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Serious Game Design Using MDA and Bloom's Taxonomy

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SERIOUS GAME DESIGN USING MDA AND BLOOM'S TAXONOMY

THESIS

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Abstract

The field of Serious Games (SG) studies the use of games as a learning tool and it has been in existence for over forty years. During this period the primary focus of the field has been designing systems to evaluate the educational efficacy of existing games. This translates to a lack of systems designed to aid in the creation of serious games, but this does not have to remain an issue. The rise in popularity of games means that there is no shortage of ideas on how to methodically create them for commercial production which can just as easily be applied to SG creation. However, showing a clear linkage between a game's components and its learning objectives is a primary difficulty.

Created by Hunicke, LeBlanc, and Zubek, the Mechanics Dynamics Aesthetics (MDA) methodology is an understandable and robust construct for creating commercial games using mechanics to produce an intended level of aesthetic appreciation from its consumers. However, an educational Serious Game (SG) must not only be fun, but through experience it must convey the intended learning objectives to its players. This thesis explores utilizing the MDA methodology, with Bloom's taxonomy, to create and evaluate a game to meet two learning objectives for a Cyber focused class.

The created game CyComEx, was designed to teach cyber students to identify tradeoffs between security and mission execution, and to explain how policies can impact cyber mission areas. The game was evaluated to have conveyed these objectives during a playthrough and that it was sufficiently enjoyable to students participating in this case study.

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SERIOUS GAME DESIGN USING MDA AND BLOOM'S TAXONOMY

I. Introduction

General Issue

Imagine being the commander of a battalion, staring out over a map of some future engagement. On the map are carefully placed markers representing several units, some friend and some foe. The friendly units are as precise as they can be, the information relaying their exact location and disposition. Those of the foe are less so, relaying the latest estimates that analysts have ascertained from the information gathered from intelligence, surveillance, and reconnaissance missions. Sure, there are some unknowns, but a promising plan of action has been formed, orders have been relayed, and in a few moments there is high confidence the plan will prove itself a successful one.

To plan the future engagement outlined in the scenario above, from the maps to the markers, the commander is using a set of tools residing at a single layer of abstraction. These tools allow commanders to visualize and plan for what their unit will face in the execution of their mission. These skills are learned and honed over years of practice and study through tabletop or real-world exercises. Moreover, the use of these types of abstractions are applied similarly across the air, sea, and land battlespace domains. However, it is in the newly recognized cyber battlespace where these types of tabletop exercises have yet to be fully realized.

One of the issues is that cyber is itself an abstraction. An entirely manmade construct, the boundaries of the cyber battlespace are limited only by humanities

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technological capability and its imagination. This makes direct abstractions like maps and unit markers difficult which in turn makes traditional tabletop methods just as difficult.

Going back to the imagined scenario, what if the same commander had to contend with terrain that moved or changed hourly or in response to detection by the enemy, or if unit dispositions and capabilities were just as malleable. At this point traditional tabletop exercises supported by one level of abstraction stars to become less useful for planning and decision making. Nevertheless, there is still a need for useful abstractions that can be used as planning and decision-making tools for the cyber battlespace. Thankfully there is an entire academic field dedicated to studying tools of abstraction used in the pursuit of learning and decision-making, the field of Serious Games (SG).

One of the first to conceptualize the field, Clark C. Abt defined serious games as games that "have an explicit and carefully thought-out educational purpose and are not solely intended to be played primarily for amusement" (Abt, 1970). In his book on the subject, Clark goes on to further extol the wide applications and uses SGs could have on a wide variety of areas as well as providing anecdotal cases in which games were applied to good effect in the real world. However, Clark's book does not cover the design and development of SGs in greater detail but rather the benefits their application might have outside a recreational context.

Problem Statement

The focus on the benefits of serious games is and has been endemic since the field's inception over four decades ago. Most research in the field focuses on whether SGs provide a significant benefit to the educational process (Blunt, 2007), how to properly incorporate

games into that process (De Gloria, Bellotti, & Berta, 2014), or how to better measure the efficiency of the provided benefit (Bellotti, Berta, & De Gloria, 2010) but very little research addresses the focused production of SGs. Therein lies the problem, how can the benefits of the field of SG study be applied to decision making within cyber without a clear process for producing SGs germane to that battlespace?

