

RESEARCH REVIEW 2022

Transformative Gamification: Making Impact across the Federal Workforce

NOVEMBER 14-16, 2022

Rotem Guttman
Senior Researcher

[DISTRIBUTION STATEMENT A] Approved for public release and unlimited distribution.

©2022

Carnegie
Mellon
University
Software
Engineering
Institute

Copyright 2022 Carnegie Mellon University.

This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

The view, opinions, and/or findings contained in this material are those of the author(s) and should not be construed as an official Government position, policy, or decision, unless designated by other documentation.

NO WARRANTY. THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

[DISTRIBUTION STATEMENT A] This material has been approved for public release and unlimited distribution. Please see Copyright notice for non-US Government use and distribution.

This material may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at permission@sei.cmu.edu.

Carnegie Mellon® and CERT® are registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

DM22-1073

Panel



Rotem Guttman

Rotem Guttman is a senior researcher and team lead at the Software Engineering Institute. His research focuses on leveraging non-traditional methods to reach the cybersecurity audience. His research interests include network security, cyber-physical modeling and simulation, cybersecurity training and education, gamification techniques for cybersecurity, cyber forensics and incident response.



Jessica Hammer

Jessica Hammer is the Thomas and Lydia Moran Associate Professor of Learning Science, jointly appointed in the HCI Institute and the Entertainment Technology Center at Carnegie Mellon University. Her research focuses on transformational games, which are games that change how players think, feel, or behave. She is also an award-winning game designer.



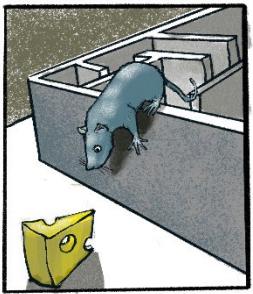
Dominic Ross

Dominic Ross is the broadcast media team lead at the SEI where his work focuses on multimedia research and transformative gamification. In that role, he designs and engineers production studios and systems used to acquire training, conferences, webinars, and broadcast video used by the federal cybersecurity workforce, Carnegie Mellon University, and the SEI.

Transformational Games



Hands On
Experimentation



Align Incentives



Increase Receptivity



Measure/ Improve
Teamwork



Skill Transfer

Hands-on Experimentation

- Rapid Feedback



Early, fast feedback can be critical to avoiding disaster.

- Wargaming
- Long DoD History – since 1800's
- Modern era:
 - Two broad categories:
 - Data-generating / analytical
 - Exploratory / interactive
 - Must maintain analytical rigor
- These two are not mutually exclusive

Extending Training Beyond Cyber – Cyber Kinetic Effects Integration (CKEI)

Integrating Cyber-Kinetics

- Allowing combined arms training
 - Cyber effects propagate into kinetic domain and vice versa
 - Cyber supports larger mission
- Every team failed on the first attempt
 - Rapid Iteration



Three Envelopes



Cybersecurity & Risk Board Game

- Requires no prior knowledge of networking, programming, or risk assessment
- Replicates organizations across different sectors of critical infrastructure
- Creates intuitive understanding of balancing risk and operational capabilities.

