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

- 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
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 …

<table>
<thead>
<tr>
<th>Simulations</th>
<th>Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will sacrifice entertainment in favor of reality</td>
<td>Will sacrifice reality in favor of entertainment</td>
</tr>
<tr>
<td>Scenario/tasks</td>
<td>Storyline/quests</td>
</tr>
<tr>
<td>Emphasis on task completion</td>
<td>Emphasis on competition</td>
</tr>
<tr>
<td>Not necessarily interactive</td>
<td>Necessarily interactive</td>
</tr>
<tr>
<td>Focus on (rule) accuracy/detailed</td>
<td>Focus on (rule) clarity/stylized</td>
</tr>
<tr>
<td>Not all simulations are games</td>
<td>All games are simulations</td>
</tr>
</tbody>
</table>
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?
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%
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

• 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:
  – Patients 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

- 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 *Apache Strike Force*
  - No transfer effects to actual flight
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.
  - *Apache Strike Force* obviously did not
  - Golf game reproduced movements with fidelity

- Cognitive task analysis of both game & task needed if transfer expected
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

• 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))
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* (Subrahmanyanam & Greenfield, 1994)

Induction-inducing instructions to play computer games (Greenfield, Camaioni et al., 1994)
Improvement in Cognitive Processes

- **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).
• 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

- 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)

- Caution: 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
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.
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

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

(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)
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).
• 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)
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
• 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)
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

• 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)
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.
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

- 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

• 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
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

• 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

• 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
• 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’ characteristics) shows instructional support more beneficial for low ability/prior knowledge students (Tobias, 1976, 1982, 1989, 2009)

• Similar research on games needed
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](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?