



# 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



**Sandia  
National  
Laboratories**



# Outline

- ▶ **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:

Sawyer, B., Smith, P. (2008). Serious games taxonomy. Presented at Serious Games Summit 2008

# Taxonomy of Serious Games

	Games for Health	Advergames	Games for Training	Games for Education	Games for Science and Research	Production	Games as Work
Government & NGO	Public Health Education & Mass Casualty Response	Political Games	Employee Training	Inform Public	Data Collection / Planning	Strategic & Policy Planning	Public Diplomacy, Opinion Research
Defense	Rehabilitation & Wellness	Recruitment & Propaganda	Soldier/Support Training	School House Education	Wargames / planning	War planning & weapons research	Command & Control
Healthcare	Cybertherapy / Exergaming	Public Health Policy & Social Awareness Campaigns	Training Games for Health Professionals	Games for Patient Education and Disease Management	Visualization & Epidemiology	Biotech manufacturing & design	Public Health Response Planning & Logistics
Marketing & Communications	Advertising Treatment	Advertising, marketing with games, product placement	Product Use	Product Information	Opinion Research	Machinima	Opinion Research
Education	Inform about diseases/risks	Social Issue Games	Train teachers / Train workforce skills	Learning	Computer Science & Recruitment	P2P Learning Constructivism Documentary?	Teaching Distance Learning
Corporate	Employee Health Information & Wellness	Customer Education & Awareness	Employee Training	Continuing Education & Certification	Advertising / visualization	Strategic Planning	Command & Control
Industry	Occupational Safety	Sales & Recruitment	Employee Training	Workforce Education	Process Optimization Simulation	Nano/Bio-tech Design	Command & Control

Reference:

Sawyer, B., Smith, P. (2008). Serious games taxonomy. Presented at Serious Games Summit 2008

# Ancient Games

5000 -2900 -2800 -2700 -2600 -2500 -2400 -2300 -2200 -2100 -2000 -1900 -1800 -1700 -1600 -1500 -1400 -1300 -1200



- 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

# Board Games

-3000

-2000

-1000

0

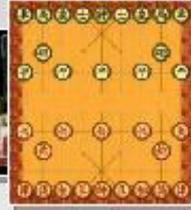
1000

2000



• -3000 Wei Hai

• -2300 Go



• -500 Chaturanga

• -200 Xiangqi



• 500 Chess



- 1938 Scrabble
- 1950 Risk
- 1843 Mansion of Happiness
- 1920 Stratego
- 1936 Monopoly

## 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

# Military Games

1700

1800

1900

2000



- 1664 Koenigspiel



- 1780 War Chess
- 1797 Military School Wargame
- 1811 Kriegsspiels



- 1879 American Kriegsspiel
- 1886 Naval War College
- 1903 Miniature Games
- 1912 Lanchester Equations
- 1929 Political-Military Gaming
- 1933 Soviet Kriegsspiel
- 1941 Japanese Wargaming
- 1948 Computer Wargames
- 1978 Janus
- 1992 MODSAF

## 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

# Electronic Games

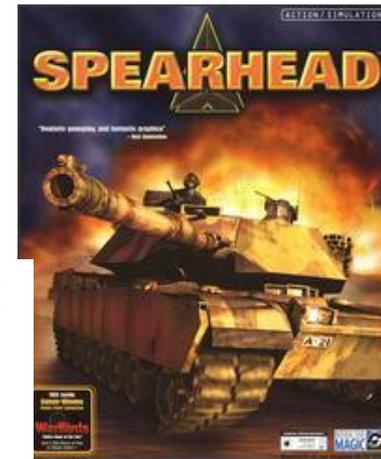


## Lessons Learned

- 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



**VCAT**  
VIRTUAL CULTURAL  
AWARENESS TRAINER™



## 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:

Bateman, C. (2008). A Game Isn't a Series of Interesting Decisions.

Suits, B. (1978). 2005: The Grasshopper: Games, Life and Utopia: Toronto: University of Toronto Press.