Improved Teamwork



Worst-case scenario – Ad Hoc workgroup

- Build trust
- Create willingness to share ideas
- Move rapidly to productivity

Strong data backing

- Randomized controlled trial
- Flow
- Cohesion

Large Team Coordination

- Massive scale
- Native coordination
- Replicable to DoD context
- GIS Arta

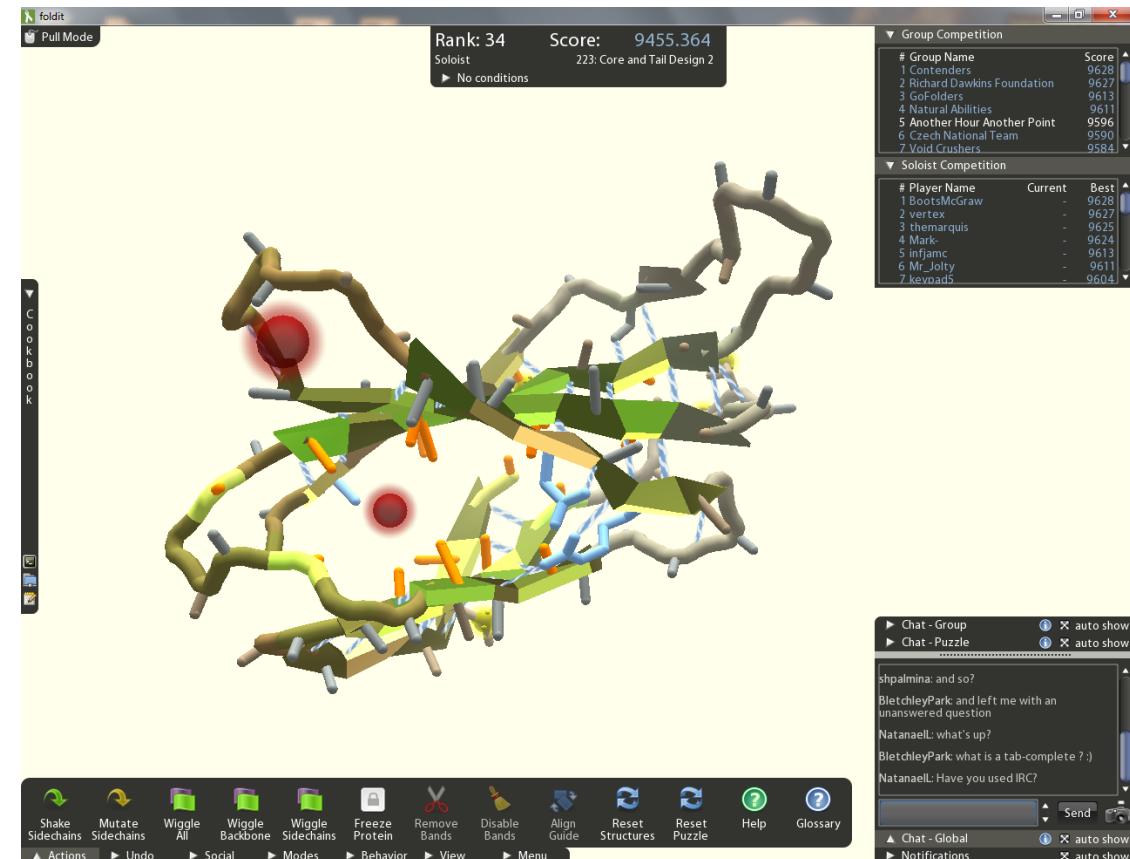
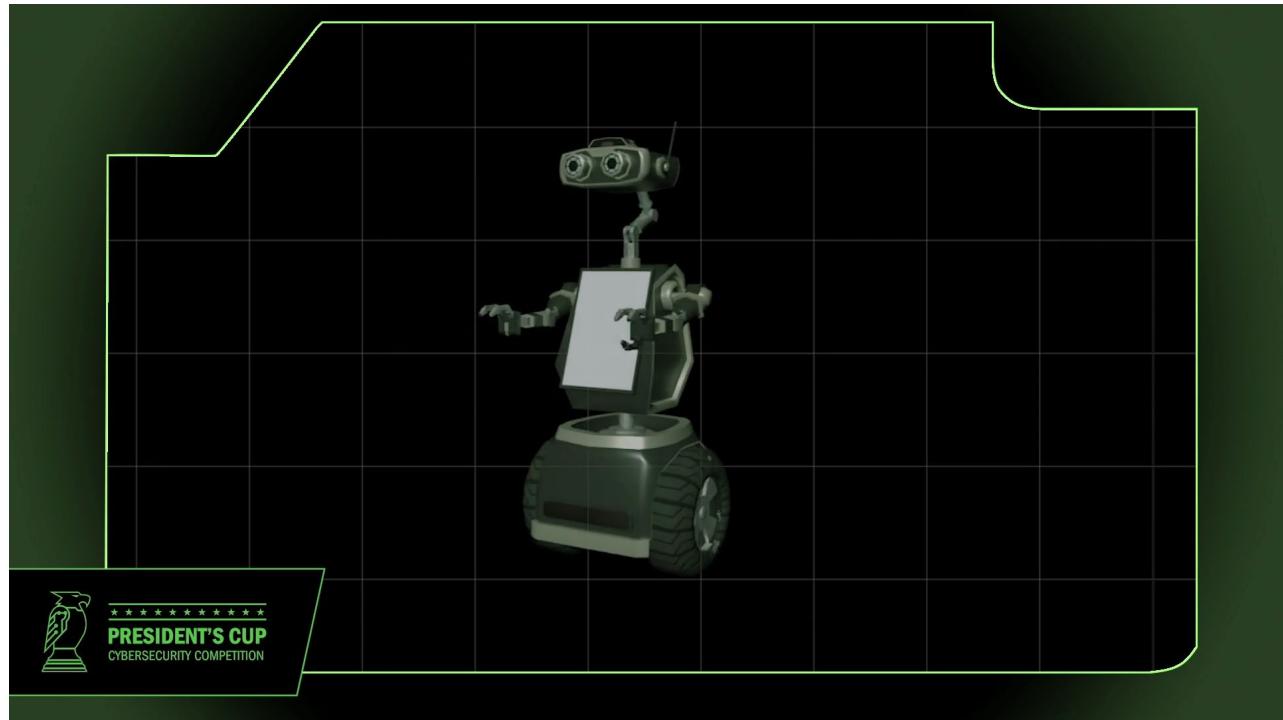


