ACQUISITION INNOVATION RESEARCH CENTER

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GAMIFICATION IN DEFENSE ACQUISITION TRAINING AND EDUCATION:

Creating an Ensemble of Experiences for Different Play Styles

NC STATE UNIVERSITY

NAVAL POSTGRADUATE SCHOOL

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EXECUTIVE SUMMARY

There have been significant advances in gaming and simulation technology over the past few years. This has also led to scholarship in the areas of game design and education and companies/studios that have successfully deployed game-based educational applications on the web and mobile marketplaces. While topic and task specific game experiences have been developed, especially in the K-12 curriculum, a general methodology for designing and developing games for adult education is missing. For designing game experiences that can be systematically applied to the various aspects of acquisitions training, we have started developing a methodology that involves the design of a suite of games with different mechanics that provide affordances for learning specific types of content. Our methodology also carefully considers that players have preferences for certain types of games and challenges. Targeting an ensemble of games with different mechanics is an inclusive approach that appeals to a range of different play styles to support the primary pedagogical purpose. In this paper, we first describe some of the theoretical foundations of game design, player modeling, and analysis of existing games. We then present two prototype games, an escape room that incorporates puzzles from content from the Federal Acquisitions Regulations (FAR) manual related to protest risk and a city building tower-defense for contingency contracting interactive scenario generation.

Key Contributions:

- Methodology for systematically mapping educational content to interactive games
- Taxonomy of game genres and player types that are relevant to acquisition students
- Escape room game with puzzles based on protest risk curriculum
- Design of a Tower Defense game for contingency contracting

INTRODUCTION

An increasing trend has developed in the last two years to explore how to employ gamification for training and education at all levels. It has been demonstrated that the interactivity and fidelity provided by games and simulation environments increase engagement and interest in educational topics (Vogel et al. 2006). The predominant practice in gamification is to design custom games for specific topics. This approach is effective in situations like flight simulators where the mapping with well-specified, precisely documented, and precision engineered real-world machines are simulated in virtual environments. In cases where there does not exist sufficient information to build close-to-realistic simulation models such as modeling adversaries in scenarios for negotiations, this simulation model does not provide a sufficient range of scenarios to be effective. There have been recent efforts to create methodologies for serious game design that are more general purpose (Blackburn and Cardona-Rivera, 2021) but these are early ideas rather than polished theories. Ke (2016) synthesized insights from 69 game-based learning articles and extracted 5 themes for effectively incorporating learning content with games. These themes relate to

1) **[Game Design]** the type of game-based action in terms of its connection to prior knowledge of material,
2) **[Game Content]** the degree of richness in the representation, simulation, and contextualization of the learning material in game actions,
3) **[Educational Integration]** the blended learning actions contrived by the game mechanics,
4) **[Assessment]** the occurrence of iterative and meta-reflective opportunities during and after gameplay, and
5) **[Feedback]** multi-faceted in-game scaffolding or learning support. Drawing from these themes, the AIRC gamification project (Phase I) led by NPS and NCSU covered the Game Design form through the development of a taxonomy related to game mechanics that are relevant to the skills acquired in acquisitions training. Table 1 below lists game mechanics and their definitions that are relevant to some aspect of acquisitions training.

Mechanics	Definitions
Communication	Active listening and clear, concise responses between two or more parties.
Conflict resolution	Process of finding a peaceful conclusion to a dispute
Deception	The act of fooling or misdirecting another person to make them believe something that is not true
Exploration	The process of gathering information or learning about an area or topic
Memory	Accurate recollection of memories information
Quests	Tasks given to player to progress towards some goal or reward.
Resource management	The process of gathering and allocating resources required for some task or goal
Scheduling	Planning and executing a procedure with respect to a set of specified events or times
Strategy	A plan or policy for achieving a goal.
Timed choice/events	Events where players have to quickly make a decision
Information asymmetry	When one party in the game possesses greater material knowledge than another (also related to deception).
Spatial reasoning	Think about or manipulate objects in 3D
Problem Solving	Finding solutions to difficult or complex issues

