Research on Using Computer Games for Instruction

Sigmund Tobias
University at Albany
State University of NY
(stobi@aol.com)

J. D. Fletcher
Institute for Defense Analyses
Alexandria VA
(fletcher@ida.org)

Purpose$_1$

- **Review research on computer Games**
  - **Includes TV games if computer controlled**
  - **Use & popularity of games**
- **Effects on:**
  - **Learning & transfer to real life or school tasks**
  - **Cognitive & psychomotor processes**
  - **Motivation & attitude**
  - **Game players**
  - **Cost-effectiveness**
- **Research-based suggestions for design of computer games useful for instruction**

Purpose$_2$

- **A continuing literature review**
  - **Initial version presented at Society for Applied Learning Technology (Fletcher & Tobias, 2006)**
  - **See also: Tobias, & Fletcher (2007)**
  - **Extended literature review in Tobias, Fletcher, Dai, & Wind (2011)**
  - **Tobias & Fletcher, (2011a)**
  - **Tobias, Fletcher, & Wind (in press)**

What Are Games?

- **Interpersonal & computer-mediated interactions, or**
- **Interactions solely with a computer to achieve goals depending on skill**
- **May involve**
  - **Chance**
  - **Competition**
  - **Imaginary setting**

On Simulations and Games …

Simulations	Games
Will sacrifice entertainment in favor of reality	Will sacrifice reality in favor of entertainment
Scenario/tasks	Storyline/quests
Emphasis on task completion	Emphasis on competition
Not necessarily interactive	Necessarily interactive
Focus on (rule) accuracy/detailed	Focus on (rule) clarity/stylized
Not all simulations are games	All games are simulations

Why Games?

- **Both interested in educational technology in training and education for half a century**
  - **Fletcher & Tobias (2011).**
  - **Tobias, Fletcher, & Wind (in press).**
- **Games the most interesting contemporary form of educational technology.**
- **Do you know anyone as interested in classroom learning, CAI, CMI, or computer tutors as they are in games?**

Popularity of Games$_1$

In US $7.3 billion spent (about 300% increase in decade) on computer games:

Video games sales = movie tix & gaining
(Tobias & Fletcher, 2011b)

- No. of games sold/second/day?
  - 8
- In US 65% play computer games. Mean age?
  - 29
- Percent of female game players?
  - 39%

Popularity of Games$_2$

- **Many game arcades & gadgets used for computer games**
- ***No. World of Warcraft players & cost?***
  - ***11.1 million players pay $15/ month (longer=discounts)***
- ***America's Army*, how many registered users?**
  - ***10,000,000***
- **50% gamers will play = or > games in 10 years.**
- **Fastest growing age group using games?**
  - **Seniors, to maintain alertness**
- **In 2005 < 12 Universities had game related courses. Now?**
  - **>200 in US & 160 worldwide.**
- **Mean playing time of students 8-18?**
  - **13.2 hours per week, boys' =16.4, girls' 9.2.**

Transfer to "Real Life" Tasks 1

- **Summarized in (Tobias, et al., 2011).**
- **Romero, Ventura et al. (2006) used Internet based game teaching CPR and found improvement in student performance**
- **Golf game designed for putting to be similar to golf play improved putting (Ferry & Ponsere, 2001)**
- **Kato, Cole et al. (2008) studied *Re-mission,* game for cancer patients**
  - ***P*atients playing the game had more knowledge about their disease**
  - **Greater compliance with the chemotherapy regimen than a no-game control group.**

Transfer to "Real Life" Tasks$_2$

- **Gopher, Weil, and Bareket (1994)**
  - **Used *Space Fortress II* (modified to be similar to flight in attention demands & cognitive load)**
  - **Found that game players (10 hours) performed better on transfer task: actual flight**
- **Hart and Battiste (1992)**
  - **Used fight program *Appache Strike Force***
  - **No transfer effects to actual flight**

