). Reentry into games could be made contingent on students' mastering the data from external sources. These are relatively simple ways of integrating learning from computer games into courses of study. Game designers will doubtless develop other, more imaginative techniques of integration.

Effects of Games on Players

The amount of time people spend playing computer games may well affect their behavior and performance away from the games they play. We discuss research on the effects of game playing in two areas: school learning and aggression.

School Learning

Roe and Muijs (1998) found that students who were frequent game players were often also frequent television viewers, users of VCRs, film viewers, or listeners to music and radio. They read less than others, spent less time with friends, had lower self-concepts and self-esteem, and scored lower on all indices of school learning and achievement. Harris and Williams (1985) found that students' English grades were negatively correlated with both time and money spent on games. Gentile's integrative article (2011) reported similar effects.

Aggression

Gentile's (2005) review of the effects of games on aggression found that despite major design flaws in some research "given the preponderance of evidence from all types of studies (experimental, cross-sectional, longitudinal, and meta-analytic), it seems reasonable to conclude that violent games do indeed have an effect on aggression" (p. 17). Similar conclusions were reached by Gentile, Lynch, Linder, and Walsh (2004).

Using the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2000), Gentile (2009) found that among youths aged 8–18, "8.5 % of video-game players exhibited pathological patterns of play as defined by exhibiting at least 6 out of 11 symptoms of damage to family, social, school, or psychological functioning" (p. 600). Players exhibiting these pathological patterns played a mean of 24.6 h per week, compared to a mean of 11.8 for those who did not. In view of these findings extensive game playing is of concern and should be studied more intensively.

Anderson et al. (2003) reviewed research on violent television and films, computer games, and music. They found "unequivocal evidence that media violence increases the likelihood of aggressive and violent behavior" (p. 81). Their summary dealing with games alone concluded that "The experimental studies demonstrate that in the short term, violent video games cause increases in aggressive thoughts, affect, and behavior; increases in physiological arousal; and decreases in helpful behavior. The cross-sectional studies link repeated exposure to violent video games with aggressive and violent behavior in the real world. The longitudinal studies further suggest long-term effects of repeated exposure to violent video games on aggression and violence" (p. 93).

Contrary to these results, Ferguson (2007) conducted a meta-analysis of 17 studies and found an average correlation of 0.14 between game playing and aggressive behavior; corrected for publication bias the correlation dropped to 0.04. A later study (Ferguson et al., 2008) had 101 undergraduate students play games that were violent, nonviolent, or gave them a choice of the two. The results indicated that neither random exposure nor previous real-life exposure to violent computer games had any effect on aggressive behavior in the laboratory using a task that involved punishing a fictional opponent. In a second study they found that trait aggression, family violence, and male gender, but not exposure to computer games, were predictive of violent crime. Ferguson and Rueda (2010) found no difference in aggression, hostile feelings, or depression following play of a violent, nonviolent, or no game at all.

Finally, Anderson and Bavelier's (2011) results present a paradox. The improvements they found in cognitive processes resulting from playing first-person shooter games raised the possibility that games that improve cognitive capabilities may also increase aggressive or hostile behavior. Whether it was the aggressive or the hostile content or the rapid reaction times that facilitated the learning noted by Anderson and Bavelier remains to be determined. Research is needed to examine if games requiring very fast reactions but lacking aggressive components lead to cognitive enhancement without increasing aggressive and/or hostile behavior.

Summary and Discussion

The negative relationships between school learning and computer game playing is a statistical finding. Whether game playing actually causes a reduction in school performance or is simply a correlate remains to be determined. Some results, e.g., Sitzmann and Ely (2009), suggest that there might even be a positive effect of playing some games on school learning. The body of research and findings on this issue, as on others related to game playing, is still young and emerging.

Given the contrary reports now available it seems possible that computer game playing may increase tendencies toward hostile and/or aggressive behavior in some individuals, but the evidence is not conclusive. Still, it would be paradoxical to assume that students can learn different knowledge, skills, and attitudes from games but *not* aggressive reactions (Tobias et al., 2011). The findings described above (see also Anderson et al., 2010) echo findings by Bandura and Walters reported in 1963 (before the use of computers) that participation in aggressive games increased aggression in non-game contexts. Even Ferguson (2007) argued about the effect size of aggressive games, rather than whether they did occur. Future research needs to clarify these effects.

An interesting alternative to games that may be increasing players' aggressiveness is to provide games with pro-social content. Greitemeyer and Oswald (2010), as summarized above, found that games with such content increased similar actions in daily life. Also, Fontana and Beckerman (2004) found that a game used to teach conflict resolution techniques increased the use of these techniques. These findings suggest research to investigate whether increases in aggressive behavior observed among some game players can be reduced by assigning them to games with pro-social content.

Attitudes Toward Games

Ronen and Eliahu (1999) reported that students they surveyed preferred using a program especially designed for developing and presenting simulation-based activities on electric circuits for homework and found it both more interesting and effective than other homework activities. On the other hand, Spicer and Stratford (2001) reported that students employing a simulation dealing with a virtual hypermedia-based field trip that emphasized televised images, with some opportunity for interaction, "were unanimous in their view that it was not a substitute for a real field course" (p. 351). This result contrasted with their findings that attitudes to the virtual trip were positive and that student learning from the trip, determined by test scores, did not differ from an actual field trip.

Adams (1998) reported that "only 60 % of geography, planning, or urban studies majors reported liking *SimCity* without reservations, while 89 % of other majors '… professed to like the program without reservation" (p. 52). Students with prior knowledge of the topic were more likely to recognize that the program was unrealistic and evaluated it more critically than less knowledgeable students. Ke (2008) found that a mathematics game, compared to learning math with pen-and-paper drills, improved attitudes to math learning but not math performance or metacognitive awareness.