# Game Industry's Definition

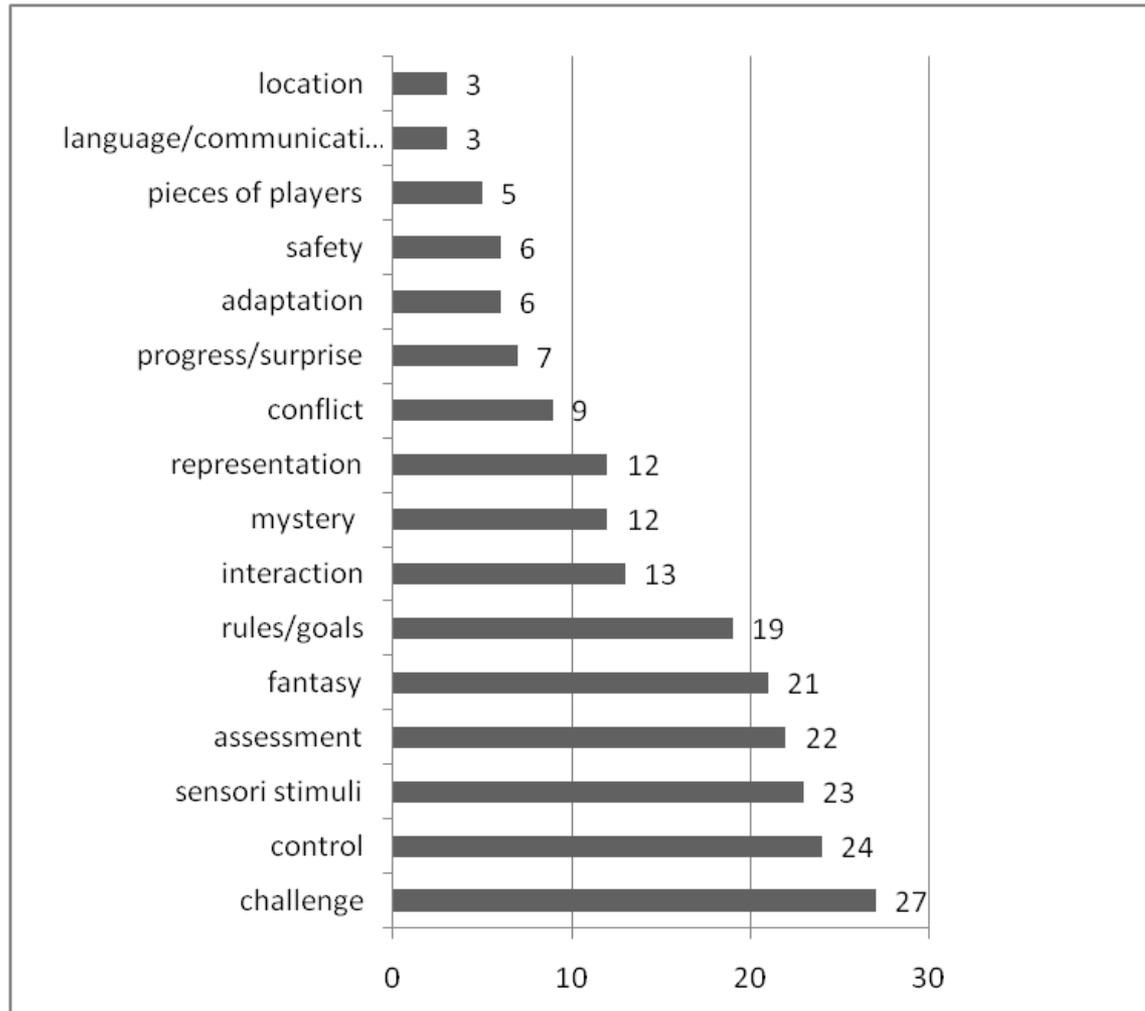
*“A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome.”* – **Katie Salen & Eric Zimmerman**

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

Reference:

Salen, K., & Zimmerman, E. (2004). Rules of play: Game design fundamentals: The MIT Press.

# Serious Game Characteristics for Learning



Reference:

Wilson, K. A., Bedwell, W. L., Lazzara, E. H., Salas, E., Burke, C. S., Estock, J. L., . . . Conkey, C. (2009). Relationships between game attributes and learning outcomes. *Simulation & Gaming*, 40(2), 217-266.