Transfer to "Real Life" Tasks$_3$ Implications of Results

- **Positive transfer seems to depend: (Tobias et al. 2011)**
  - **_Not_ on perceived game/task similarity**
  - ***But*** **on whether game & task utilize similar cognitive/motor processes**
    - ***Space Fortress II*** **and actual flight shared attentional and cognitive process demands.**
    - ***Appache Strike Force*** **obviously did not**
    - **Golf game reproduced movements with fidelity**
  - **Cognitive task analysis of both game & task needed if transfer expected**

Transfer to "Real Life" Tasks 4

- **Specially developed surgical simulators have been shown to be effective in surgery**
  - **Laparoscopic surgery → tiny camera & instruments controlled by joystick like devices outside body (Tobias, et al., 2011).**
- **Surgical simulators available in many areas, e.g., endoscopy, hernia surgery, bronchial surgery etc…**

Transfer to "Real Life" Tasks$_5$

- **Evidence (Rosser et al. 2007) suggests that laparoscopic surgeons who play "off the shelf" computer games make less errors and work faster than non players**
- **Other research reports that laparoscopic surgeons improve proficiency with specially designed computer simulations (Cannon-Bowers, Bowers, & Procci, (2011); Tobias et al. (2011)**

Improvement in Cognitive Processes$_1$

- **Importance**
  - **All transfer depends on cognitive processes**
  - **Therefore, improvement in cognitive processes is the most general type of transfer**
  - **Improved performance expected on tasks using same processes (Tobias et al., 2011)**
- **Spatial processes improved by *Marble Madness* (Subrahmanyam & Greenfield, 1994)**
- **Induction-inducing instructions to play computer games (Greenfield, Camaioni et al., 1994)**

Improvement in Cognitive Processes$_2$

- **Attentional skills- improved dividing visual attention (Greenfield, deWinstanley, et al., 1996; Gopher et al. 1994)**
  - **Visual attention measure related to performance (Arthur et al. ’95)**
- **Spatial visualization (Okagaki & Frensch, 1996)**
- **Are process gains from games domain specific?**
  - **Yes (Sims & Mayer, 2002).**
  - **No (Bliss et al., 1991).**

Improvement in Cognitive Processes$_3$

- **Anderson & Bevalier (2011) found that:**
- **Playing fast action games, increased:**
  - **speed of processing,**
  - **cognitive resources, or an**
  - **ability to flexibly allocate resources, or an**
  - **sensitivity to inputs in the environment.**
- **May transfer to enhanced ability to:**
  - **read fine print, or drive.**
  - **flexibly alternate between tasks**

Improvement in Cognitive Processes$_4$

- **Anderson & Bevalier's results**
  - **Could lead to improvements in pilot's skills (Gopher et al., 1994), or surgeons in laparoscopic surgery (Rossser et al., 2007)**
- **<u>Caution:</u> Outside of Anderson & Bevalier (2011) cognitive process studies often:**
  - **Used self-reports or test items similar to game, i.e., near transfer**
  - **Had findings based on few studies**
- **Replication needed to enhance confidence**

Psychomotor Processes

- **Improvements not as well documented, though some suggest improvements in:**
  - **Airplane piloting**
  - **Golf putting (Ferry & Ponsere, 2001)**
  - **Special surgical procedures**
  - **Anderson & Bevalier tasks**
  - **Fine & gross motor & balance skills (Gentile, 2011)**
- **Further research on psychomotor processes needed**

Cost Effectiveness of Games (1)

Why bother? (Fletcher, 2010a)

- ***All decision making is a choice among alternatives (Simon, 1956).***
- ***Explicitly or implicitly, costs (of all kinds) inform all decisions.***
  - ***Monetary***
  - ***Students' time***
- ***Cost analysis makes this factor (and some of the reasoning behind the decision) explicit.***

Cost Effectiveness of Games (2)

