Bridging the Gap: How to Build Effective Game-based Training

(Tutorial 1425)

Dr. Jan Cannon-Bowers, Cubic
Katelyn Procci, Cubic
Jennifer Loglia, Cubic
Skilan Ortiz, Cubic
Budd C. Darling III, Cubic
Dr. Clint Bowers, University of Central Florida
Tutorial Objectives

- Learn how to leverage the vitality of commercial games in serious game-based training to making training more effective.
  - Outline the benefits of game-based training
  - Apply learning science to training game design
    - Cognitive Load Theory
    - Schematic Processing
    - Scaffolding
    - Goal Setting
    - Flow Theory
    - Feedback
    - Motivation
  - Employ commercial gaming elements for instructional purposes
  - Assess limitations and challenges
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Advantages of Game-based Training

- More motivating
  - Can positively impact training outcomes

- Situated learning
  - May be video games’ greatest strength
Cost Effectiveness

Game-based training has **higher up-front costs, but better return-on-investment** in the long run.

<table>
<thead>
<tr>
<th></th>
<th>Dev. Hours for One Hour of Instructional Content</th>
<th>Total Hours of Instructional Content</th>
<th>Total Dev. Hours</th>
<th>Hours Spent Using</th>
<th>Dev Hours / Using</th>
<th>GP* Gained per Hour</th>
<th>Total GP Gained</th>
<th>Dev. Hours / + 1 GP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CBT</strong></td>
<td>220&lt;sup&gt;1&lt;/sup&gt;</td>
<td>5</td>
<td>1,100</td>
<td>5&lt;sup&gt;3&lt;/sup&gt;</td>
<td>220</td>
<td>+ 0.500&lt;sup&gt;2&lt;/sup&gt;</td>
<td>+ 2.5</td>
<td>440.0</td>
</tr>
<tr>
<td><strong>GBT</strong></td>
<td>1,000&lt;sup&gt;1&lt;/sup&gt;</td>
<td>5</td>
<td>5,000</td>
<td>104&lt;sup&gt;2&lt;/sup&gt;</td>
<td>48.08</td>
<td>+ 0.125&lt;sup&gt;2&lt;/sup&gt;</td>
<td>+ 13</td>
<td>384.6</td>
</tr>
</tbody>
</table>

<sup>1</sup>Sitzmann, 2011; 2Fletcher, 2011; 3Austin, 2013

*GP = Grade Placement is a standardized metric for quantifying learning gains and is based on the work of Suppes, Fletcher, & Zanotti (1975).
What Works and What Doesn’t

- Blend of sound instructional principles
- Balanced combination of instructional principles and game play elements
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Cognitive Load

- The amount of mental resources being spent on learning or doing a task

Three different types of cognitive load

- Intrinsic
  - The difficulty of the material

- Extraneous
  - Unnecessary cognitive load brought on by poorly designed instruction

- Germane
  - The cognitive resources dedicated to the construction of schemas
Parappa the Rapper 2
“A schema is a script and/or structure for common occurrences that run on auto-pilot.”

(Procci and Bowers, in press)

We use schemas for:
- Tackling new problems
- Learning
Diablo series

- RMB: attack
- LMB: move
- Numbers 1-4 control keys on your hot bar
- I: opens/closes inventory
- Spacebar: close all open windows
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Level Design

- Learning Theory Overview
  - Scaffolding
  - Goals
  - Flow

- Application
Scaffolding

Instruction should be at the level between what the learner can achieve on their own and what they can achieve with instructional support.

Zone of Proximal Development

- Games are the same
Scaffolding

Zone of Proximal Development and Good Gameplay Balance

Anxiety / Frustration

Level of Potential Development / Achievement

Actual Developmental / Skill Level

Boredom

Task Difficulty

Individual's Skill Level
Goals

- Specific goals are the best
  - Directs attention
  - Persistent

- Difficult goals = \(\uparrow\) effort and better performance

- Stimulate prior knowledge and skill

- Satisfying!
Flow

Activity Requirements promote Focused Attention, Limited Stimulus Field leading to Experiences resulting in Outcome