# A Feature Level Comparison

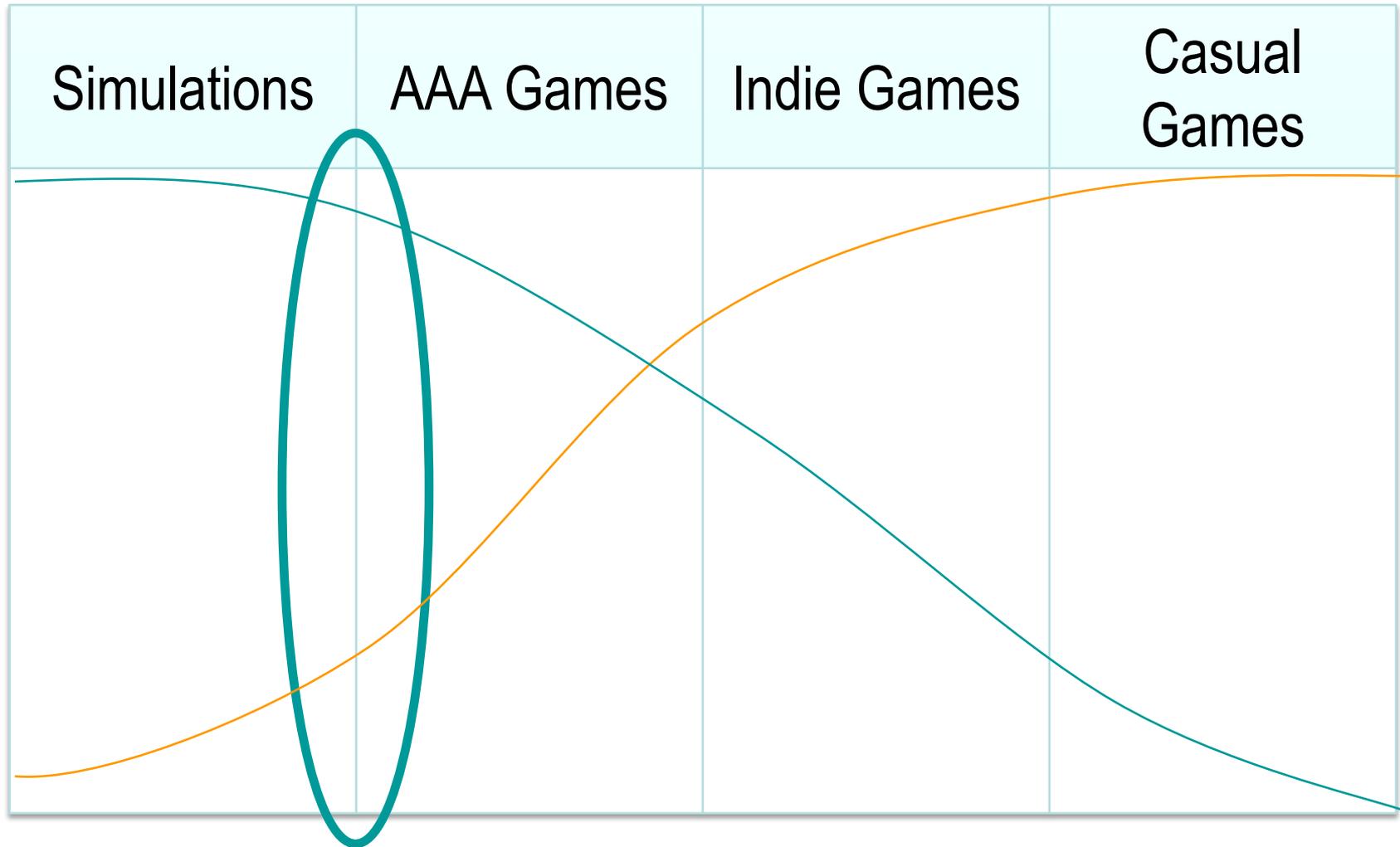
Conventional Games	Serious Games
System	
Players	Control
Conflict	Challenge
Rules	Rules/Goals
Outcomes	Feedback (Assessment/Sensory Stimuli)
Artificial	Narrative (Fantasy/Mystery)