Table 1. Game mechanics and their definitions

We further refined the game mechanics vocabulary to incorporate some aspects of acquisitions training that are missing from the general vocabulary of games. The final 15 terms that we identified are: Communication, Logistics, Problem Solving, Resource Management, Risk Management, Planning, Coordination, Trading, Budgeting, Teamwork, Cooperation, Collaboration, Memorization, and Information Gathering. With this more refined set of terms, we analyzed 58 popular existing games across several genres to identify the mechanics that these games were best at communicating through interaction. A detailed spreadsheet with the relevant analysis is presented in Appendix A (Game Training Matrix Excel File).

PLAYER TYPES

Research in game design and game studies (Bartle 96, Yee 2016, Hamari et al. 2014, Ip and Jacobs 2005) identified segmentation of players according to the types of experiences that primarily appeal to them. Bartle's taxonomy of player types is one of the most widely adopted in the game studies literature. Bartle categorizes players into Killers, Achievers, Socializers, and Explorers. Yee and Ducheneaut look at the motivations of players and further refine Bartle's taxonomy to include other dimensions of interest such as Immersion and Creativity.

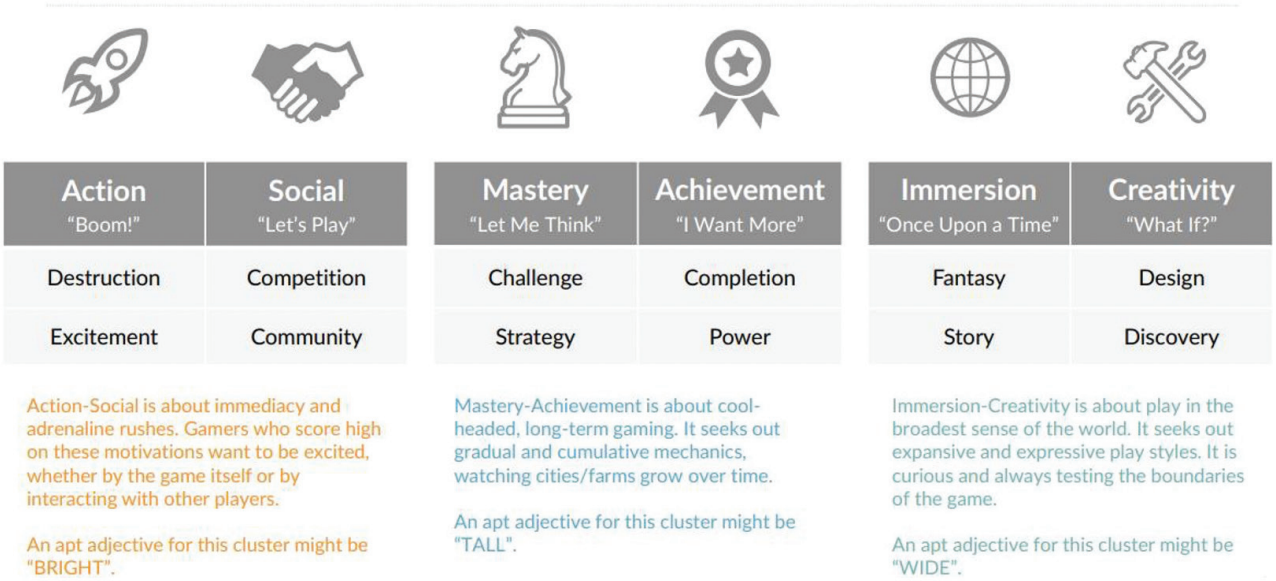


Figure 1. Yee and Ducheneaut's Gamer Motivation Inventory labels based on player experience

Consistent with Bartle's taxonomy, we labeled the 58 games the type of players that are supported in the play modes for these games across the 15 labels for the type of relevant acquisition skills that could be taught through these mechanics. Figure 2 below shows part of the spreadsheet that includes labels. The full spreadsheet along with label definitions is provided as an attachment to this report.