Premises (supported by data):

- Time spent on learning tasks produces learning

- Time spent on learning tasks requires resources

- With equal effectiveness, learning tasks that require fewer resources are cost-effective compared to learning tasks that require more resources

Cost & Effectiveness of Games (3): Example

	Classroom Instruction	Game-Based Instruction
Target Gain in Grade Placement	0.75	0.75
Grade Placement gain per hour	0.0056 (a)	0.0125 (b)
Hours of activity needed	134	60
Per student cost per hour	$8.73	---
Total per student cost	$1,170	$400 (c)
Total cost for 25 students	$29,250	$10,000

(a) National average of 180, 7-hour days and assuming 1 year gain in grade placement per year; $11,000 per student per year

(b) Fletcher (2010b)

(c) $300 console + $100 game/per student; one time only cost

Motivation and Attitude

- **Attitudes to games generally more positive than to other instructional methods**
- **But:**
  - **Ss familiar with domain more critical of game fidelity than novices (Adams, 1998)**
  - **Ss prefer field experiences to simulated ones, despite positive attitudes to simulation (Spicer & Stratford, 2001)**
- **Interaction with prior experience & knowledge? (Dai & Wind, 2011; Tobias & Fletcher, 2011c)**

Aggression & Hostility$_1$

- **Players of aggressive games:**
  - **Manifest more aggression & hostility in daily life**
  - **Access more aggressive thoughts (Gentile, 2011)**
- **Implication -- reduce game aggression, or..**
- **Design games to teach pro-social reactions (Greitemeyer & Oswald, 2010; Tobias et al., 2011))**
  - **More likely to help after mishap**
  - **More willing to assist in further experiments**
  - **Intervened more often in a harassing situation**
- **Conflict resolution techniques taught by games (Fontana & Beckerman, 2004)**
- **Do pro-social games reduce aggression & hostility? (Tobias et al., 2011).**

Aggression & Hostility$_2$

- **Some dispute increased aggression findings**
  - **Even dissenters agree (Ferguson & Kilburn, 2010) that there is a small effect**
- **If games teach anything, wouldn't they also teach aggression related reactions? (Tobias et al., 2011).**
- **Paradox: Bevalier used fast paced action games (first person shooters) in studies where perceptual & cognitive processes improved**
  - **Are improvements worth increase in aggression?**
  - **Will non aggressive games have same results? (Tobias & Fletcher, 2011c)**

Game Playing Frequency

- **Gentile (2009) stratified random sample of 1178 US residents 8-18**
- **8.5% =“Pathological players”**
  - **Had 6/11 symptoms from *Diagnostic & Statistical Manual of Mental Disorders***
  - **Mean playing time = ?**
  - **24.6 hrs/wk**

Characteristics of Game Players$_1$

- **Frequent game players are also**
  - **More aggressive (Anderson & Bushman, 2002; Gentile, 2011)**
  - **Heavy TV, VCR, & film viewers**
  - **Listeners to music & radio.**
  - **Read less, spend less time with friends,**
  - **Have lower self concepts & self esteem**
  - **Lower school achievers (Harris & Williams, 2001; Roe & Mujis, 1998; Gentile, 2011)**

Animated Instructional Agents

- **Agents interacting with players usually improve attention, attitude, & often learning & transfer**
- **Possible domain interaction**
  - **No improvement in teacher decisions (Baylor, 2002)**
  - **Does facilitation occur mainly on less complex content?**
- **Agents have never been found to reduce learning so why not use them? (Moreno, 2005)**

Suggestions for Developers & Purchasers

- **Include:**
  - **Human, rather than digitized voices (Atkinson, Mayer & Merrill 2005)**
  - **First person references to players in games/simulations (Mayer & Moreno, 2000)**
  - **Pictorial, rather than verbal, guidance (Mayer, Mautone, & Prothero, 2002)**