Research Objectives/Questions/Hypotheses

The primary objective of this research is to develop and evaluate a cyber-security serious game using a modified methodology for producing serious games. The process is based off of a current process used to produce commercial computer games called the Mechanics Dynamics Aesthetics (MDA) methodology (Hunicke, LeBlanc, & Zubek, 2004) and a method for applying Bloom's taxonomy to serious games (Buchanan, Wolanczyk, Zinghini, Division, & Visions, 2009). The hypothesis is that a game produced using this modified methodology addresses its designed lesson objectives and is enjoyable to play.

Research Focus

In order to meet the research objective my focus primarily delved into the process for creating games, the evaluation of serious games, and the cyber battlespace. Games design research uncovered a general focus on the methodical creation of commercial computer games for a consumer's enjoyment. Serious game research uncovered a general focus on evaluating the efficiency of designed games at meeting lesson objectives through the results of student surveys. Lastly, open source research was performed to fill out cyber policy, resources, and mission areas.

Investigative Questions

Execution and design of the case study will attempt to address the following questions. Did the methodology produce a game that mapped to learning objectives? Was the methodology successful in producing a game enjoyable enough to play outside a learning environment?

Methodology

The basic methodology of this research follows a design and evaluate strategy. Using the method proposed above an SG focused towards specific learning objectives germane to current cyber educational coursework taught at AFIT was designed. The game was presented to course instructors with the aim to have it played during class by students. Students were then asked to complete a voluntary and anonymous survey. Data from those surveys were then used to evaluate the game's ability to convey the learning objectives and their enjoyment of the game.

Assumptions/Limitations

The primary assumption made during execution of the case study used to evaluate this research was that the students answering the surveys were rational human beings and that they were not unduly influenced by anyone involved in the case study when they provided their responses evaluating the game. This was mitigated as much as possible by assuring that survey submission was completely voluntary. It was also stressed that truthful responses to survey questions were much more useful to the research effort than favorable but untruthful answers. Furthermore, students were specifically instructed not to identify themselves in anyway on their surveys so that their answers would remain anonymous.

The primary limitation for this case study was access to students. Due to the time necessary to complete the waiver process for human research, develop the serious game, and coordinate time from one of the targeted classes to play and evaluate the game, the sample size of surveyed individuals was rather small. Only one class was surveyed, and it consisted of thirteen individuals. This sample size is not on its own large enough to permit statistical significance testing.

Implications

Abt stated that the abstraction provided by games allowed individuals to step outside of the compartmentalization necessary of highly technical societies (Abt, 1970). A methodology for creating serious games that directly links itself to lesson objectives while providing an approachable and enjoyable experience for its consumers can be used to create a body of useful tools. These tools can be used to help others to step into the highly specialized compartment that is the cyber domain. Innovation in teams is driven through collaborative efforts across the team, with each member attacking the same problem using their different perspectives and backgrounds (Kelley & Kelley, 2013). These tools can assist leaders from any battlespace domain with technical or non-technical backgrounds collaborate on strategic and operational decisions, setting the stage for innovation not only within cyber but across all other battlespace domains.

II. Literature Review

The Mechanics Dynamics Aesthetics (MDA) methodology is a system for producing commercial games that was designed to consciously track linkages between a games mechanics and its aesthetic value to consumers (Hunicke, et al., 2004). Bloom's taxonomy is a method used by instructors to design coursework to set objectives that move their students through the levels of learning for an academic area (Buchanan, et al., 2009). Modifying MDA with features from Bloom's taxonomy produces a methodology that can be used to create serious games which encourage learning and are enjoyable to play but more importantly make linkages between the game's components and its learning objectives. This chapter reviews similar systems produced by the serious game field that are designed to either construct or evaluate games and presents a case for why the modified MDA methodology is needed.

