Video Game as a Tool to Teach “Heat Transfer” Fundamentals

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Outline

• Traditional teaching vs. video game
• Status of educational video game
• Advantages and limitations of game-based teaching
• Brief introduction of Heat Transfer and the game development
• Future work
Traditional Teaching vs. Video Game

• Only **28%** of seniors believe that schoolwork is meaningful
• Only **21%** of seniors think their course are interesting
• **76%** of children play games every week
• Teenagers commonly spend **5 to 8 hours** per week playing games
  • equals or surpasses the time spent on homework each week
Impact of traditional education relatively smaller compared with video game
**World of Warcraft**
over 10 million current subscribers, with
~2.5 million in North America
currently the world's most-subscribed
massively multiplayer online role-playing
game (MMORPG)

**Food Force**
1 million players in its first 6 weeks
and 4 million players in its first year
Can video games be effectively used in STEM education?
**Using Video Games As a Educational Teaching Tool**

- **Full Spectrum Warrior**
- Teach (real) soldiers to be flexible and adaptable to a broad range of operational/combat scenarios.
- Developed by U.S. Department of Defense
Educational Video Game

- Whyville
  - one of the most popular virtual worlds with a player base of more than 7 million.
  - for children from ages 8–16
  - learning about a broad range of topics, from science and business to art and geography
River City

- Interactive computer simulation
- for middle grades science students to learn scientific inquiry and 21st century skills.
- Developed at Harvard University
- Supported by National Science Foundation
### Table 1. Learning outcomes of several games compared to lecture on same material.

<table>
<thead>
<tr>
<th>Game</th>
<th>Topic</th>
<th>Audience</th>
<th>N (study size)</th>
<th>Learning outcome over lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimenxian/Evolver</td>
<td>Algebra</td>
<td>High school</td>
<td>193</td>
<td>7.2%</td>
</tr>
<tr>
<td>Geography Explorer</td>
<td>Geography</td>
<td>College</td>
<td>273</td>
<td>15 to 40%</td>
</tr>
<tr>
<td>NIU Torcs</td>
<td>Numerical methods</td>
<td>College</td>
<td>86</td>
<td>2× more time spent on homework, much more detailed concept maps</td>
</tr>
<tr>
<td>River City</td>
<td>Ecology/biology</td>
<td>Middle/high</td>
<td>≈2000</td>
<td>15 to 18%, on average</td>
</tr>
<tr>
<td>Supercharged!</td>
<td>Electrostatics</td>
<td>Middle school</td>
<td>90</td>
<td>+8%</td>
</tr>
<tr>
<td>Virtual Cell</td>
<td>Cell biology</td>
<td>College</td>
<td>238</td>
<td>40%, on average</td>
</tr>
</tbody>
</table>

Advantages of Video Game

• Interactive, which involves more engagement
• Active, participatory style of learning in games also departs from the traditionally passive lecture
• Can be adapted to the pace of the user.
• Simultaneously present information in multiple visual and auditory modes, which capitalizes on different learning styles.
• Reinforcing information acquisition
  • Almost every keystroke yields a response from the game.
  • Students in a typical classroom get to ask 0.11 questions per hour
• stead流 stream of positive rewards accompanies a game's rapid feedback.
  • greater self-confidence/self-efficacy
  • a higher level of accomplishment
• Learner control over navigation through tasks and activities contributes to effective learning
• Games invite more time on task
• Combine learning and fun
Challenges of Educational Video Game

- Infrastructural developments to improve quantity (of users)
- Quality (of product)
- Sustainability (of business models)
Heat Transfer Theory

- Convection
- Conduction
- Radiation
Objective

- Create a video game to help teach **key concepts and problem-solving skills** in Heat Transfer.
- **Evaluate** how the game impact learning and student engagement.
Game development

- Adobe Flash CS5.5
- Mines: Lessons
- Puzzles
Welcome to ALPHA Mine

Use this facility to collect materials for Shield Doors.
3 Modes of Heat Transfer

Heat energy is transferred in 3 basic ways. Usually, more than one mode of heat transfer is at work on a system at the same time. We will focus on one mode at a time for now.

Click on a Mode below for a demonstration.

Conduction

Conduction: heat transfers between solid systems in contact, like metal or wood.

Convection: heat transfers through a fluid system, like air or water.

Radiation: heat that emits from a hot object, like the sun, transfers across vacuum spaces.

Drag one of the solids to touch the other.
The Target Rate of Heat Transfer is: 47400 W.
Area (A) is: 3 m^2.

Temperature 1 (T1) is:
100° C.

Temperature 2 (T2) is:
50° C.
Door 1’s thickness (L_1) is:
75 cm.
The Target Rate of Heat Transfer is: 58278 W. Area (A) is: 3 m^2.

Temperature 1 (T1) is: 100° C.

Temperature 2 (T2) is: 50° C.
Door 1's thickness (L1) is: 59 cm.
Survey questions

• How clear were the lessons in communicating the basic concepts of heat transfer?
• How easy was it for you to understand what you needed to do in the Lessons?
• What did you like most about the lessons?
• What would you change about the lessons?

How clear were the lessons in communicating the basic concepts of heat transfer?

<table>
<thead>
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<th>Rating</th>
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<th>Percentage</th>
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<tr>
<td>1 - Unclear</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>42%</td>
</tr>
<tr>
<td>5 - Very Clear</td>
<td>6</td>
<td>32%</td>
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</table>

Rate the effectiveness of the game sample in helping you to understand the material from the lessons

<table>
<thead>
<tr>
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<th>Percentage</th>
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<tr>
<td>1 - Not very helpful</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>26%</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>37%</td>
</tr>
<tr>
<td>5 - Very Helpful</td>
<td>3</td>
<td>16%</td>
</tr>
</tbody>
</table>
Comparing Students in Game-Based and Traditional Courses

- Two groups of students
  - One group takes lecture
  - One group takes game
- A quiz will be conducted to evaluate the understanding of students to the contents
Summary

• A video game in being developed to teach “Heat Transfer” fundamentals in undergraduate class
• Some initial test data are presented that suggest that the game might be a suitable platform for education and research
Acknowledgement

Team members

- Project lead: Fanbin Kong
- Art design: Som Downs
- Programming: Michael Meindl
- Technical support: Adam Blaschke

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