Important Game Features$_1$

- **Research does not support discovery (inductive) learning with minimal or no guidance**
  - **See Tobias & Duffy (2009)**
- **Players should reflect about the reasons for correct answers but not incorrect ones (Moreno & Mayer, 2005)**
- **Fading steps in worked out examples (Renkl & Atkinson, 2003)**

Important Game Features$_2$

- **In complex games cognitive load should be reduced, e.g., by providing pictorial guidance (Mayer, Mautone, & Prothero, 2002)**
- **Games should be integrated into the curriculum, not stand alone (Tobias et al, 2011)**
  - **Huge amounts of time Ss spend on games at home unlikely to improve school learning because not integrated into curriculum**

Summary- Suggestions for Game Developers & Purchasers$_1$

- **Run cognitive task analysis to**
  - **find cognitive & psychomotor processes required by task**
  - **Design/buy game/simulation shown to use those processes as intensively as possible**
  - **Evaluate whether transfer occurred**
    - **Can not be assumed**
  - **Revise as necessary**
- **Provide guidance for those who want it**

Summary- Suggestions$_2$

- **Teams needed to develop games with expertise in (Tobias & Fletcher, 2011c).**
  - **Game design**
  - **Cognitive task analysis**
  - **Instructional systems design**
  - **Research on games/simulations**
  - **May be more expensive but will have long run pay off in transfer & sales.**

Recommendations$_2$

- **Results suggest a negative relationship between frequency of game playing and school achievement (Gentile, 2011)**
- **Games *should* lead Ss to curriculum related resources (Tobias et al., 2011).**
  - **Game links could direct Ss to Web or printed sources**
  - **Game re-entry could be contingent on having that information**

Discussion$_1$

- **Research needed on**
  - **Whether motivational increases due to games generalize to subject matter domain**
  - **Identification of cognitive processes used in games**
- **Alternate instructional methods → to different outcomes only if different cognitive processes engaged (Tobias, 1982; 2009)**

Discussion$_3$

- **Research has shown that personalizing game interactions improves learning (Tobias et al., 2011)**
- **Does use of student's name also improve learning?**
- **In mathematics research shows that use of S's names improves learning.**
- **Simple to do in game contexts**

Discussion$_4$

- **Games irrelevant to task often used to "jazz up" instruction**
- **Concern that game may be recalled not instructional content**
  - **Seductive detail effects in text research (Schraw, 1998)**
  - **Seductive details should be studied in game contexts**

Discussion$_5$

- **Some findings indicate that games are especially beneficial for Ss with low prior domain knowledge (Dai & Wind, 2011).**
- **Similar findings in multimedia (Fletcher & Tobias, 2006) & general learning**
- **ATI research (adapting instruction to Ss' charateristics) shows instructional support more beneficial for low ability/prior knowledge students (Tobias, 1976, 1982, 1989, 2009)**
- **Similar research on games needed**

Discussion$_5$

- **Simulation students spent more time on task than controls assigned to read (Betz (1995-96)**
- **Game students received more instruction (Laffey et al. 2003)**
- **Important to determine time on task in game & comparison modes (Tobias, et al., 2011)**
- **Could any game benefits be due to persistence?**
- **Devices inducing persistence on educational tasks are valuable, but clarity about effective variables needed.**

Other Game Resources

- ***Annual "Games for Change" meeting in NYC***
  - ***2008 Meeting summarized in Issue ADL Newsletter, Issue 12***
- **Annual "Games for Health Meeting," USA**
- **Annual Games, Learning, & Society Conference in Madison WI.**
  - **2006 Conf. summarized in Issue 3 of:**

  ADL Newsletter for Educators and Educational Researchers. **Freely available at:**

  http://www.academiccolab.org/newsletter/ADLnewsletter.html
- **Increasing presence of games research at national meetings (AERA, IEEE, etc…)**
- **Meetings such as this one**

Thank you!

Questions? Comments? Complaints?