Similarly Ronen and Eliahu (2000) reported that the same simulation used in their prior study described above (Ronen & Eliahu, 1999) contributed to students' confidence and enhanced their motivation to stay on task. They noted that the simulation helped 70 % of the students with the task. Neither students with insufficient understanding of the domain nor those with substantial understanding profited from the simulation.

Rodrigo et al. (2008) found that observers' ratings of frustration and boredom for students were higher for a computer game than for an intelligent tutoring system. However, the tutoring system and the game did not deal with the same subject area, were used by students in different years, and were not used for the same amounts of time. Finally, the results for several other variables were not significant when evaluated by the multiple t tests reported. A multivariate analysis of variance may have altered the pattern of the results.

Agency, or control, over game play may determine the level of involvement and motivation in using a game for learning (Sitzmann & Ely, 2009), as also demonstrated by Klimmt, Hartmann, and Frey (2007). Vos, van der Meijden, and Denessenm (2011) found that students who constructed games showed greater motivation, perceived confidence, interest, effort, and deep strategy use than those who played a previously constructed game.

Summary and Discussion

Even though computer games are clearly popular, results of attitudes to game studies are mixed. There seems to be a hint of interaction between attitudes and prior domain knowledge (Dai & Wind, 2011; Tobias & Fletcher, 2011b). Therefore, studying both variables simultaneously may help determine the features of games and simulations that are most important in improving attitudes and facilitating learning from games for students with differing levels of domain familiarity.

Collecting attitudinal data on educational games may be especially important since researchers (Games & Squire, 2011) and game designers (Prensky, 2011) indicate that games specifically designed for educational purposes are not as much fun to play compared to those designed only for fun. Educational games are certainly not as widely distributed, or as successful financially as those developed for amusement.

Cost-Effectiveness Analysis

The problem for decision makers in education and training is not simply to improve current practice with new and more effective approaches. They must also balance such improvements against what must be given up, i.e., costs to implement and employ them. Without knowledge of costs, decision makers' risk is greater and their decisions more precarious. Without this knowledge, they may well opt for the status quo, no matter how promising a new direction might be.

The cost-effectiveness argument for using games in learning appears to be fourfold (Fletcher, 2011):

(a) People will voluntarily persist in playing games longer than they will engage in non-game learning.

(b) If the game is instructionally relevant, this engagement increases time on (learning) tasks.

(c) Increased time on learning tasks will yield increased learning.

(d) Therefore, people may learn more from games than from some other instructional environments without increasing costs.

There is support for this argument. For instance, if, as Gentile (2009) reported, young people aged 8–18 are averaging 13.2 h per week playing computer games, not because they have to, but because they want to, then they might persevere equally persistently in playing games with embedded learning material.

Cost analyses use a variety of techniques. Two of the most common are Return on Investment (ROI) and Cost-Effectiveness Analysis (CEA).

Return on Investment

The basic formula for calculating ROI is as straightforward as its name suggests. As discussed by Phillips (2003) and others, it is

$$\text{ROI} = \frac{\text{Value of the result} - \text{Cost of the investment}}{\text{Cost of the investment}}$$

ROI shows the net value returned per unit of cost invested. It is usually calculated for some period of time, such as a year. The time period chosen depends on those seeking information and performing the analysis. There are, of course, spikes, dips, and diminishing returns to be considered with differently timed units of investment. ROI requires "Value" and "Cost" to be commensurable—expressed in the same unit of measure, which is usually and most frequently monetary.

The issues that arise with the investment side of ROI usually concern what cost elements should be included, how to define them, and what values should be assigned to parameters such as discount, interest, depreciation, inflation, and amortization rates. Levin and McEwan (2001), Phillips (2003), Rossi, Lipsey, and Freeman (2003), and Fletcher (2010) among others have discussed the use and application of these matters in general. They should be considered in the specific case of game-based learning.

Cost-Effectiveness

Unlike ROI, CEA does not require commensurability. Effectiveness can be expressed in whatever terms that are most useful to analysts and decision makers. However, and also unlike ROI, CEA is a relative term; it must be expressed in reference to other alternatives—such as use of games versus conventional classroom instruction.

Cost-effectiveness is usually calculated as a ratio providing the amount of effectiveness delivered per unit cost. It is common practice in determining cost-effectiveness to hold costs constant and observe variations in effectiveness (e.g., amount learned) or to hold effectiveness constant and observe variations in costs (e.g., time to criterion). For example, Fletcher, Hawley, and Piele (1990) examined the costs to increase scores one standard deviation on a standard mathematics test under five alternatives: increasing length of school day, reducing class size, using hired tutors, using peer tutors, and using computer-based instruction. Ross, Barkaoui, and Scott (2007) provide a review of 31 carefully selected studies with examples of CEA in education.

Summary and Discussion

Cost analyses are as subject to controversy as are any other analyses or assessments. Differences in data, data definitions, analysis techniques, models, and assumptions are all subject to question. It is unlikely that any cost analysis will satisfy all decision makers. The problem has been mitigated elsewhere by the acceptance of specifications and standards. Analysts have suggested a variety of models with practicable, well-defined cost elements for education (Fletcher, 2010; Levin, 1983; Levin & McEwan, 2001), industrial training (Kearsley, 1982; Phillips, 2003), and military training (Fletcher & Chatham, 2010; Knapp & Orlansky, 1983), but these are rarely noted, heeded, or used. They could be reconciled and abstracted into a unified, generally applicable model, but at present they remain separated by different approaches, cost elements, and definitions.

The best that can be done today in cost analysis for game-based learning, as in any other analysis, is to be compulsively explicit so that decision makers can determine how well the specific objectives and methodology of any particular cost analysis apply to and inform the decisions they must make. In short, these analyses can never be perfect, but they can, and should, be as explicit as possible. Decisions about implementing and using game-based learning need to be explicitly informed by empirically derived cost data, which, as indicated above, is often scarce, or absent.