1	Game/Genre	Link	Taxonomy Types	Communication	Logistics	Problem solving	Spatial reasoning	Resource management	Risk management	Planning	Coordination	Trading	Budgeting	Teamwork	Cooperation	Collaboration	Memorization	Information Collection
2	7 Days to Die	video	KASE		X	X		X	X	X				X		X		
3	12 Minutes	video	AE		X	X	X		X	X							X	X
4	80 days (CYOA)	video	AE					X		X		X	X				X	X
5	Among Us	video	KS	X	X	X			X	X	X			X	X	X	X	X
6	Animal Crossing	video	ASE	X				X		X		X	X					
7	Bloons TD 6	video	AS	X		X	X	X		X	X	X	X	X		X		
8	Bluff/Liar's Dice		KS	X		X			X								X	X
9	Codenames	website	S	X		X			X	X	X			X		X		X
10	Crazy Taxi	video	A		X	X	X		X	X			X					
11	Detriot: Become Human		ASE	X	X	X	X	X	X								X	X
12	Diner Dash	video	A		X		X	X	X	X			X					
13	Dungeons and Dragons	website	KASE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	Embr	video	ASE	X	X	X			X		X			X		X		
15	Endless runners	a,b,c	A						X	X								
16	Escape Room Simulator		ASE	X		X	X							X		X		X
17	Euro Truck Simulator 2/ Simulators (Genre)	video	AE		X			X	X	X			X					

Legend
Video games
Board games
Card games
K - Killers
S - Socializers
A - Achievers
E - Explorers

Figure 2. Extensive labeling for 58 popular games of different genres based on Bartle's player types and an Acquisition specific mechanics label set that was developed in phase 1. [LINK to Full Spreadsheet]

GAME DESIGN AND DEVELOPMENT

Based on our study of player types and game types, we chose to incorporate the development of different genre of games with acquisition and contracting curriculum as a basis for students in the game development concentration at NCSU. The game designs were chosen based on coverage of different types of skill and chance. The four game types that we chose were:

1) Pinball/Pachinko: mostly chance based reactive; short duration gameplay with high replayability
2) Endless Runner: fast paced reactive with more player control; quick multiple-choice type questions
3) Escape Room: slower paced with puzzle solving components that directly relate to curricular materials **[Phase 1: Development] [Phase 2: Study]**
4) Base Building Tower Defense: Dynamic pacing with resource management and strategic reasoning **[Phase 1: Concept Development] [Phase 2: Development] [Phase 3: Study]**

DESIGN PROCESS

The design process for our games is based on the Mechanics, Dynamics, and Aesthetics framework proposed by Hunicke, Zubek, and LeBlanc (2004). Consistent with this approach, we began each game with a storyline narrative that we expect players to relate to based on their experience of gameplay. These stories are further refined into actions (mechanics) that players take in the game followed by the dynamics that come about with respect to the sequence of actions and consequences for the games. An example board from a Pachinko game design is shown in Figure 3.