# 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

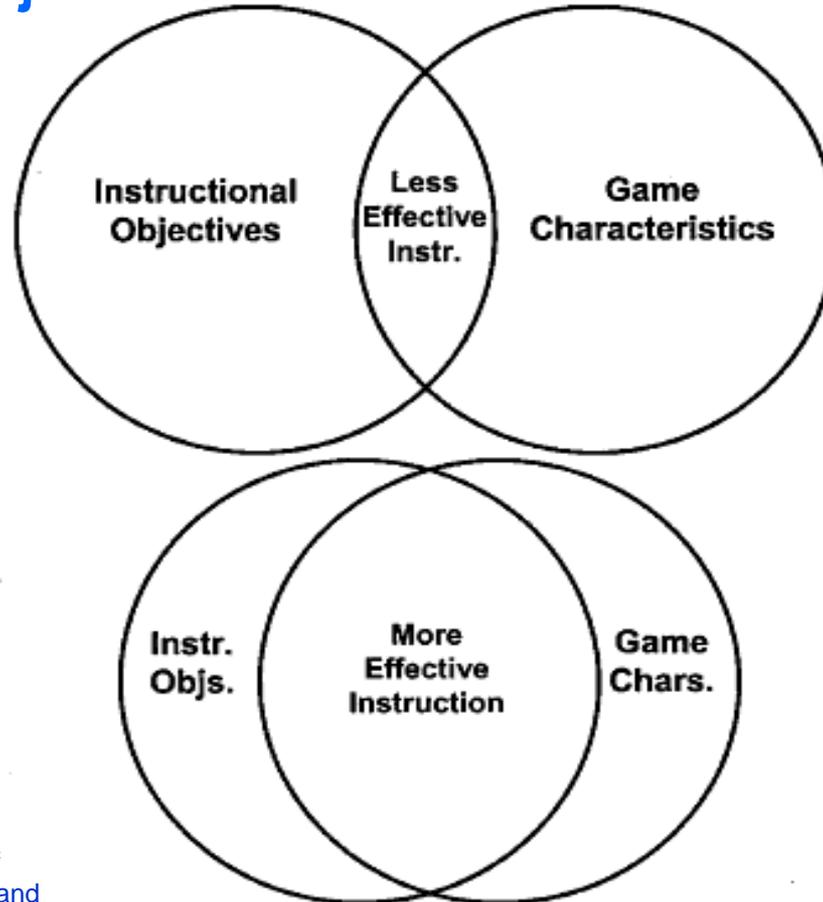


# Expected Fidelity v Gaming Features



# Learning Objectives v. Gaming Characteristics

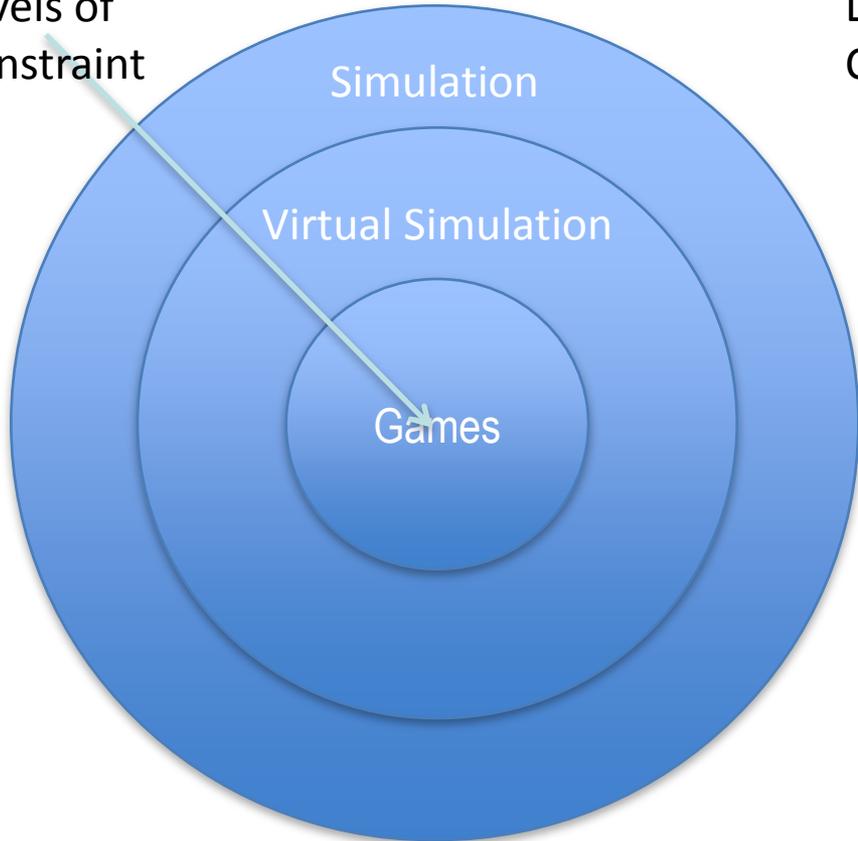
When gaming characteristics are closely matched to learning objectives instructional effectiveness improves.



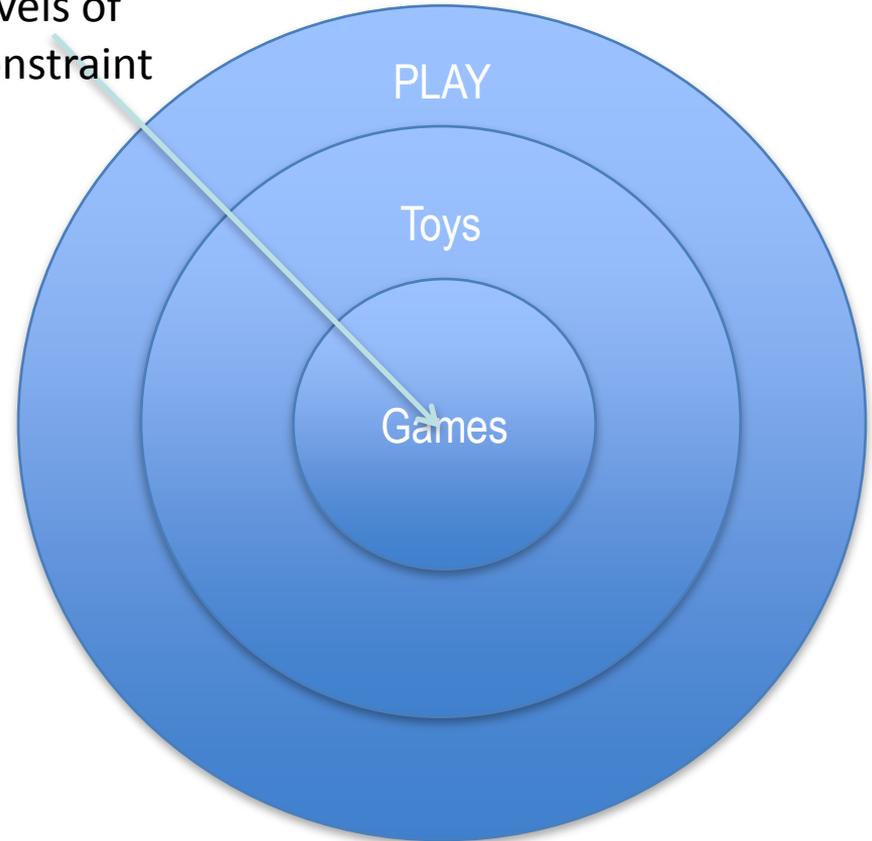
Reference:  
Hays, R. T. (2005). The effectiveness of instructional games: A literature review and discussion: DTIC Document.

