Global Force Serious Gaming: History, Theory, Pedagogy, and Military Application

Elaine Raybourn, Ph.D., Sandia Labs/ADL
Curtis Conkey, Ph.D., US Army, AMRDEC, SSDD
Peter Smith, Ph.D., Katmai/ADL
Tutorial Introductions
  - Elaine

Section 1: History
  - Curtis

Section 2: Pedagogy and Design: Peter, 20 minutes
  - Peter

Section 3: Theory and Military Application: Elaine, 20 minutes
  - Elaine

Discussion and Questions
  - All
Section 1: Definitions and History

DEFINITIONS AND A SHORT HISTORY OF GAMING FOR MILITARY TRAINING
BASED ON PREVIOUS WORK BY DR. ROGER SMITH, PETER SMITH, BEN SAWYER, AND CURTIS CONKEY.
Serious Games Evolving Definition

The application of games or gaming technologies primarily for non-entertainment purposes.

• 1970 - “We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement.”
  – Abt, C. Serious Games. New York: The Viking Press

• 2005 – “Serious Game: a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.”
  – Zyda, M. “From visual simulation to virtual reality to games”. IEEE Computer.

• 2008 – “Resources from the field of videogames reapplied for purposes beyond entertainment including education, healthcare, productivity, defense, workforce development, & more”
  - Ben Sawyer, Founder of Serious Games Initiative & Games for Health

Trend

As games have moved from the board games into the video generation and has expanded it’s reach into multiple industries, the definition has both been expanded
Names Used for Serious Games

- Educational Games
- Simulation
- Virtual Reality
- Alternative Purpose Games
- Edutainment
- Digital Game-Based Learning
- Tactical Decision-making Simulation

- Immersive Learning Simulations
- Social Impact Games
- Persuasive Games
- Games for Change
- Games for Good
- Synthetic Learning Environments
- Game-Based “X”

Reference:
# Taxonomy of Serious Games

<table>
<thead>
<tr>
<th>Category</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defense</td>
<td>Rehabilitation &amp; Wellness, Recruitment &amp; Propaganda, Soldier/Support Training, School House Education, Wargames / planning, War planning &amp; weapons research, Command &amp; Control</td>
</tr>
<tr>
<td>Healthcare</td>
<td>Cybertherapy / Exergaming, Public Health Policy &amp; Social Awareness Campaigns, Training Games for Health Professionals, Games for Patient Education and Disease Management, Visualization &amp; Epidemiology, Biotech manufacturing &amp; design, Public Health Response Planning &amp; Logistics</td>
</tr>
<tr>
<td>Marketing &amp; Communications</td>
<td>Advertising Treatment, Advertising, marketing with games, product placement, Product Use, Product Information, Opinion Research, Machinima, Opinion Research</td>
</tr>
<tr>
<td>Education</td>
<td>Inform about diseases/risks, Social Issue Games, Train teachers / Train workforce skills, Learning, Computer Science &amp; Recruitment, P2P Learning Constructivism Documentary?</td>
</tr>
<tr>
<td>Corporate</td>
<td>Employee Health Information &amp; Wellness, Customer Education &amp; Awareness, Employee Training, Continuing Education &amp; Certification, Advertising / visualization, Strategic Planning, Command &amp; Control</td>
</tr>
</tbody>
</table>

Reference:
Games have always had a serious purpose

- Fortune Telling, Battle Planning, Gambling
- Religious Divination for Weather, Politics, Disease
- Accounting for crops, animals, and trade

Game mechanisms began to emerge 5000 years ago

- Random number generator, playing board, rules, strategies

“Serious” is from the perspective of the society

- Fortune Telling and Divination in 3000BC are equivalent to mathematics and science in 2000AD
Lessons Learned

• The board game form and the rules that govern it evolved over many centuries
• Strategies for controlling territory vs. capturing enemy pieces have been at odds for over 2000 years
Lessons Learned

- The sophistication of modeling advances hand-in-hand with available computer technology
- The crossover of Entertainment and Serious applications is not new
  - It was part of ancient games. It was part of gaming in the 1800’s and the 1950’s
Lessons Learned

• Computer games are one combination of a number of important computer technologies
• The “serious use” of games is another combination of these technologies
  – It is motivated by the gaming applications, but not identical
Serious Games - Early visionaries

- SGI Flight, 1983
- Harpoon, 1989
- Marine Doom, 1996
- Close Combat: Marines
- Spearhead, 1998

Highlights

- Early Entrepreneurs - see potential of gaming/simulation technologies for training
  - SGI, Harpoon, Spearhead
- Combination of original and derived works
  - Derived Work – Marine Doom – Modded version of Doom – The First Moddable Game.
  - Close Combat: Marines
- Early Adopters/Experimenters
  - Games is a “bad” word – euphemisms used like Tactical Decision Makers
Serious Games: Breakout Years