The chapter begins by briefly introducing game design and its associated terminology. Afterwards the chapter will present an example of a game design and an evaluation system produced by the serious game field, the Game Object Model (GOM) and Learning Mechanics-Game Mechanics (LM-GM) system, and a commercial game design process, the MDA methodology. Finally, the chapter describes how applying Bloom's taxonomy to the MDA methodology creates a serious game design process that better traces game mechanics to learning objectives.

Introduction to Games and Terminology

Games have been around for a very long time, some of the oldest evidence of them dates back nearly five millennia (Kastrenakes, 2013), but for most of that time games were

not expressly designed. Games like Chess, Go, and Backgammon were developed and modified over generations with their rules only having been codified recently during the modern age. However, with the advent and commercialization of video games, a concerted effort has gone into designing and discovering better ways to create games. Yet the motivations for creating these systems was not based in education and while games have been created which have educational value, this was more happy coincidence than an intended result (De Gloria, et al., 2014). Widely credited with rise of serious games, Clark C. Abt's book *Serious Games* described the potential for utilizing games as an instructive and transformative tool across all facets of society from education to political or military policy (Abt, 1970). In Abt's description, games can be purposefully designed to spur thought an innovation and their approachability is a key factor in this equation. Games provide individuals whose specialization lies outside of the subject matter an ability to participate and contribute.

Despite being nearly half a century old, the field of serious games is still young and terms that should be well defined have not yet been standardized across the field. An example of this, the game mechanic is widely considered to be a basic building block for games but has many different definitions within the field (Sicart, 2008). Some would describe game mechanics as the defined ways a player can interact with the game state to attain their goal (Järvinen, 2008). Others might describe mechanics as a games fundamental constituents which for video games resides at the data or algorithm level (Hunicke, et al., 2004). In order to mitigate any confusion, this paper defines game mechanics as the "methods invoked by agents designed to interact with the game state" (Sicart, 2008).

The fact that the definition for game mechanics is in flux within the game industry, let alone the serious game field, means that there are many ways to categorize game mechanics. Adams and Dormans separate mechanics into five separate categories Physics, Economy, Progression, Tactical Maneuvering, and Social Interaction. (Adams & Dormans, 2012) As described later, the Learning Mechanics-Game Mechanics system splits game mechanics into 38 separate categories but also holds that more might exist (Arnab, et al., 2015). A website devoted to tracking all things board games lists 51 separate categories and includes descriptions of example mechanics that would belong to each (BoardGameGeek, 2019). Regardless of who many, what these categories have in common is that they describe how the agents or players interact with mechanics or rather they describe the dynamics these mechanics produce. For the purposes of simplicity and clarity, this paper will use as seperate its mechanics into the five categories Adam and Dormans enumerates in their book *Game Mechanics* (Adams & Dormans, 2012). To briefly cover each: Physics is the science of motion and force in the game world; Internal Economy is the process by which game elements are collected, consumed, and traded; Progression Mechanisms are those that dictate how players move through the game thematically; Tactical Maneuvering deals with placing game components for offensive or defensive advantages; and Social Interaction deals with incentivizing or restricting interactions among players.

Adding to the confusion some might say that a game's rules enumerate its mechanics, but this is not necessarily the case. A game's rules are not always the same as its mechanics because rules only encompass what the user needs to know to play the game and does not address the background game mechanics that need to be implemented for a

user to play computer games (Adams & Dormans, 2012). Classic boardgames are a general exception because typically they do not require any complex math or calculations to play so there is no appreciable difference between mechanics and rules. However, as the result of the design portion of this paper is to produce a board game, the terms rules and mechanics are used interchangeably throughout.

Game Design Methodologies

Created by Alan Amory, the Game Object Model (GOM) is a process that aids in the design of educational computer games as well as a framework for evaluating the use of computer games within an educational context. The GOM (Fig. 0-1. Visual representation of the Game Object Model (Amory, 2007).