# Learning Games

Levels of  
Constraint



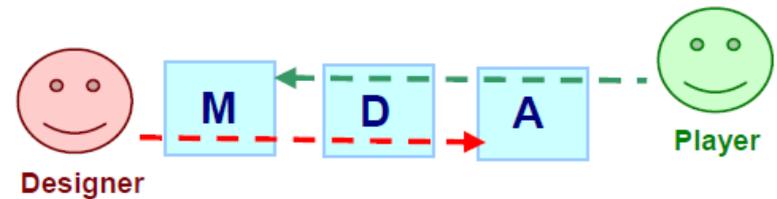
Levels of  
Constraint



**Learning Games are at the intersection of Play, Simulation, and Pedagogy.**

# The MDA Design Model

- MDA 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.

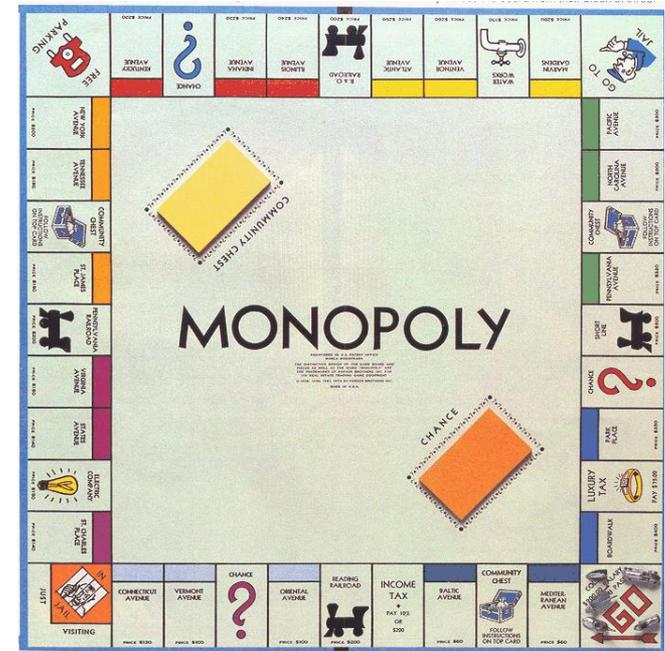


Reference:

Hunicke, LeBlanc, Zubec (2005) A Formal Approach to Game Design and Game Research,.