- Americas Army, 2002
- DARWARS AMBUSH, 2003
- DARWARS Tactical Iraqi, 2003
- Full Spectrum Warrior, 2004
- Adaptive Thinking & Leadership, 2004
- GDC Serious Games Summit, 2005
- Close Combat: First to Fight, 2005
- BiLAT, 2006
- Serious Games Showcase & Challenge, 2006

Highlights

- Capacity of gaming technology to engage in training gains widespread attention
  - several high visibility efforts
  - US ARMY, DARPA, Marine Corp
- Focused applications
  - Recruiting, Language Training, Squad Tactics
- First Major Conferences
  - Lots of discussion about what to call “serious games”
Serious Games - Formalization

- US Army forms TCM Gaming Command, 2007
- US Army official game for training, 2009
  - VBS2/Game After Ambush, 2009
- Virtual Cultural Awareness Trainer, 2009

Highlights

- US Army formalizes process of bringing games into training with formation of TRADOC Capability Command (TCM) Gaming
  - Formal requirements are developed
- First major request for product results in VBS2 deployment to US Army training commands.
- US Marines continue to develop on several fronts
- Games no longer a “bad” word
Research, Empirical Data, and ROI

• There are effects-based studies and then there are empirical studies
  – Lots of effects work out there
  – Little empirical research – hard to do
• Several Meta-studies of gaming effects show positive results
  – Fletcher 2006
  – Hays 2005
  – Alexander 2005
  – ONeil 2005
• Empirical studies emerging
  – Roman – IITSEC 2008
  – Mautone – IITSEC 2009/2010
  – Orvis – IITSEC 2010
• More empirical studies needed
• Return on Investment is not well defined and understood
• The mounting body of evidence supports use of games for training
Games - Key Points

• Games are a solution, not the only solution
• Games allow the military to leverage industry investments in gaming technology
• Games are accepted by younger generation
• Incorporate Instructional System Design into game design
• Students are learning through the use of games
Remember, it’s not about games

... It’s about TRAINING!
Section 2: Pedagogy and Design

The composition of a serious game and how to design one that works

Based on:
previous work by Peter Smith in this area.
Designing Serious Games

- What are the components of a Serious Game?
- How are these components different than a simulation?
  - Before we can answer these questions, how do we define games?

“A game is a series of interesting decisions.” – Sid Meir

“A good strategy game may well be a series of interesting decisions – but a good game is something that meets the play needs of its audience.” – Chris Bateman

“Games are indefinable; There is no common threads that link them all.”
– Ludwig Wittgenstein

“Playing a game is a voluntary attempt to overcome unnecessary obstacles.”
– Bernard Suits

References:
**Game Industry’s Definition**

“A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome.” – **Katie Salen & Eric Zimmerman**

<table>
<thead>
<tr>
<th>Elements of game definition</th>
<th>Parlett</th>
<th>Abt</th>
<th>Huizinga</th>
<th>Callois</th>
<th>Suits</th>
<th>Crawford</th>
<th>Costikyan</th>
<th>Avedon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proceeds according to rules that limit players</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conflict or Contest</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Goal-oriented/outcome-oriented</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity, process, or event</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Involves decision-making</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Serious and absorbing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never associated with material gain</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artificial/Outside/Ordinary life</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creates special social groups</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voluntary</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make-believe/Representational</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System of parts/Resources and tokens</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A form of Art</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Reference:**
Serious Game Characteristics for Learning

Reference:
A Feature Level Comparison

<table>
<thead>
<tr>
<th>Conventional Games</th>
<th>Serious Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Control</td>
</tr>
<tr>
<td>Players</td>
<td>Challenge</td>
</tr>
<tr>
<td>Conflict</td>
<td>Rules/Goals</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Feedback (Assessment/Sensory Stimuli)</td>
</tr>
<tr>
<td>Artificial</td>
<td>Narrative (Fantasy/Mystery)</td>
</tr>
</tbody>
</table>
Systems are Simulations

- **Objects**
  - Parts and Elements of System
- **Attributes**
  - Properties of System and its Objects
- **Internal Relationships**
  - How Objects Interact
- **Environment**
  - External forces acting upon system
Expected Fidelity v Gaming Features

<table>
<thead>
<tr>
<th>Simulations</th>
<th>AAA Games</th>
<th>Indie Games</th>
<th>Casual Games</th>
</tr>
</thead>
</table>

The diagram illustrates the expected fidelity in gaming features across different genres, with a focus on Simulations.
When gaming characteristics are closely matched to learning objectives instructional effectiveness improves.