- Challenge / Skill Balance
- Clear Goals
- Immediate Feedback

Merging Action & Awareness

- Concentration
- Control
- Loss of Self-Consciousness
- Time Distortion

Autotelic Experience
Flow

Task Difficulty vs. Individual's Skill Level

- Anxiety / Frustration
- Level of Potential Development / Achievement
- Zone of Proximal Development / Good Gameplay Balance
- Actual Developmental / Skill Level

Flow!
Flow

- Developed by Jenova Chen
  - Minimal controls, highly usable
  - Adjusts to player to achieve skill/challenge balance
Level design considerations

- Feature clear, specific goals
- Be challenging, but not impossible
- The relationship between the challenge/skill **cannot** be static

So how do you incorporate this into, not just a game, but a *learning* game?
Step 1: Cognizant Design

- Gameplay Basics
- Introduce Instructional Content
- Increase Gameplay Difficulty
- Incorporate More Instruction
- Instruction Linked to Gameplay
- Increase Game Difficulty
- Increase Content Difficulty
- Increase Content Difficulty
- Increase Game Difficulty
- Increase Content Difficulty
Application

Step 2: Realtime Adjustment

- Game should be adaptive
- Workload can be assessed with a secondary task
  - How do you embed a secondary task?
  - How do you know what to adjust?
Application

 Embedding a secondary task
Dynamic adjustment – use intelligent tutoring system

- Trace gameplay behaviors across time
- Determine whether mistakes are related to:
  - Gameplay
  - Understanding
  - Both
- Adjust difficulty (instruction, gameplay, both) accordingly
  - Present additional feedback and training as needed
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Feedback

Two types of feedback
- **Outcome feedback** – how many widgets you made
- **Process feedback** – how you *made* those widgets
  - Was the process efficient? Did you make *quality* widgets?

When to use each?
- Novice vs. expert
- During vs. at the end

Timeliness
- Immediate feedback is key
Feedback

After Action Report (AAR)

- Diagnosis of performance
  - Learning objectives
  - Creating a link
  - Meaning
- Can occur in multiple places
Feedback

Good feedback
Scoring and Achievements

- Form of feedback
- Used to increase achievement
- Success in entertainment games
  - Double edged sword
Scoring and Achievements

- Good achievements

![Diagram of good achievements](image1)

ClassRealm

The ultimate classroom adventure.

ClassRealm provides a platform for teachers to introduce gamification into their classrooms, encourage better behaviour patterns, and promote creative expression.
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Gameplay Elements: “Detective Mode”
Gameplay Elements: “Boundary Indicators”
Gameplay Elements: Realtime Flashback
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Example – Project ASPIRE

Assessment complete. Which action is appropriate?

A) Cognitive Restructuring - Take the Marine through a brief cognitive intervention to correct their irrational thinking.

B) Watch and Wait - Don't do anything now, but check in with this Marine again later.

C) Refer them to someone else - This Marine needs help from someone with more experience, like a doctor.
In *Project ASPIRE*, evaluation was based on their decisions:

- If they selected the correct response in a conversation, we could infer that they understood the conversational technique they had learned.

- If they made the correct decision about how to treat the Marine, we could infer that they understood what was wrong with the Marine based on the conversation and knew what to do next.
We tried to lessen cognitive load by:

- Having all non-player spoken text narrated
- Limiting the conversation options to three
- Reducing the length of the conversation options as much as possible
Feedback was delivered in two main ways:

1. For simple, routine decisions (e.g., what to say during a conversation)
   - Immediate outcome feedback, both visual and auditory
   - Detailed process feedback displayed during AAR

   Why?

2. For critical decisions (e.g., important decisions about what to do next)
   - Immediate outcome feedback, both visual and auditory
   - Immediate detailed process feedback displayed on-screen
   - Review of process feedback displayed during AAR

   Why?
Example – Project ASPIRE
Feedback

Cognitive Restructuring

Well, I think this is a perfect opportunity to examine what is really preventing you from sleeping. One way to do this is to look at your thoughts because the way we think can influence our mood.

Choose Your Response

First, it sounds like you are having a hard time relaxing as soon as you aren’t busy. Maybe trying to think about ways to stay busy would be helpful.

First, it sounds like you are putting a lot of pressure on yourself to get rid of any worries so that you can sleep, and those thoughts may make it worse.

First, it sounds like you are worrying way too much about things in the past. Thoughts about the past are not helpful in the present, so you should try to just let go of them.