# 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)



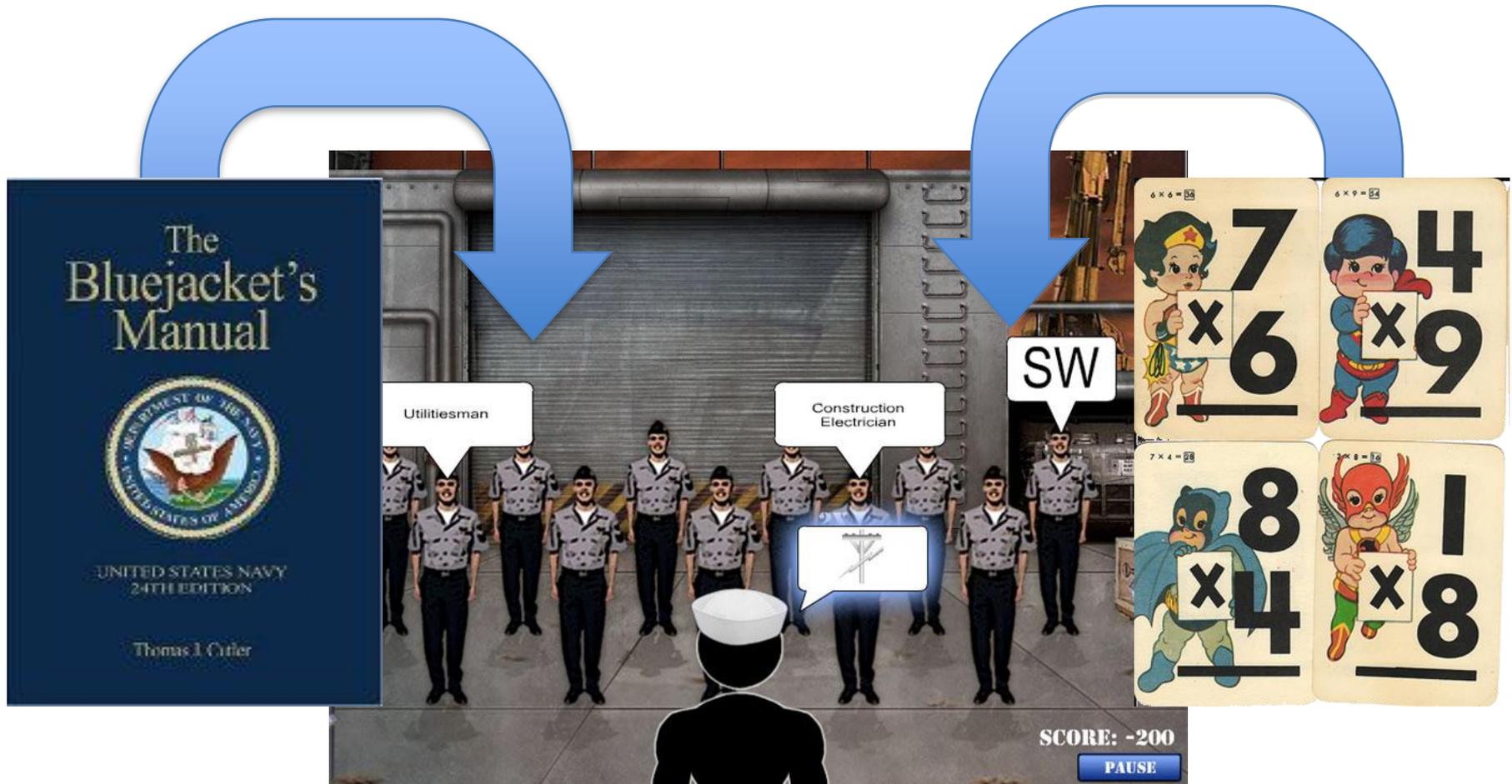
# Instructional Design v Game Design

Table I. Newtonian Concepts in the Inventory.

	Inventory Item
<b>0. Kinematics</b>	
Velocity discriminated from position	20E
Acceleration discriminated from velocity	21D
Constant acceleration entails parabolic orbit	23D, 24E
changing speed	25B
Vector addition of velocities	(7E)
<b>1. First Law</b>	
with no force	4B, (6B), 10B
velocity direction constant	26B
speed constant	8A, 27 A
with cancelling forces	18B,28C
<b>2. Second Law</b>	
Impulsive force	(6B), (7E)
Constant force implies constant acceleration	24E, 25B
<b>3. Third Law</b>	
for impulsive forces	2E, IIE
for continuous forces	
<b>4. Superposition Principle</b>	
Vector sum	
Cancelling forces	
<b>5. Kinds of Force</b>	
<b>5S. Solid contact</b>	
passive	
Impulsive	
Friction opposes motion	
<b>5F. Fluid contact</b>	
Air resistance	
buoyant (air pressure)	
<b>5G. Gravitation</b>	
acceleration independent of	
parabolic trajectory	



# Mechanics



## Insignia Searcher

- Gaming Features
  - Control
  - Challenge
  - Rules
  - Goals
  - Narrative
  - Feedback



# Aesthetics

**TIME LEFT: 4**  
**ROUND: 1**

**QUESTION TIME: 4**

1

2

3

AM

4

4X

Aviation Structural Mechanic

5

6

**SCORE: 4700**

**PAUSE**

# 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:

RAYBOURN, E.M. (2011) HONING EMOTIONAL INTELLIGENCE WITH GAME-BASED CRUCIBLE EXPERIENCES, INTERNATIONAL JOURNAL OF GAME-BASED LEARNING, 1(1), 32-44.

# 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:

Raybourn, E.M. (2011) Honing Emotional Intelligence with Game-based Crucible Experiences, International Journal of Game-Based Learning, 1(1), 32-44.