) is comprised of six separate state spaces: the game space, visualization space,
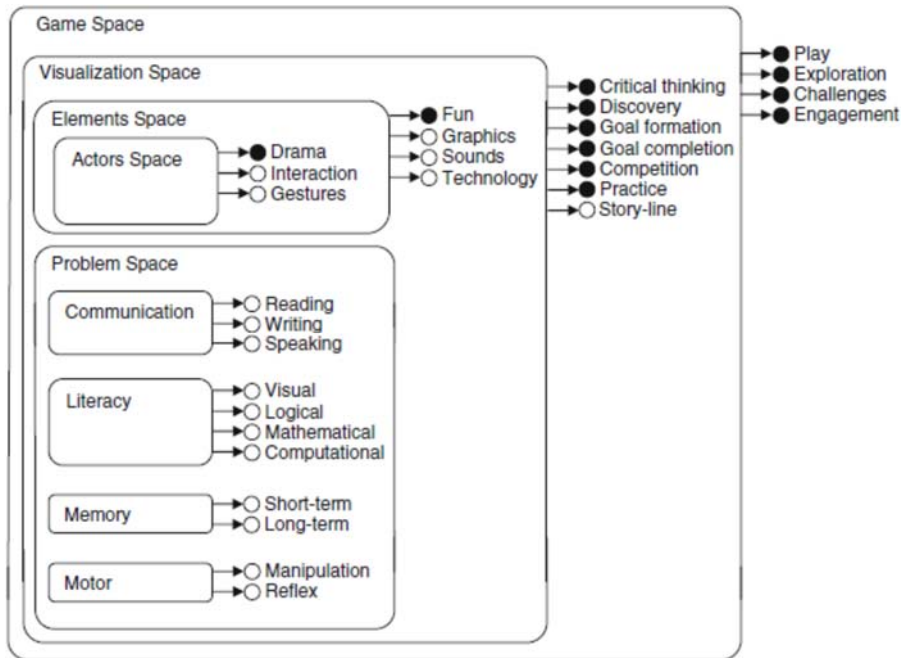
elements space, actor space, and problem space (Amory, 2007).

Fig. 0-1. Visual representation of the Game Object Model (Amory, 2007).

Aspects of the game are then binned into one of these state spaces while also being labeled as either an abstract or concrete object (Arnab, et al., 2015). GOM is a very complex model that breaks game design down into a framework that is reminiscent of object-oriented programming. This top down design does a good job of creating a strategic level checklist that computer game designers can use to design games using an educator's input, but its complexity demonstrates the hurdles faced by educators trying to develop serious games. GOM does not describe how these state spaces are meant to map to the learning objectives educators need to cover. Nor does it describe a linkage between what features of the GOM motivate learning, fun, or both. So, once a game is finished there is no way to provide game developers constructive feedback to modify its state spaces if there is a problem.

The Learning Mechanics – Game Mechanics (LM-GM) system identifies general purpose game mechanics, labeled "serious game mechanics," which link learning patterns
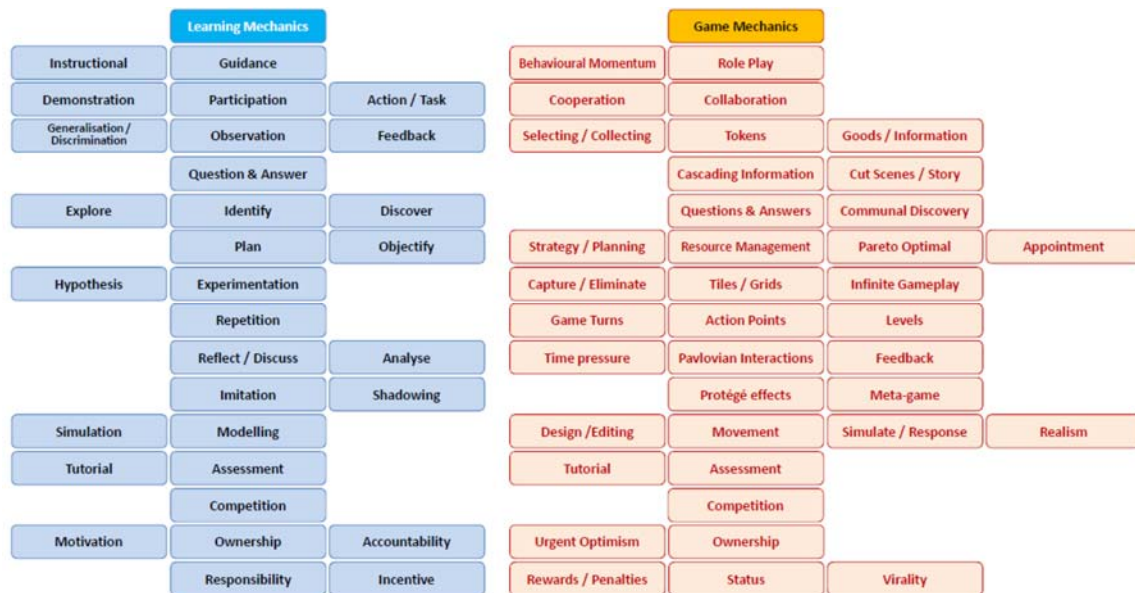
Fig. 0-2. Example of an LM-GM Mapping (Arnab, et al., 2015).