Using Games for Evaluation

It has been suggested that computer games may become an important new capability in evaluation (Everson, 2011; Gee & Shaffer, 2010). Shute (2011) proposes a "stealth" evaluation paradigm to assess learning from games unobtrusively enabling data collection without interrupting game play. Stealth evaluation would reduce the division between game play, instruction, and evaluation. If research supports such use of games some interesting research possibilities arise. It would be useful to study whether enjoyment in game playing reduces test anxiety, which is generally associated with being evaluated (Tobias, 1992), compared to other forms of evaluation. If such reductions occur, research could then examine whether games may be more useful, or accurate, assessment tools especially for individuals high in test anxiety.

Summary and Discussion

At present there are few examples and less data on the application and value of computer games used for evaluation. For instance, there has been very little, if any, research on the psychometric properties of games. How many games must be played for how long to ensure reliability, validity, and precision in assessing not just game proficiency but also progress toward achieving specified instructional goals? Some of the techniques developed for assessing learning in intelligent tutoring systems and in simulation-based learning may well be applicable, but few games now employ them in a systematic manner. In any case, it is difficult to imagine any successful instructional program without some systemic assessment of learning. Research and development must be completed to develop techniques and procedures for game-based learning assessment if we are to be serious about the use of games in instruction.

Discussion

The research reviewed above indicates that games hold promise as instructional delivery systems, a conclusion also reached by Honey and Hilton (2011) in a special committee report of the National Academies charged with studying the effectiveness of using games in science instruction. As noted above, there is research support for that conclusion, but the evidence is much thinner than the enthusiasm for using game-suggests, leading to two implications.

First, further research and theoretical development are urgently needed in a variety of areas. We have made some suggestions above, and summarize others below. However, space constraints make it impossible to discuss the many questions that should be investigated. We have done so elsewhere (Tobias & Fletcher, 2011b; Tobias et al., 2011), as have others. Second, the study and development of computer games in instruction need a generally agreed-upon taxonomy of games used in this manner.

Taxonomy of Games

The literature is filled with such terms as "serious games," "educational games," "fast action games," "first person shooters," etc. While these terms are convenient shorthand descriptions of game genres, they are insufficiently precise to differentiate the characteristics of games from each other. There is a need for a generally accepted taxonomy of games. That is especially important because different types of games may have different learning outcomes.

A taxonomy will make it possible to relate types of games to the learning results that may be expected from them. Such specificity helps game developers and researchers organize the knowledge base about game-based learning, identify needed research more effectively, and provide research-based prescriptions for using different types of games. Gentile (2011) proposed five dimensions of game play, four of which may be applied in developing a game taxonomy. They are content of play, game context, game structure, and mechanics of game play.

An additional layer in a game taxonomy should cover student characteristics. There is evidence (e.g., Dai & Wind, 2011; Tobias et al., 2011) that outcomes vary for different types of individuals. For example, Kamill and Taitague (2011) found that a vocabulary game facilitated vocabulary acquisition for some students who were *not* native speakers of English, but had little effect on native English speakers. Similarly, Fraas (1982) reported that students with lower prior knowledge of economics, or lower scholastic aptitude, profited more from games than others with higher knowledge or aptitude. As suggested elsewhere (Gustafsson & Undheim, 1996; Tobias, 2009) interactions with prior knowledge are often reported in the literature dealing with instruction generally and may be one of the most frequently replicated effects in research on adapting instruction to student characteristics. Emerging techniques for modeling prior knowledge with links to ontological descriptions of subject matter seems a particularly promising approach in this area (e.g., Grubiši , in preparation).

Interactions between prior knowledge and instructional support (Tobias, 1973, 1976, 1989, 2009) predict that students with limited prior knowledge need substantial support to learn, whereas those with extensive prior knowledge could succeed with little support. As Dai and Wind (2011) suggest, games may be especially useful for students who do not succeed with traditional instructional methods, a conclusion also reached in the National Research Committee report (Honey & Hilton, 2011). Because they can adjust more readily to learners, games may not require as much prior knowledge as school-based instruction. Furthermore, the strong motivation to play games may be an antidote for students with low motivation for school and/or learning, leading them to work longer and more intensely than they do in traditional instructional settings. These factors all suggest that a taxonomy of games should include information about the types of students for whom particular types of games may be especially beneficial.

Recommendations for Game Design

A number of research-based recommendations for the design of games were made by Tobias and Fletcher (2007), and extended elsewhere (Tobias et al., 2011). We have summarized these and updated them in Table 38.2, which also includes citations of selected research reviews.

The rationale for many recommendations in Table 38.2 were derived directly from the various issues discussed above; hence there is little reason for repeating them here. We shall add to those discussions to amplify material that was only summarized above, or to add information not mentioned previously.

Virvou and Katsionis (2008) found that novice players wasted time learning to navigate the game, and hence instructional support in the form of guidance is especially important for them. The desirability of providing pictorial, rather than textual, instructional support derives from the multimedia principle (Fletcher & Tobias, 2005) that the recall of pictorial material is usually more accurate than for textual content, presumably because it reduces the cognitive load for game players (Mayer, Mautone, & Prothero, 2002).

Discovery learning, one form of constructivist instruction, has been sharply criticized from a number of quarters (Kirschner, Sweller, & Clark, 2006; Mayer, 2004). The controversy about the effectiveness of constructivist or explicit instructional approaches has been summarized elsewhere (Tobias & Duffy, 2009) and is beyond the scope of this chapter. It should be noted, however, that both constructivists and their critics recommend guidance, though definitions of the term differ somewhat (Tobias & Duffy, 2009). Similarly, the recommendation to maximize user involvement is widely shared by both constructivists and supporters of explicit instruction though, again, definitions of user involvement vary. Collecting user responses in the game is, of course, vital because it provides clues regarding students' present status and comprehension of the game.