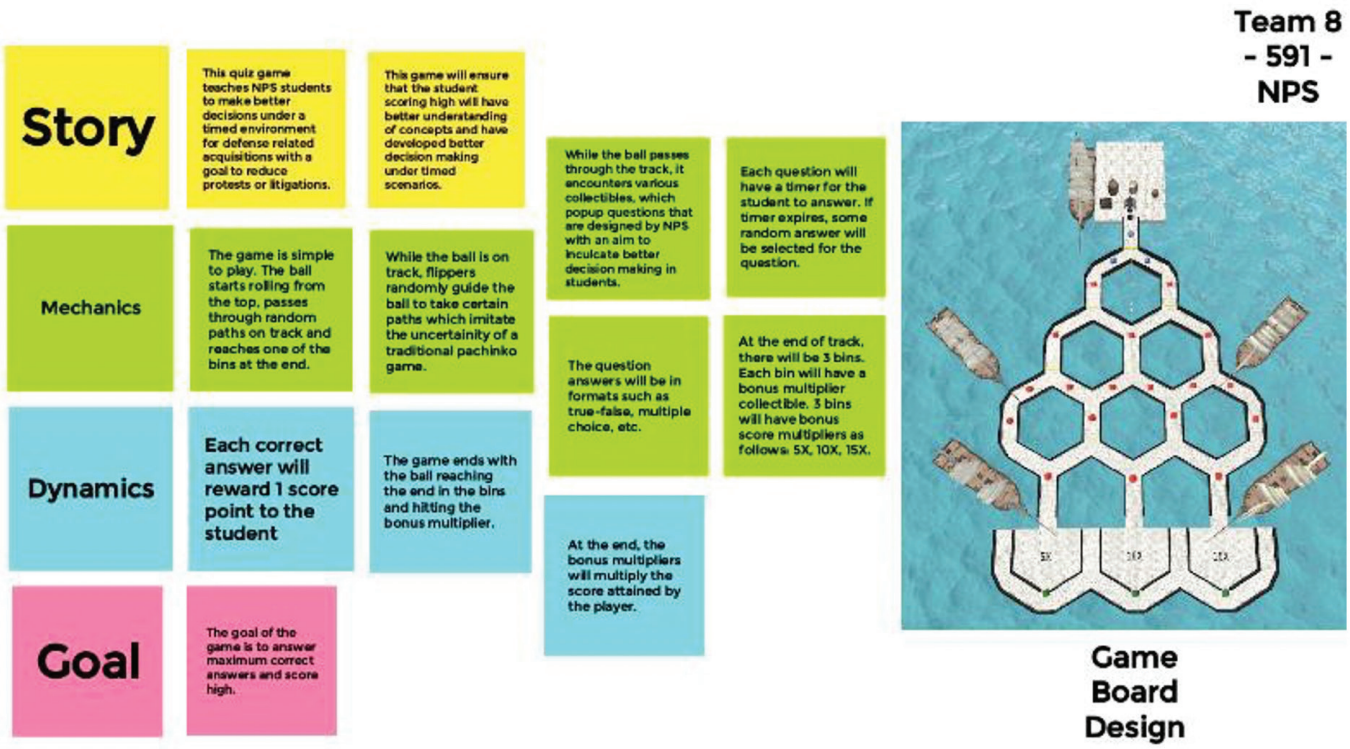


Figure 3. Design board for a game of Protest Pachinko

DEVELOPMENT PROCESS

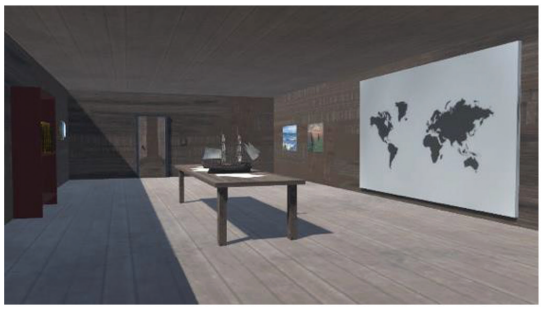
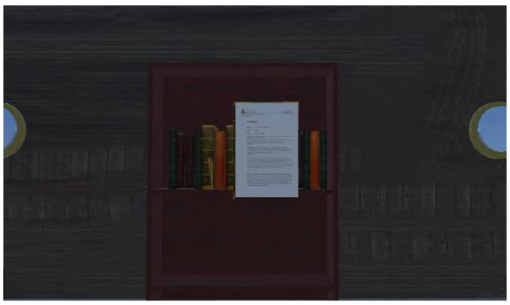
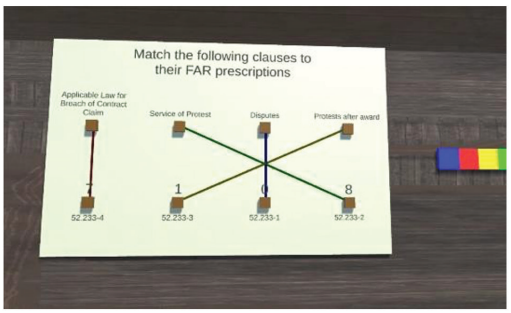
For development, we utilize two popular game engines, Unity 3D and Unreal Engine. There are several benefits of these existing game engines for game development. First, these engines have over several decades focused on creating efficient tools for supporting game development which includes tools for importing content (art assets, audio, etc.), programming support for common functions such as rendering, navigation, and user interface development, one-click deployment on multiple platforms (web, mobile, PC, console), and a community of experts who provide excellent support for creative development.