Image courtesy of Animation Research Labs, University of Washington

Measurement

Mandate from EO 13870:

- “to identify, challenge, and reward the United States Government's best cybersecurity practitioners and teams across offensive and defensive cybersecurity disciplines.”
- Team Finals Client
- Immersive
- Team oriented challenges
- Narratively driven



Human-AI Decision Evaluation System (HADES)



A demonstration of the HADES test harness in use

Narratively driven example

- Evaluating the effect of:
 - Stakes
 - AI recommendations
 - Not all explainability is helpful!
- Simulated AI with drop-in capability
 - Full lifecycle support

Aligned Incentives



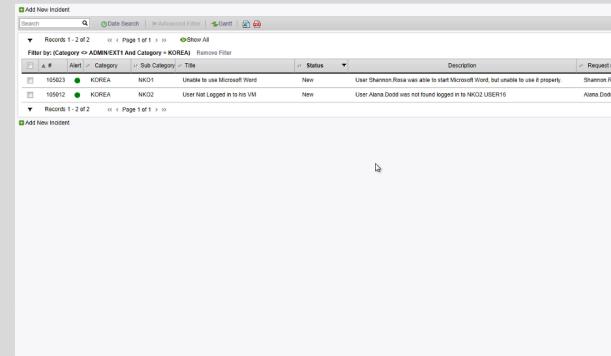
You get the behavior you incentivize,
not the behavior you ask for.

Games allow us to change the incentive structure

- Incentives ≠ Payment
 - Incentives tied to motivation
 - Games can provide motivation
 - Narrative Engagement
 - Competitive / Cooperative
 - Status / Power / Vengeance / Collection

Aligned Incentives

Synthetic Client Helpdesk



“Cheating” as a benefit

- Properly aligned incentives encourage beneficial “cheating”
 - Rules of Engagement violation → Mission Focus
 - Studying history to “Cheat” at Civilization¹, Ars Magica²
 - SAT Vocabulary preparation via Magic the Gathering³

[1] K. D. Squire, *Replaying history: Learning world history through playing “Civilization III”*. Indiana University, 2004.

[2] K. Heller and J. Hammer, “Playing History: How Ars Magica Players Develop Historical Literacy,” *Meaningful Play*, 2012.

[3] A. M. Dodge, “Examining Literacy Practices in the Game Magic: The Gathering,” *American Journal of Play*, vol. 10, Art. no. 2, 2018.

Transfer of Skills



[1] G. Culbertson, S. Wang, M. Jung, and E. Andersen, "Social Situational Language Learning through an Online 3D Game," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, New York, NY, USA, 2016, pp. 957–968.

[2] Z. A. Wen, Z. Lin, R. Chen, and E. Andersen, "What.Hack: Engaging Anti-Phishing Training Through a Role-Playing Phishing Simulation Game," in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, New York, NY, USA, 2019, pp. 1–12.

Transformative Gamification: Making Impact
©2022

Learning works best *in context*

- Games can provide that context
- Games can enhance future learning

Examples:

- Foreign Language Role Playing Game
 - Avg. 8.7 words learned in ~40 min¹
- Phishing Training Game
 - 36.7% improvement in player's ability to identify phishing email compared to control group²

Transfer of Skills

Experiences must be designed to support skills transfer!

- Multiple approaches to evaluating games
- Not all games provide utility!



- Preparation for Future Learning (PFL)¹
 - Clear goals
 - Immediate feedback
 - Specific knowledge
 - Outward pointers
- Limited DoD resources
- Leverage personal time by making content engaging enough for the audience to self-select during leisure time.
- Extend reach beyond DoD enterprise (defend the nation).

[1] J. D. Bransford and D. L. Schwartz, "Chapter 3: Rethinking Transfer: A Simple Proposal With Multiple Implications," *Review of Research in Education*, vol. 24, Art. no. 1, 1999.

VR Prototyping

Examples

- F-16 Connection Requirements
- Connecting to larger scale simulations
- Forensics use case



Improved Receptivity



Games can provide an alternative reality

Properly designed these can create:

- Increased comfort asking questions¹
- Disrupt established power dynamics to elicit better data²
- Allow practice in a safe environment³

[1] A. To, J. Holmes, E. Fath, E. Zhang, G. Kaufman, and J. Hammer, "Modeling and Designing for Key Elements of Curiosity: Risking Failure, Valuing Questions," *Transactions of the Digital Games Research Association*, 2017.