Designing computer games is an extremely complex activity. It is unlikely that any one individual possesses all the skills needed to do this effectively. In agreement with others (Belanich & Orvis, 2006; Jayakanthan, 2002; Leutner, 1993; O'Neil, Wainess & Baker, 2005; Squire, 2005), we continue to recommend that game design be a team process

Table 38.2 Recommendations for designs

Recommendation	Supporting literature
1. Conduct cognitive task analysis to identify the cognitive processes engaged by game and required by task	Brown et al. (1997), Fery and Ponserre (2001), Gopher et al. (1994), Green and Bavelier (2003), Greenfield (1998), Greenfield, Brannon, and Lohr (1994), Greenfield, Camaioni, Ercolani, Weiss, and Lauber (1994), Greenfield, deWinstanley, Kilpatrick, and Kaye (1994), Mayer et al. (2002), Moreno and Mayer (2004, 2005), Okagaki and Frensch (1994), Rosser et al. (2007), Sims and Mayer (2002), Subrahmanyam and Greenfield (1994), Tobias et al. (2011)
2. Provide guidance	
(a) Provide pictorial support	Fletcher and Tobias (2005), Greenfield, Camaioni et al. (1994), Kalyuga, Ayres, Chandler, and Sweller (2003), Lee (1999), Mayer (2001, 2006), Mayer et al. (2002), Moreno (2005), Moreno and Mayer (2005), Rieber (2005), Swaak and de Jong (2001), Sweller (2006)
(b) Encourage reflection about correct answers	Moreno (2005), Moreno and Mayer (2005)
(c) Provide guidance/support for discovery learning	Kirschner et al. (2006), Mayer (2004), Swaak and de Jong (2001), Tobias and Duffy (2009)
3. Use first person in dialogue	Moreno and Mayer (2000, 2004)
4. Use animated agents in interactions with players	Baylor (2002), Moreno (2005), Moreno and Flowerday (2006), Moreno et al. (2001)
5. Use human, rather than synthetic voices	Atkinson, Mayer, and Merrill (2005)
6. Maximize user involvement	Fletcher (2004), Wishart (1990)
7. Reduce cognitive load	Kirschner et al. (2006), Mayer et al. (2002), Sweller (2006)
8. Maximize motivation	Lepper and Malone (1987), Malone (1981a, 1981b), Malone and Lepper (1987)
9. Increase pro-social content and reduce aggressive content	Anderson and Bushman (2001), Anderson and Dill (2000), Fontana and Beckerman (2004), Gentile (2005), Tobias et al. (2011)
10. Revise games and task analyses	Hays (2005), O'Neil et al. (2005)
11. Integrate games w/instructional objectives and other instruction	Leutner (1993), Gremmen and Potters (1997), Sitzmann and Ely (2009), Henderson et al. (2000), Tobias et al. (2011)
12. Keep abreast of emerging research findings	O'Neil et al. (2005), Tobias et al. (2011)
13. Use teams to develop instructional games	Squire (2005), Tobias & Fletcher, 2011a, 2011b

(Tobias & Fletcher, 2007, 2011b; Tobias et al., 2011). In addition to game designers and computer and interface specialists, game development teams should include subject matter experts in the domain to which games are expected to transfer, as well as experts in instructional systems design, cognitive task analysis, and game research. It may be difficult, and certainly costly, to have so many different specialists on a game development team. However, costs of development teams are decreased because many of the specialists mentioned above do not have to be regular team members, but could be consulted as needed.

Final Word

Ensuring learner motivation has always been a critical aspect of good instructional design (Martin & Reigeluth, 1999). The evident attraction of games for a significant portion of the learning population is proving to be equally irresistible to instructional designers. The research is clear; people do learn from games. What we need is a way to design games so that people learn what they need to learn. We need and do not yet have generally effective techniques, processes, and procedures for designing games that reliably achieve intended instructional objectives. Integrating the motivating aspects of games with good instructional design is critical—Kirkley, Tomblin, and Kirkley (2005) proposed a tool facilitating this integration. Such integration is a serious and challenging endeavor, which, if it can be successfully articulated in systematic procedures that reliably achieve instructional goals, will yield sizable benefits for learning technology. At the very least, the effort to meet this challenge should teach us much about using games in instruction and how to design more motivating instruction overall.

References

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

Aleven, V., Stahl, E., Schworm, S., Fischer, F., & Wallace, R. (2003). Help seeking and help design in interactive learning environments. *Review of Educational Research, 73*, 277–320.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders*. Washington, DC: American Psychiatric Association.

*Anderson, A. F., & Bavelier, D. (2011). Action game play as a tool to enhance perception, attention and cognition. In S. Tobias & J.D. Fletcher (Eds.) *Computer Games and Instruction* (pp. 307–330). Charllotte, NC: Information Age

Anderson, C. A., Berkowitz, L., Donnerstein, E., Huesmann, R. L., Johnson, J. D., Linz, D., et al. (2003). The influence of media violence on youth. *Psychological Science in the Public Interest, 4*, 81–110.

Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A meta-analytic review of the scientific literature. *Psychological Science, 12*, 353–359.

Anderson, C. A., & Dill, K. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology, 78*, 772–790.

*Anderson, C. A., Shibuya, A., Ihori, N, Swing, E. L., Bushman, B. J., Sakamoto, A., Rothstein, H. R., & Saleem, M. (2010). Violent video game effects on aggression, empathy, and prosocial behavior in Eastern and Western countries: A meta-analytic review. *Psychological Bulletin, 136*(2), 151–173.

Atkinson, R. K., Mayer, R. E., & Merrill, M. M. (2005). Fostering social agency in multimedia learning. Examining the impact of an animated agent's voice. *Contemporary Educational Psychology, 30*, 117–139.

Bailey, K., West, R., & Anderson, C. A. (2010). A negative association between video game experience and proactive cognitive control. *Psychophysiology, 47*, 34–42.

Bandura, A., & Walters, R. H. (1963). *Social learning and personality development*. New York, NY: Holt, Rinehart, & Winston.