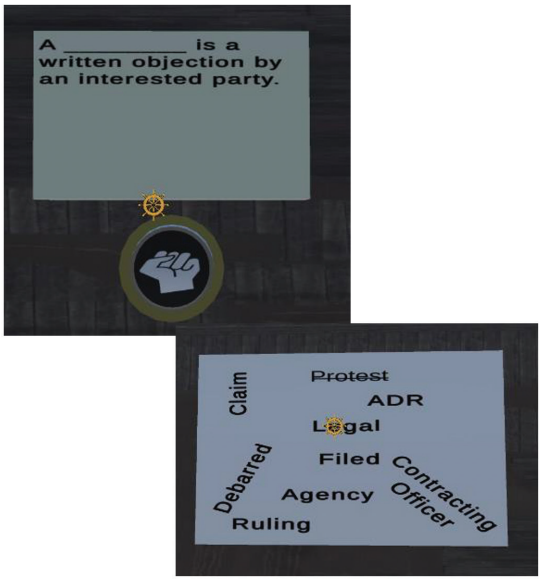
ESCAPE ROOM PROTOTYPE

An escape room is a type of game where players are locked in a room (real or virtual) with a puzzle to solve. On solving the puzzle, the room is unlocked and a new locked area opens up with a different puzzle. After solving a series of puzzles that are usually connected through a single narrative, players are able to escape the experience. This genre of games has recently become quite popular both as physical escape room installations and as virtual experiences. The variety of puzzles that can be incorporated in an escape room provide affordances to incorporate educational content for serious games. Escape rooms also provide a slower paced reflective experience which allows design of puzzles that may require players to research or look up textbook content for figuring out answers to puzzles. Some puzzles also involve communication and coordination between team members if there are multiple students within teams that are collaborating on the game. A comprehensive database of different types of puzzles has been created by the MIT's puzzle club that organizes their annual MIT Mystery Hunt (https://puzzles.mit.edu/).

For our prototype we chose 5 types of puzzles that matched well with the protest risk content in the Federal Acquisitions Regulation (FAR) manual.

Puzzle 1: Text cipher based on multiple choice question There is a multiple choice question on a wall. The answer options are random characters (rather than A,B,C,D). The correct answer character then connects the letter A to the shifted alphabet. Player now decodes the message to reveal a clue. The clue points to a painting on the wall across from the cipher. Upon clicking the correct painting, the exit code is revealed.		

Puzzle 2: Map location based on the contract document There is a protest document in the bookcase that indicates a location. Upon clicking the location on the world map, the exit code is revealed.		
Puzzle 3: True/False questions There are tables with candles that have True/False questions. The answers correspond to whether the laps are lit or unlit. After correctly setting lamp states, the code is revealed by lit lamps.		
Puzzle 4: Matching game with clauses in the FAR manual There is a board with clause numbers and descriptions from the FAR manual on the wall. Correctly matching the clauses to numbers in the order of the specified colored threads gives the exit code.		