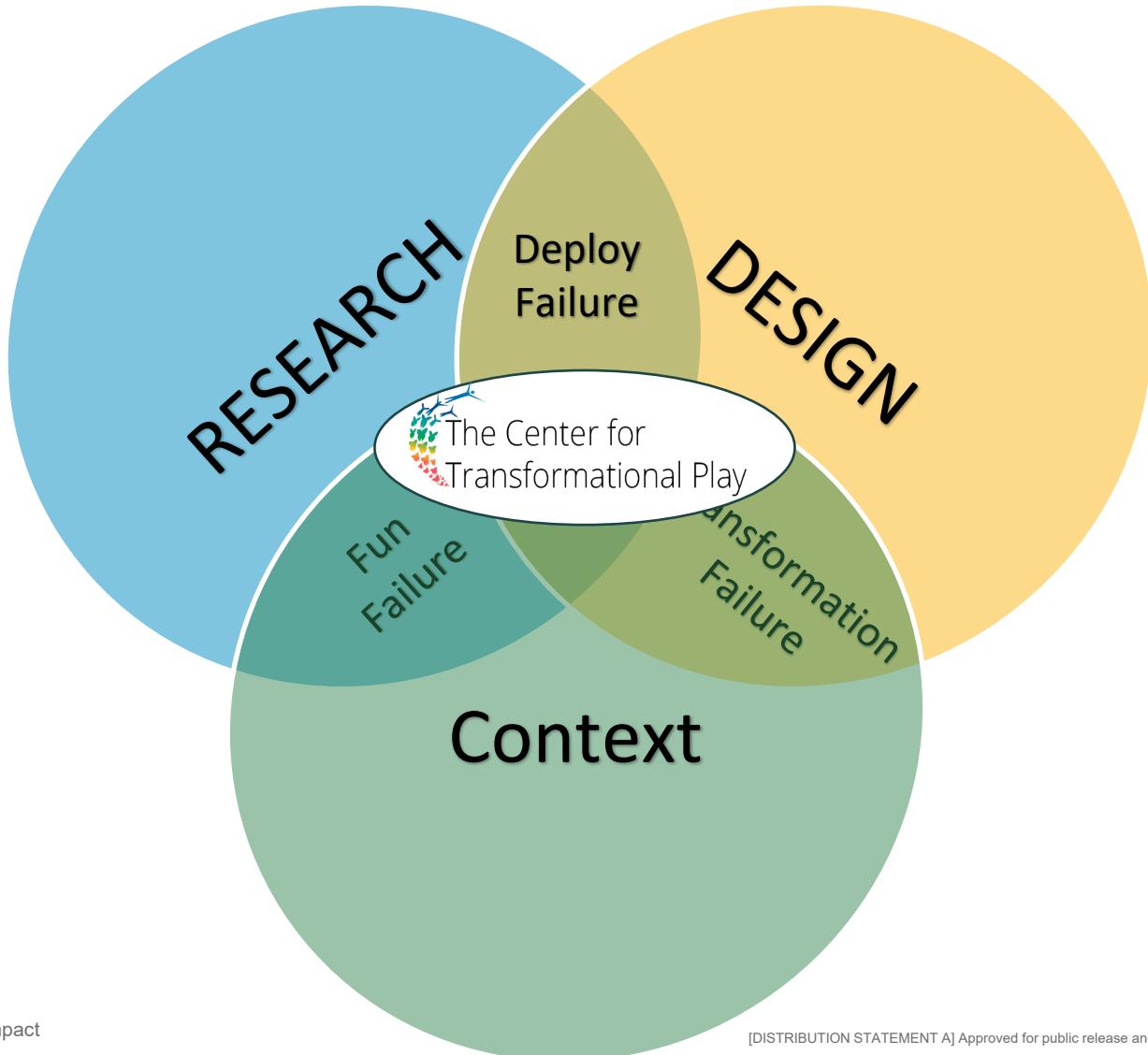
[2] K. Burgas and H. V. Yanamandala, "Ripple: A Role-Playing Game (RPG) That Shifts Power Dynamics in Healthcare," in *Proceedings of the Participatory Design Conference 2022 - Volume 2*, New York, NY, USA, 2022.

[3] T. Chen, M. Stewart, Z. Bai, E. Chen, L. Dabbish, and J. Hammer, "Hacked Time: Design and Evaluation of a Self-Efficacy Based Cybersecurity Game," in *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, New York, NY, USA, 2020, pp. 1737–1749.

Improved Receptivity

- Semi-Fantastic Setting
 - Suspension of Disbelief
 - Prevent defensiveness
 - Retain applicability to prevent negative training value





Transformative Gamification: Making Impact across the Federal Workforce

Questions?