Barab, S., Gresalfi, M., & Ingramp-Noble, A. (2010). Tranformational play: Using games to position person, content, and context. *Educational Researcher, 39*(7), 525–536.

Barnet, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy of far transfer. *Psychological Bulletin, 128*, 612–637.

Baylor, A. L. (2002). Expanding preservice teachers' metacognitive awareness of instructional planning. *Educational Technology Research and Development, 50*, 5–22.

Belanich, J. & Orvis, K. A. (2006). *Training games and instructional systems design*. Paper presented at the Annual Meeting of the Society for Applied Learning Technology meeting, Alexandria, VA.

Betz, J. A. (1995–1996). Computer games: Increase learning in an interactive multidisciplinary environment. *Journal of Technological Systems, 24*, 195–205.

Bickley, W. R. (1980). *Training Device Effectiveness: Formulation and Evaluation of a Methodology* (Research Report 1291). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences.

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

*Cannon-Bowers, J., Bowers, C., & Procci, K. (2011). Using video games as educational tools in healthcare. In S. Tobias & Fletcher, J.D. (Eds.) *Computer games and instruction* (pp. 47–72). Charlotte, NC: Information Age.

Coller, B. D., & Shernoff, D. J. (2009). Video game-based education in mechanical engineering: A look at student engagement. *International Journal of Engineering Education, 25*(2), 308–317.

Costabile, M. F., De Angeli, A., Roselli, T., Lanzilotti, R., & Plantamura, P. (2003). Evaluating the educational impact of a tutoring hypermedia for children. *Information Technology in Childhood Education Annual, 289–308*.

Crandall, B., Klein, G., & Hoffman, R. R. (2006). *Working minds: A Practitioner's guide to cognitive task analysis*. Cambridge, MA: MIT Press.

Dai, D. Y., & Wind, A. P. (2011). Computer games and opportunity to learn: Implications for teaching students from low socioeconomic backgrounds. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and learning* (pp. 447–502). Charlotte, NC: Information Age Publishing, Inc.

Dehn, D., & van Mulken, S. (2000). The importance of animated interface agents: A review of empirical research. *International Journal of Human-Computer Studies, 52*, 1–22.

Din, F., & Calao, J. (2001). The effects of playing educational video games on kindergarten achievement. *Child Study Journal, 31*, 95–102.

Donchin, E. (1989). The learning strategies project. *Acta Psychologica, 71*, 1–15.

Entertainment Software Association. (2009). *Industry facts*. Retrieved April 25, 2009, from http://www.theesa.com/facts/index.asp

Everson, H. T. (2011). Video games to assess learning. *ADL Newsletter for Educators and Educational Researchers*. http://research.adlnet.gov/newsletter/academic/201103.htm

Ferguson, C. J. (2007). Evidence for publication bias in video game violence effects literature: A meta-analytic review. *Aggression and Violent Behavior, 12*(4), 470–482.

Ferguson, C. J., & Rueda, S. M. (2010). The hitman study: Violent video game exposure effects on aggressive behavior, hostile feelings, and depression. *European Psychologist, 15*(2), 99–108.

Ferguson, C. J., Rueda, S. M., Cruz, A. M., Ferguson, D. E., Fritz, S., & Smith, S. M. (2008). Violent video games and aggression: Causal relationship or byproduct of family violence and intrinsic violence motivation? *Criminal Justice and Behavior, 35*(3), 311–332.

Fery, Y. A., & Ponserre, S. (2001). EnhanCing the control of force in putting by video game training. *Ergonomics, 44*, 1025–1037.

Fisher, C. W., & Berliner, D. C. (Eds.). (1985). *Perspectives on instructional time*. New York, NY: Longman.

Fletcher, J. D. (2004). Technology, the Columbus effect, and the third revolution in learning. In M. Rabinowitz, F. C. Blumberg, & H. Everson (Eds.), *The design of instruction and evaluation: Affordances of using media and technology* (pp. 139–157). Mahwah, NJ: Lawrence Erlbaum Associates.

*Fletcher, J. D. (2010). Cost Analysis in Evaluation Studies. In E. Baker, B. McGaw, & P. Peterson (Eds.) *International Encyclopedia of Education, Third Edition* (pp. 585–591). Burlington, MA: Elsevier.

*Fletcher, J. D. (2011). Cost analysis in assessing games for learning. In S. Tobias & J. D. Fletcher (Eds.), *Computer Games and Learning* (pp. 417–434). Charlotte, NC: Information Age Publishing, Inc.

Fletcher, J. D., & Chatham, R. E. (2010). Measuring return on investment in military training and human performance. In P. E. O'Connor & J. V. Cohn (Eds.), *Human performance enhancements in high-risk environments* (pp. 106–128). Santa Barbara, CA: Praeger/ABC-CLIO.

Fletcher, J. D., Hawley, D. E., & Piele, P. K. (1990). Costs, effects, and utility of microcomputer assisted instruction in the classroom. *American Educational Research Journal, 27*, 783–806.

Fletcher, J. D., & Tobias, S. (2005). The multimedia principle. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 117–133). New York, NY: Cambridge University Press.

Fletcher, J. D., & Tobias, S. (2006). Using computer games and simulations for instruction: A research review. *Society for Applied Learning Technology Meeting New Learning Technologies* (pp. 1–34).

Fontana, L. & Beckerman, A. (2004). Childhood violence prevention education using video games. *Information Technology in Childhood Education Annual, 16*, 49–62.

Fraas, J. W. (1982). The influence of student characteristics on the effectiveness of simulations in the principles course. *The Journal of Economic Education, 13*, 56–61.

Games, A., & Squire, K. D. (2011). Searching for the fun in learning: A historical perspective on the evolution of educational video games. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp. 17–46). Charlotte, NC: Information.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy?* New York City, NY: Palgrave.