# Social-Process Simulation Design

## Characteristics of Social-Process Simulations

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

Gredler, 1992

Reference:

Raybourn, E.M. (2010). Designing Games as Social-Process Simulation Crucible Experiences: Toward Developing and Assessing Intercultural Adaptability. Applied Human Factors and Ergonomics, Taylor & Francis, Ltd.

# 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*



LISTEN

OBSERVE

ANALYZE

COMMUNICATE

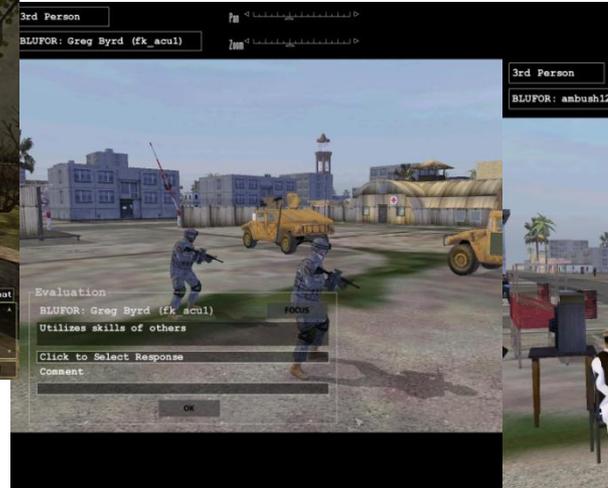
Reference:

Raybourn, E.M. (2010). *Designing Games as Social-Process Simulation Crucible Experiences: Toward Developing and Assessing Intercultural Adaptability*. Applied Human Factors and Ergonomics, Taylor & Francis, Ltd.