Reference:
Learning Games are at the intersection of Play, Simulation, and Pedagogy.
The MDA Design Model

- **Mechanics**: describes the particular components of the game, at the level of data representation and algorithms.
- **Dynamics**: describes the run-time behavior of the mechanics acting on player inputs and each others' outputs over time.
- **Aesthetics**: describes the desirable emotional responses evoked in the player, when she interacts with the game system.

Reference:
Mechanics

- This is the underlying **System** that makes a game work.
- This should be considered the number 1 place to enforce **Learning Objectives**
- If your Core Mechanic is **Bad** your game is **Bad** (Note: I did not use the word FUN)
### Table 1. Newtonian Concepts in the Inventory.

<table>
<thead>
<tr>
<th>Kinematics</th>
<th>Inventory Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity discriminated from position</td>
<td>20E</td>
</tr>
<tr>
<td>Acceleration discriminated from</td>
<td>21D</td>
</tr>
<tr>
<td>velocity</td>
<td></td>
</tr>
<tr>
<td>Constant acceleration entails</td>
<td>23D, 24E</td>
</tr>
<tr>
<td>parabolic orbit</td>
<td></td>
</tr>
<tr>
<td>changing speed</td>
<td>25B</td>
</tr>
<tr>
<td>Vector addition of velocities</td>
<td>(7E)</td>
</tr>
</tbody>
</table>

**1. First Law**

- with no force: 4B, (6B), 10B
- velocity direction constant: 26B
- speed constant: 8A, 27 A
- with cancelling forces: 18B, 28C

**2. Second Law**

- Impulsive force: (6B), (7E)
- Constant force implies constant acceleration: 24E, 25B

**3. Third Law**

- for impulsive forces: 2F, 11F
- for continuous forces: 2F, 11F

**4. Superposition Principle**

- Vector sum: 26B, 28C
- Cancelling forces: 26B, 28C

**5. Kinds of Force**

- 5S. Solid contact:
  - passive
  - Impulsive
  - Friction opposes motion

- 5F. Fluid contact:
  - Air resistance
  - Buoyant (air pressure)

- 5G. Gravitation:
  - Acceleration independent of parabolic trajectory

*Arms Image*
Mechanics

Insignia Searcher
Dynamics

• Gaming Features
  – Control
  – Challenge
  – Rules
  – Goals
  – Narrative
  – Feedback
Evaluate and Iterate the Design

- Learning Effectiveness *(Trumps Everything)*
  - Bring Design to Experts Before Building
  - Ensure Secondary Mechanics to not Interfere with Core Mechanic
  - Ensure All Mechanics Support Learning
    - If they don’t, remove them
    - Even if they are Really Fun

- Play Mechanics *(From a Game Perspective)*
  - Paper Prototype and Play Test if Possible
  - Use Other Games as Proof of Concept
Section 3: Theory and Military Application

MULTI-PLAYER GAMES FOR TRAINING: A CASE STUDY OF CURRENT STATE

Based on:
Section Outline

- Introduction
- Theory
- Methods
  - Real-Time Feedback & Evaluation
- Evidence
- Non-kinetic collective training
  - Transition Team Non-kinetic Mission
  - Summary
  - Results
  - Recommendations
- Conclusion
“Good games do not simulate physical reality; they mirror emotional reality.” - Chris Crawford (2003, p. 31)
Why Crucibles?

Crucibles are necessary to train Military adaptability and leadership

• A crucible is a heat-resistant container that can be heated to very high temperatures.
• Not all serious games or game-based learning applications are crucible experiences. Many cognitive game-based learning applications including those for language, culture, and decision-making are not crucible experiences (even though they may be presented in engaging 3D virtual environments) and often do not teach a person who he or she is, but rather what he or she knows (Raybourn, 2011).

Reference:
### Characteristics of Social-Process Simulations

<table>
<thead>
<tr>
<th>Task</th>
<th>Focus</th>
<th>Role of Problem</th>
<th>Participant Actions</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>To interact with others to address a particular challenge</td>
<td>Actions executed by others and the effects on one’s own assumptions, goals, strategies</td>
<td>Implicit: it arises from conflicting participant goals or actions</td>
<td>Use of social communication such as negotiation, persuasion, confrontation, writing, etc.</td>
<td>Reactions of other participants</td>
</tr>
</tbody>
</table>

Reference:
Cross-cultural Crucible Experiences

- Key elements:
  - Challenge own assumptions
  - Hone emotional intelligence
  - Relational skills
  - Self-aware
  - Analyze, reflect
  - Communication competence

- *Adaptive Thinking & Leadership, developed with Army Game Project*
- *DARPA DARWARS Nonkinetic Engagement Module*

Reference:
Real-time Feedback System and in-game assessment & evaluation for crucible multi-player training

- Role for Evaluators
- Real-time role for observer controllers
- New instructor and trainee interfaces
- Real-time feedback & metacognitive training
- In-game assessment hooks to AAR
- Quantitatively display non-lethal training criteria
Reflective Observer/Evaluator
After Action Review
Theory: Why multiple roles?