*Gee, J. P. (2011) Reflections on empirical evidence on games and learning. In S. Tobias & J. D. Fletcher (Eds.), *Computer Games and Learning* (pp. 223–232). Charlotte, NC: Information Age Publishing, Inc.

Gee, J. P., & Shaffer, D. W. (2010). Looking where the light is bad: Video games and the future of assessment. *Epistemic Game Group Working Paper No. 2010–02*. Madison, WI: University of Wisconsin-Madison.

Gentile, D. A. (2005). *Examining the effects of video games from a psychological perspective*: *Focus on violent games and a new synthesis*. Ames IA: Iowa State University. http://www.mediafamily.org/research/Gentile_NIMF_Review_2005.pdf. Accessed March 22, 2007.

Gentile, D. (2009). Pathological video-game use among youth ages 8 to 18. A national study. *Psychological Science, 20*, 594–602.

Gentile, D. A. (2011). The multiple dimensions of video game effects. *Child Development Perspectives, 5*, 75–81.

*Gentile, D. A., Lynch, P. J., Linder, J. R., & Walsh, D. A. (2004). The effects of violent video game habits on adolescent hostility, aggressive behaviors, and school performance. *Journal of Adolescence, 27*, 5–22.

Gopher, D., Weil, M., & Bareket, T. (1994). Transfer of skill from a computer game trainer to flight. *Human Factors, 36*, 387–405.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*, 534–537.

Greenfield, P. M. (1998). The cultural evolution of IQ. In U. Neisser (Ed.), *The rising curve: Long-term gains in IQ and related measures* (pp. 81–123). Washington, DC: American Psychological Association.

Greenfield, P. M., Brannon, c., & Lohr, D. (1994). Two-dimensional representation of movement through three-dimensional space: The role of video game expertise. *Journal of Applied Developmental Psychology, 75*, 87–103.

Greenfield, P. M., Camaioni, L., Ercolani, P., Weiss, L., & Lauber, B. A. (1994). Cognitive socialization by computer games in two cultures: Inductive discovery or mastery of an iconic code. *Journal of Applied Developmental Psychology, 75*, 59–85.

Greenfield, P. M., deWinstanley, P., Kilpatrick, H., & Kaye, D. (1994). Action video games and informal education: Effects on strategies for dividing visual attention. *Journal of Applied Developmental Psychology, 75*, 195–223.

Greitemeyer, T., & Oswald, S. (2010). Effects of prosocial video games on prosocial behavior. *Journal of Personality and Social Psychology, 98*, 211–221.

Gremmen, H., & Potters, J. (1997). Assessing the efficacy of gaming in economic education. *Journal of Economic Education, 28*(4), 291–303.

Grubišić, A. *AC-Ware Tutor*. (Still unpublished). Split, Croatia: Faculty of Science.

Gustafsson, J.-E., & Undheim, J. O. (1996). Individual differences in cognitive functions. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 186–242). New York, NY: Simon & Schuster Macmillan.

Harris, M. B., & Williams, R. (1985). Video games and school performance. *Education, 105*, 306–309.

Hart, S. G., & Battiste, V. (1992). Flight test of a video game trainer. In *Proceedings of the Human Factors Society 36th Annual Meeting* (pp. 1291–1295). Santa Monica, CA: Human Factors and Ergonomics Society.

Hays, R. T. (2005). *The effectiveness of Instructional games: A literature review and discussion (Technical report 2005004)*. Orlando, Fl: Naval Air Warfare Center.

Henderson, L., Klemes, J., & Eshet, Y. (2000). Just playing a game? Educational simulation software and cognitive outcomes. *Journal of Educational Computing Research, 22*, 105–129.

Honey, M. A., & Hilton, M. (Eds.). (2011). *Committee on science learning: Computer games, simulations, and education*. Washington, DC: National Research Council.

Hoover, A., & Fletcher, J. D. (2011). The Armed Forces Qualification Test (AFQT) as a leading indicator in distributed learning performance. In, *Proceedings of the 79th Military Operations Research Society Symposium*, Alexandria, VA: Military Operations Research Society.

Jackson, G.T., & McNamara, D. (2011). *Natural language assessment within game-based practice.* Paper delivered at the annual convention of the American Educational Research Association, New Orleans, April.

Jayakanthan, R. (2002). Application of computer games in the field of education. *Electronic Library, 20*, 98–102.

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38*, 23–31.

Kamill, M. L., & Taitague, C. (2011). Developing an electronic game for vocabulary learning: A case study. In S. Tobias & J. D. Fletcher

(Eds.), *Computer games and instruction* (pp. 331–352). Charlotte, NC: Information Age.

Karle, J. W., Watter, S., & Shedden, J. M. (2010). Task switching in video game players: Benefits of selective attention but resistance to proactive interference. *Acta Psychologica, 134*, 70–78.

Kato, P. M., Cole, S. W., Bradlyn, A. S., & Pollock, B. H. (2008). A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial. *Pediatrics, 122*, 305–317.

Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay? *Computers & Education, 51*, 1609–1620.

Kearsley, G. (1982). *Costs, benefits, & productivity in training systems*. Reading, MA: Addison-Wesley.

Kirkley, S. E., Tomblin, S., & Kirkley, J. (2005). Instructional design authoring support for the development of serious games and mixed reality training. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference*.

Kirschner, P., Sweller, J., & Clark, R. E. (2006). Why minimally guided learning does not work: An analysis of the failure of discovery learning, problem-based learning, experiential learning and inquiry-based learning. *Educational Psychologist, 41*(2).

Klimmt, C., Hartmann, T., & Frey, A. (2007). Effectance and control as determinants of video game enjoyment. *CyberPsychology and Behavior, 10*, 845–848.

Knapp, M.I., & Orlansky, J. (1983). *A cost element structure for defense training* (IDA Paper P-1709). Alexandria, VA: Institute for Defense Analyses. (AD A139 164).