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



JFKSWCS Adaptive Thinking & Leadership



DARWARS Ambush NK! Evaluator



DARWARS Ambush NK! PEO-STRI

- 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

Unlimited Government use

# 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)



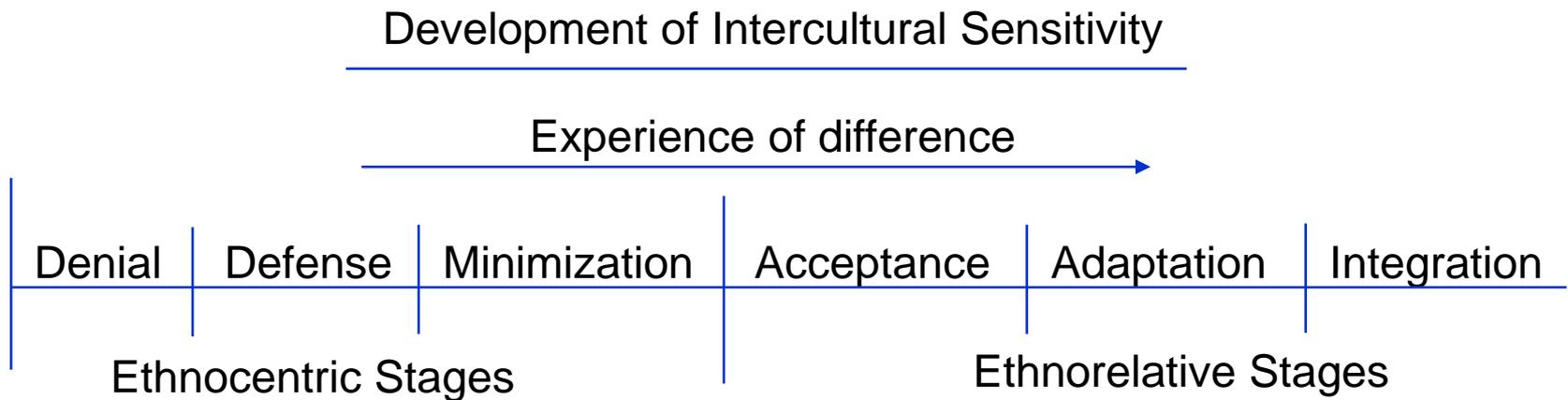
Photo courtesy of US Embassy, Iraq

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.***

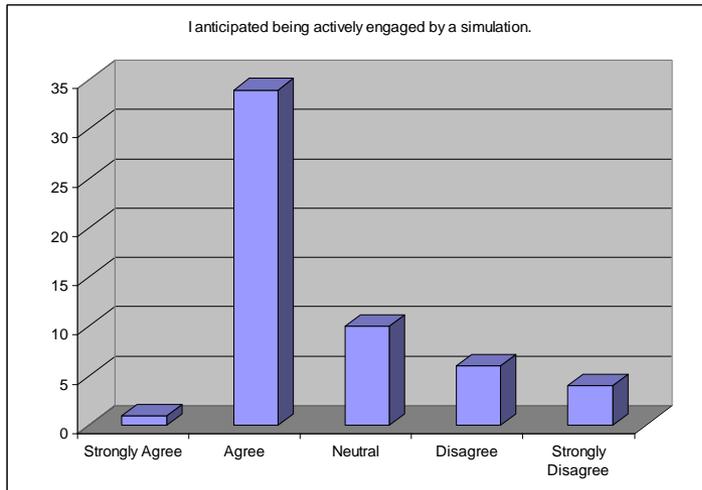
# Theoretical Foundations Continued

- **Developmental Model of Intercultural Sensitivity, Bennett (1993)**

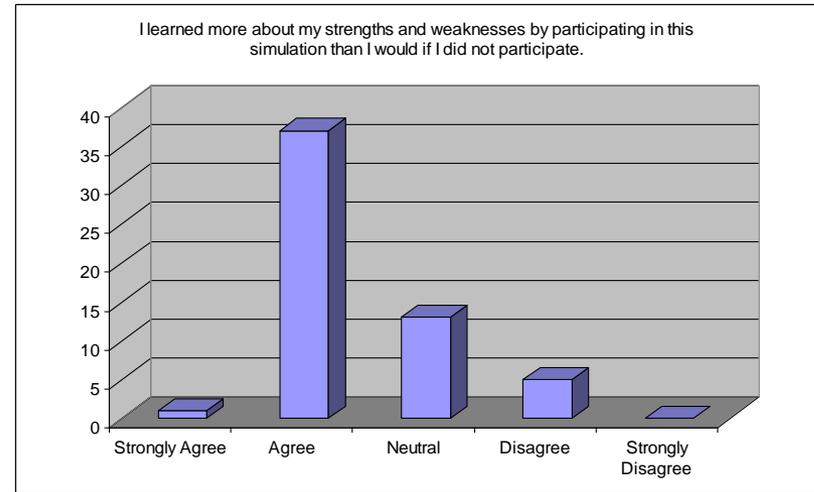


Milton Bennett, 1993

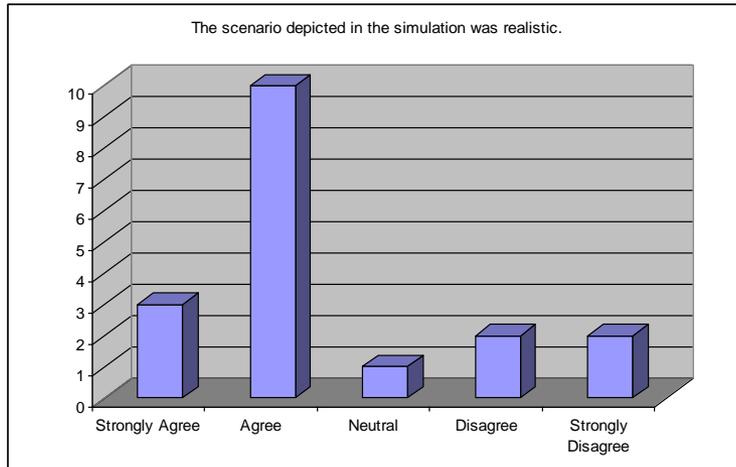
# Field Research Findings with Special Forces Officers



**“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:

Raybourn, E. M., Deagle, E., Mendini, K., & Heneghan, J. (2005). Adaptive Thinking & Leadership Simulation Game Training for Special Forces Officers. I/ITSEC 2005 Proceedings, Interservice/ Industry Training, Simulation and Education Conference Proceedings, November 28-December 1, Orlando, Florida.

# Quasi-Experimental Design



Team member as Sgt. Jones, OPFOR computer to the right

- 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?

# Empirical Research with Novices

*This finding has been corroborated by Special Forces Officers who participated in training designed with multiple roles (Raybourn 2009; Raybourn et. al., 2005)*



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:

Raybourn, E.M. (2009). Beyond Game Effectiveness Part I: An Empirical Study of Multi-role Experiential Learning. I/ITSEC 2009 Proceedings, Interservice/ Industry Training, Simulation and Education Conference Proceedings, November 30- December 04, Orlando, Florida, USA.

# USMC Transition Team Non-Kinetic Crucible Training

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

# 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

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# Questions?

For more information contact:

**Elaine M. Raybourn, Ph.D.**

[elaine.raybourn@adlnet.gov](mailto:elaine.raybourn@adlnet.gov), [emraybo@sandia.gov](mailto:emraybo@sandia.gov)

**Curtis Conkey, Ph.D.**

[curtis.conkey@mda.mil](mailto:curtis.conkey@mda.mil)

**Peter Smith, Ph.D.**

[peter.smith.ctr@adlnet.gov](mailto:peter.smith.ctr@adlnet.gov)