- Experiential Learning Theory (Kolb, 1984)
- Social Learning Theory (Bandura, 1971)
- Mirror Neurons (Rizzolatti, 1990)
- Developmental Model of Intercultural Sensitivity (Bennett, 1993)
- Metacognition (Flavell, 1979)

Metacognitive agility is possessing the ability to analyze and reflect on the way one or others think, discern different tasks or problems requiring different types of cognitive strategies, and employ those strategies to enhance learning and performance (Raybourn, 2007a,b).

Metacognitive agility plays an important role in leadership and intercultural adaptability.
• Developmental Model of Intercultural Sensitivity, Bennett (1993)

Development of Intercultural Sensitivity

Experience of difference

<table>
<thead>
<tr>
<th>Denial</th>
<th>Defense</th>
<th>Minimization</th>
<th>Acceptance</th>
<th>Adaptation</th>
<th>Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnocentric Stages</td>
<td></td>
<td></td>
<td>Ethnorelative Stages</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Milton Bennett, 1993
Field Research Findings with Special Forces Officers

“I anticipated being actively engaged by a simulation.”

“I learned more about my strengths and weaknesses by participating in this simulation than I would if I did not participate.”

“The scenario depicted in the simulation was realistic.”

Reference:
Quasi-Experimental Design

- 85 participants, mostly novices
- Quantitative & qualitative data

- DARWARS Ambush! NK (non-kinetic) used as experimental environment
  - Trainee
  - Reflective Observer/Evaluator

- Non-kinetic engagement mission
  - Intercultural competence
  - Leadership
  - Adaptive thinking
  - Interpersonal communication
Research Questions

• **RQ1:** Do participants, regardless of role (either player observation/evaluation role), report change with respect to learning?

• **RQ2:** Are there significant differences among groups participating in different roles in non-kinetic engagement training, especially when one role requires more active participation than the other?
Players reported learning about *their own* communication and self-awareness.

*Both* Observer/Evaluators and Players reported learning about decision making, problem solving, and cultural awareness.

*Both* Observer/Evaluators and Players reported being *engaged*.

Reference:
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Difficulty</th>
<th>Crucible</th>
<th>Objective</th>
<th>Friction Point</th>
<th>Emotional Intelligence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand Area</td>
<td>Familiarize</td>
<td>None</td>
<td>Listening</td>
<td>None</td>
<td>Appraising emotions (nonverbal)</td>
</tr>
<tr>
<td>2. Convoy Planning</td>
<td>Familiarize</td>
<td>None</td>
<td>Planning</td>
<td>No advance notice of link up</td>
<td>Accurately Appraise emotions</td>
</tr>
<tr>
<td>3. Link up with Iraqi Police</td>
<td>Crawl</td>
<td>Communication</td>
<td>Language</td>
<td>Iraqi Police actions and link up location not</td>
<td>Regulating own Emotions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>difficulty BOLO</td>
<td></td>
<td>communicated</td>
<td></td>
</tr>
<tr>
<td>4. VIP Pickup</td>
<td>Walk</td>
<td>Communication</td>
<td>Language</td>
<td>Lead vehicle stops, VIP location ambiguous</td>
<td>Regulating own Emotions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>breakdown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. VIP Escort</td>
<td>Walk/Run</td>
<td>Civilian Accident</td>
<td>Language</td>
<td>Civilians need medical attention</td>
<td>Regulating others Emotions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Police Meeting</td>
<td>Run</td>
<td>Security Advising</td>
<td>Language</td>
<td>Iraqi Police execute security incorrectly</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Necessary Communication breakdown</td>
<td>Cultural Awareness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• *Put individuals and teams in observation/evaluation roles and switch mindsets*
• Real-time reflective observation/evaluation role links curriculum to crucible training, stimulates leadership development
• Errors yes, but build confidence
• Engender team communication about non-kinetic engagement down range
• Train emotional resiliency, culture, language, non-kinetic engagements collectively
• Introduce a graduated scale of cultural awareness exposure in crucibles
  – Expose trainees to joint, multicultural team exercises from the beginning (LtG Karlheinz Viereck, Deputy Chief of Staff, DCOS, Joint Force Training Headquarters, SACT)
Acknowledgements

• US Army PEOSTRI Army Games for Training
• US Army JFKSWCS
• USMC
• DARPA
• Sandia Laboratories LDRD Program
• OSD TRS & ADL Initiative


Questions?

For more information contact:

**Elaine M. Raybourn, Ph.D.**
elaine.raybourn@adlnet.gov, emraybo@sandia.gov

**Curtis Conkey, Ph.D.**
curtis.conkey@mda.mil

**Peter Smith, Ph.D.**
peter.smith.ctr@adlnet.gov