Laffey, J. M., Espinosa, L., Moore, J., & Lodree, A. (2003). Supporting learning and behavior of at-risk young children: Computers in urban education. *Journal of Research on Technology in Education, 35*, 423–440.

Lee, J. (1999). Effectiveness of computer-based instructional simulation: A meta-analysis. *International Journal of Instructional Media, 26*(1), 71–85.

Lepper, M. R., & Malone, T. W. (1987). Intrinsic motivation and instructional effectiveness in computer-based education. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction* (Cognitive and Affective Process Analyses, Vol. 3, pp. 255–286). Hillsdale, NJ: Lawrence Erlbaum Associates.

Leutner, D. (1993). Guided discovery learning with computer-based instruction games: Effects of adaptive and non-adaptive instructional support. *Learning and Instruction, 3*, 113–132.

Levin, H. A. (1983). *Cost-effectiveness: a primer*. Beverly Hills, CA: Sage Publications.

Levin, H. M., & McEwan, P. J. (2001). *Cost-effectiveness analysis*. Thousand Oaks, CA: Sage.

Mestre, J. P. (2005). *Transfer of learning from a modern multidisciplinary perspective*. Greenwich, CT: Information Age Publishing.

Malone, T. W. (1981a). What makes computer games fun? *Byte, 6*, 258–277.

Malone, T. W. (1981b). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 4*, 333–369.

Malone, T. w., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivation for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction* (Cognitive and affective process analyses, Vol. 3, pp. 223–253). Hillsdale, NJ: Lawrence Erlbaum Associates.

Mane, A., & Donchin, E. (1989). The space fortress game. *Acta Psycholgica, 71*, 17–22.

Martin, B. L., & Reigeluth, C. M. (1999). Affective education and the affective domain: Implications for instructional-design theories and models. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: a new paradigm of instructional theory (Vol 2)* (pp. 485–510). Mahwah, NJ: Lawrence Erlbaum.

Mayer, R. E. (2001). *Multimedia learning*. New York, NY: Cambridge University Press.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist, 59*(1), 14–19.

Mayer, R. E. (2006). Ten research-based principles of multimedia learning. In H. F. O'Neil Jr. & R. S. Perez (Eds.), *Web-based learning: Theory, research, and practice* (pp. 371–390). Mahwah, NJ: Lawrence Erlbaum. Associates.

*Mayer, R. E. (2011). Multimedia learning and games. In S. Tobias & J.D. Fletcher (Eds.) *Computer games and instruction* (pp. 281–306). Charlotte, NC: Information Age.

Mayer, R. E., Mautone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology, 94*(1), 171–185.

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*. New York, NY: Penguin Press.

*Moreno, R. (2005). Multimedia learning with animated pedagogical agents. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 507–523). New York, NY: Cambridge University Press.

Moreno, R., & Flowerday, T. (2006). Students' choice of animated pedagogical agents in science learning: A test of the similarity-attraction hypothesis on gender and ethnicity. *Contemporary Educational Psychology, 31*, 186–207.

Moreno, R., & Mayer, R. E. (2000). Engaging students in active learning: The case for personalized multimedia messages. *Journal of Educational Psychology, 92*, 724–733.

Moreno, R., & Mayer, R. E. (2004). Personalized messages that promote science learning in virtual environments. *Journal of Educational Psychology, 96*, 165–173.

Moreno, R., & Mayer, R. E. (2005). Role of guidance, reflection, and interactivity in an agent-based multimedia game. *Journal of Educational Psychology, 97*, 117–128.

Moreno, R., Mayer, R. E., Spires, H. A., & Lester, H. A. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19*, 177–213.

O'Neil, H. F., Wainess, R., & Baker, E. L. (2005). Classification of learning outcomes: Evidence from the computer games literature. *The Curriculum Journal, 16*, 455–474.

Okagaki, L., & Frensch, P. A. (1994). Effects of video game playing on measures of spatial performance: Gender effects in late adolescence. *Journal of Applied Development Psychology, 15*, 33–58.

Orlansky, J., & String, J. (1977). *Cost-effectiveness of flight simulators for military training (IDA paper P-1275)*. Alexandria, VA: Institute for Defense Analyses.

Phillips, J. J. (2003). *Return on investment in training and performance improvement programs* (2nd ed.). Oxford, UK: Butterworth-Heinemann.

Prensky, M. (2011). Comments on research comparing games to other instructional methods. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp. 251–278). Charlotte, NC: Information Age Publishing.

*Randel, J. M., Morris B. A., Wetzle, C. D., & Whitehead, B. V. (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulation and Gaming, 23*, 261–276.

Rieber, L. P. (2005). Multimedia learning in games, simulations, and microworlds. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (p. 549567). New York, NY: Cambridge University Press.

Rodrigo, M. M. T., Baker, R. S. J. D., D'Mello, S, Gonzalez, M. C. T., Lagud, M. C. V., Lim, . . . Viehland, N.J.B. (2008). Comparing learners' affect while using an intelligent tutoring system and a simulation problem solving game. In B. P. Woolf, E. Aïmeur, R. Nkambou, & S. Lajoie (Eds.), *Proceeding ITS '08 Proceedings of the 9th international conference on Intelligent Tutoring Systems* (pp. 40–49). Berlin, Heidelberg: Springer-Verlag. (http://www.cs.cmu.edu/~rsbaker/RBDetal2008.pdf). Retrieved 2 11, 2009

Roe, K., & Muijs, D. (1998). Children and computer games: A profile of the heavy user. *European Journal of Communication, 13*, 181–200.