Project ASPIRE: Simple Decision Feedback
Project ASPIRE: Critical Decision Feedback

Good try, but you are incorrect.

Our experts would suggest that PFC Garcia is in the Yellow Zone, but is close to entering the Orange Zone. Although she is experiencing some typical distress in the aftermath of a potentially traumatic event, she is also reporting significant sleep problems that have lasted for more than 2 weeks and alludes to the fact that she might be "messing up" and is having trouble concentrating. These issues may worsen, pushing PFC Garcia into the Orange Zone unless addressed.
Example – Project ASPIRE
Feedback

Level Overview
Score: 53%

PFC Garcia is experiencing some typical distress in the aftermath of a potentially traumatic event, but she is also reporting significant sleep problems and alludes to the fact that she might be “messing up” and is having trouble concentrating. Right now, she is in the Yellow Zone, but might enter the Orange Zone unless addressed. Cognitive Restructuring is appropriate to address irrational beliefs, which are likely preventing the Marine from moving past the event.

Correct Stress Level Color: YELLOW
Presenting Problems Identified: 1/3
- Insomnia
- Experience of Potentially Traumatic Event
- Concentration Difficulties

What the Marine said:
Eh, it is nothing, Sir... I just haven't slept much since Greene got hurt... You know how it is. I keep thinking about the things that went wrong and just feel guilty for even complaining... At least I still have my legs.

Your response:
Well, I hate that you're feeling this way, but remember what you are feeling is normal and that you are strong enough to get through it. Let me know if you need anything, okay?

Feedback:
Incorrect. This response is supportive, but fails to assess the severity of problems and the level of impairment (if any).

What the Marine said:
I hear you and I appreciate your offer, but I don’t need anything from you at this time...

Correct Treatment Method:
Cognitive Restructuring - Take the Marine through a brief cognitive intervention to correct their irrational thinking.
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Limitations and Challenges

- **Usability – impact on cognitive load**
  - Germane
  - Extraneous
    - Too challenging
    - Can’t master the controls

- **Video game self-efficacy**
  - Orvis, Horn, & Belanich (2009)
  - Brusso, Orvis, Bauer, & Tekleab (2012)
Example: *Project ASPIRE*

Regression model predicting post-test scores.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
<th>pr^2</th>
<th>sr^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.758</td>
<td>2.616</td>
<td>.775</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes Played</td>
<td>0.034</td>
<td>0.060</td>
<td>0.110</td>
<td>.580</td>
<td>.062</td>
<td>.099</td>
</tr>
<tr>
<td>Game Score</td>
<td>-0.034</td>
<td>0.037</td>
<td>-0.192</td>
<td>.360</td>
<td>.076</td>
<td>-0.164</td>
</tr>
<tr>
<td>VGSE</td>
<td>0.084</td>
<td>0.041</td>
<td>0.438</td>
<td>.056</td>
<td>.572</td>
<td>.356</td>
</tr>
<tr>
<td>SUS</td>
<td>0.056</td>
<td>0.034</td>
<td>0.400</td>
<td>.118</td>
<td>.475</td>
<td>.287</td>
</tr>
<tr>
<td>Pre-Test Score</td>
<td>-0.175</td>
<td>0.217</td>
<td>-0.151</td>
<td>.431</td>
<td>.094</td>
<td>-0.141</td>
</tr>
</tbody>
</table>

\[ F(5,24) = 2.732, \ p = .050, \ R^2 = .418 \]
Agenda

Introduction
- Advantages, Cost Effectiveness, What Works and What Doesn’t

Instruction
- Cognitive Load & Schematic Processing
- Level Design, Scaffolding, Goals, & Flow
- Feedback & Scoring and Achievements
- Gameplay Elements

Example
- Project ASPIRE

Conclusion
- Limitations and Challenges
- Summary / Recommended Readings
Summary

- Game-based training has a higher up-front cost, but better return-on-investment
- The science of learning can be used to guide effective training game design:
  - Managing cognitive load through usability (schemas)
  - Using scaffolding techniques and specific goals that are difficult yet achievable (dynamic difficulty adjustment)
  - Tailoring feedback to expertise level and learning progress
  - Motivating with achievements
- Commercial gameplay elements make for engaging and instructionally-sound gameplay
Recommended Readings


Thank You!