Puzzle 5: Fill in the blanks There is an answer wall that asks the player to bring a coin with the symbol that represents the answer that fills the blank to the question. On the opposite wall are the nine coins that the player can use to answer the questions. Below the coins are four chests that each contain one digit of the code that needs to be entered into the keypad to exit the room, and the chests will only open once the player successfully fills the blanks with the right coins. There is also a word bank near the starting door that is intended to give the player a hint at what the symbols on the coin mean.		

PLAYTESTING AND DEPLOYMENT

We conducted a playtest study with students at the Naval Postgraduate School familiar with the FAR manual. Overall, we found that students found the game to be enjoyable and challenging. The final game prototype developed during Phase 1 is deployed on Itch.io and is playable on the web with a passcode.

TOWER DEFENSE DEVELOPMENT

A base building tower defense game involves resource management for building a base to maintain a certain number of units (attack, defense, and resource gathering units). During the day, the player utilizes resources (contracting mechanisms) to build the base. During the night, an enemy attacks the base. The player's objective is to last for as many days as is possible given their resources. Instead of direct manipulation of adding buildings and workers, we designed the interface to have base building operations through a contracting interface that provides specific types of contract instruments for procuring base defenses, workers, and site construction facilities. Figure 4. shows the initial prototype implementation that includes some of the basic gameplay systems that have been put in place for the prototype.

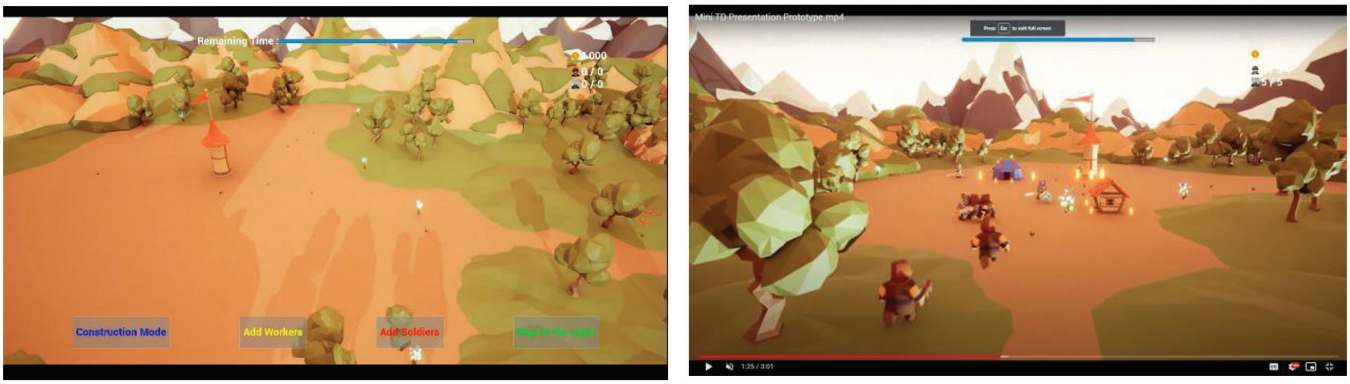


Figure 4. Tower defense early prototype

We are moving forward with further refinement of these game types, and anticipate developing further insights into preferred game types that can benefit training curriculum for contract officers and other areas.

CONCLUSION

During Phase 1, we developed a methodology to systematically map game mechanics to player types, and game mechanics to educational content specifically for acquisitions-related topics. This provides us with a taxonomy that guides the development of a suite of games that provide coverage over learning content and types of student preferences in terms of their gaming experience. We also developed several game prototypes such as protest pinball, escape room, and contingency contracting tower-defense. Phase 1 deliverables demonstrate the feasibility of developing these types of games, their scope, and the suitability of the interdisciplinary team of management, computer science, and game/curriculum design experts at NPS and NCSU to successfully carry out Phase 2 projects and beyond.

APPENDIX A

Please refer to separate Microsoft Excel file entitled Game Training Matrix.

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DISCLAIMER

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