Ronen, M., & Eliahu, M. (1999). Simulation as a home learning environment- Students' views. *Journal of Computer Assisted Learning, 15*, 258–268.
Ronen, M., & Eliahu, M. (2000). Simulation — a bridge between theory and reality: the case of electric circuits. *Journal of Computer Assisted Learning, 16*, 14–26.
Ross, J. A., Barkaoui, K., & Scott, G. (2007). Evaluations that consider the cost of educational programs: The contribution of high quality studies. *American Journal of Evaluation, 28*, 477–492.
Rosser, J. C., Jr., Lynch, P. J., Cuddihy, L., Gentile, D. A., Klonsky, J., & Merrell, R. (2007). The impact of video games on training surgeons in the 21st century. *Archives of Surgery, 142*, 181–186.
Rossi, P., Lipsey, M. W., & Freeman, H. E. (2003). *Evaluation: A systematic approach* (7th ed.). Thousand Oaks, CA: Sage.
Schraagen, M., Chipman, S., & Shalin, V. (Eds.). (2000). *Cognitive task analysis*. Mahwah, NJ: Lawrence Erlbaum.
*Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. In S. Tobias & Fletcher, J.D. (Eds.) *Computer games and instruction* (pp. 503–524). Charlotte, NC: Information Age Publishing.
Sims, V. K., & Mayer, R. E. (2002). Domain specificity of spatial expertise: The case of video game players. *Applied Cognitive Psychology, 16*, 97–115.
Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology, 64*(2), 489–528.
Sitzmann, T., & Ely, K. (2009). *A meta-analytic examination of the effectiveness of computer-based simulation games* (Advanced Distributed Learning Technical Report). Alexandria, VA.
Spicer, J. I., & Stratford, J. (2001). Student perceptions of a virtual field trip to replace a real field trip. *Journal of Computer Assisted Learning, 17*, 345–354.
Squire, K. (2005). *Game-based leaning: Present and future state of the field. Masie Center e-Learning Consortium*, February, 2005. Retrieved on May 22, 2006, from http://www.masie.com/xlearn/Game-Based_Learning.pdf
Squire, K. (2006). From content to context: Videogames as designed experiences. *Educational Researcher, 35*(8), 19–29.
Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.
Subrahmanyam, K., & Greenfield, P. M. (1994). Effect of video game practice on spatial skills in girls and boys. Special Issue: Effects of interactive entertainment technologies on development. *Journal of Applied Developmental Psychology, 15*, 13–32.
Sung, Y.-T., Chang, K.-E., & Lee, M.-D. (2008). Designing multimedia games for young children's taxonomic concept development. *Computers & Education, 50*(3), 1037–1051.
Suppes, P., Fletcher, J. D., & Zanotti, M. (1975). Performance models of American Indian students on computer-assisted instruction in elementary mathematics. *Instructional Science, 4*, 303–313.
Suppes, P., Fletcher, J. D., & Zanotti, M. (1976). Models of individual trajectories in computer-assisted instruction for deaf students. *Journal of Educational Psychology, 68*, 117–127.
Swaak, J., & de Jong, T. (2001). Discovery simulations and the assessment of intuitive knowledge. *Journal of Computer Assisted Learning, 17*, 284–294.
Sweller, J. (2006). The worked example effect and human cognition. *Learning and Instruction, 16*(2), 165–169.
Tobias, S. (1973). Review of the response mode issue. *Review of Educational Research, 43*, 193–204.
Tobias, S. (1976). Achievement treatment interactions. *Review of Educational Research, 46*, 61–74.
Tobias, S. (1982). When do instructional methods make a difference? *Educational Researcher, 11*(4), 4–9.
Tobias, S. (1989). Another look at research on the adaptation of instruction to student characteristics. *Educational Psychologist, 24*, 213–227.
Tobias, S. (1992). The impact of test anxiety on cognition in school learning. In K. Hagtvet (Ed.), *Advances in test anxiety research* (Vol. 7, pp. 18–31). Lisse, Netherlands: Swets & Zeitlinger.
Tobias, S. (2009). An eclectic appraisal of the success or failure of constructivist instruction. In S. Tobias & T. M. Duffy (Eds.), *Constructivism. Success or failure?* (pp. 335–350). New York, NY: Taylor and Francis.
Tobias, S., & Duffy, T. D. (2009). *Constructivist instruction: Success or failure?* New York, NY: Routledge, Taylor and Francis.
Tobias, S., & Fletcher, J. D. (2007). What research has to say about designing computer games for learning. *Educational Technology., 47*(5), 20–29.
Tobias, S., & Fletcher, J. D. (2011). Introduction. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp. 3–16). Charlotte, NC: Information Age.
*Tobias, S., & Fletcher, J. D. (2011b). Computer games, present and future. In S. Tobias & J. D. Fletcher (Eds.) *Computer Games and Instruction* (pp. 525–545). Charlotte, NC: Information Age.
*Tobias, S., Fletcher, J. D., Dai, D. Y., & Wind, A. P. (2011). Review of research on computer games. In S. Tobias & J. D. Fletcher (Eds.), *Computer Games and Learning* (pp. 127–222). Charlotte, NC: Information Age Publishing.
Tompson, G. H., & Dass, P. (2000). Improving students' self-efficacy in strategic management: The relative impact of cases and simulations. *Simulation & Gaming, 31*, 22–41.
Virvou, M., & Katsionis, G. (2008). On the usability and likeability of virtual reality games for education: The case of VR-ENGAGE. *Computers and Education, 50*(1), 154–178.
Vos, N., van der Meijden, H., & Denessenm, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & Education, 56*, 127–137.
Wise, A. F., & O'Neil, H. F. (2009). Beyond more versus less. A reframing of the debate on instructional guidance. In S. Tobias & T. D. Duffy (Eds.), *Constructivism. Success or failure?* (pp. 84–115). New York, NY: Taylor and Francis.
Wishart, J. (1990). Cognitive factors related to user involvement with computers and their effects upon learning from an educational computer game. *Computers and Education, 15*(1–3), 145–150.
Wittwer, J., & Renkl, A. (2008). Why instructional explanations often do not work: A framework for understanding the effectiveness of instructional explanations. *Educational Psychologist, 43*, 49–64.