and entertainment (Arnab, et al., 2015). This is done by juxtaposing game mechanics that have a parallel relationship with identified learning modalities side by side and listing those in an LM-GM map (Fig. 0-2.).

What this provides to educators is a visual mapping of a game's components with the learning modalities they are familiar with. Using this map, they can then make a better determination as to whether the game meets their needs and learning objectives. This makes LM-GM better than GOM at analyzing an existing game's potential because it links educational patterns to serious game mechanics which educators can use to augment their curricula, but it does not address how to use LM-GM to create a game.

The aim of the Mechanics, Dynamics, and Aesthetics (MDA) process is to bridge the gap between game design, development, criticism, and research (Hunicke, et al., 2004). It does this by looking at the game design process and breaking it down into three distinct components. Game designers tweak and design mechanics. The interaction of these mechanics develops and makeup game dynamics. The interplay of dynamics produces an aesthetic that is then consumed by players. Each component described in MDA is a lens through which the game can be viewed, and each contributes to the overall success or failure of the game in critical ways.

Breaking it out in this way gives the system a great deal of traceability. Mechanics are put into the game to fulfill certain dynamics the designers want to create. Dynamics are then evaluated against whether they meet certain aesthetic goals. If a specific aesthetic goal is not being met, then all designers need to do is evaluate the dynamics that feed into it. Designers can then focus on the mechanics that support a subpar dynamic. Any mechanics

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that do not adequately support a dynamic in fulfilling its part in meeting an aesthetic goal is then said to be unbalanced and is then balanced or edited, until it does.

Success for a commercial game is measured in entertainment value. It then follows that for MDA the Aesthetic goals make the game fun to play. However, as the authors describe fun is not an exact enough term to design to. Instead they break out this concept into a taxonomy of fun. This taxonomy lists eight categories of activities that support a game's entertainment value. Those categories are sensation, fantasy, narrative, challenge, fellowship, discovery, expression, submission (Hunicke, et al., 2004). Each area engages the players in different ways to create experiences players value and are the artifacts that players consume.

The authors stress that we think about games more as artifacts than media in that a game's content is not its visual or physical stimuli but its behavior, in effect that games are systems that build behaviors (Hunicke, et al., 2004). Building these behaviors effectively requires designers to focus not just on building the game but also how players will consume them (Fig. 0-3. The different perspectives of design and consumption (Hunicke, et al., 2004). This has the added benefit of encouraging experience-driven designs as opposed to feature driven designs (Hunicke, et al., 2004). Building behaviors and experience in their students is at the forefront of an educator's mind when evaluating a serious game and the author's emphasis on these qualities while enumerating MDA shows its potential for
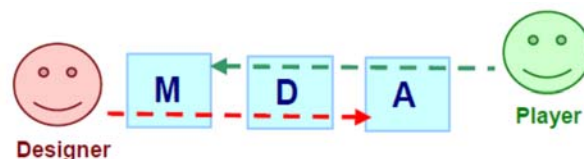
Fig. 0-3. The different perspectives of design and consumption (Hunicke, et al., 2004).

serious game design.

The MDA process provides traceability from mechanics to the behaviors and experiences designed into the game. The only jump needed to make this a serious game design process is to the ability to apply MDA so that it links in lesson objectives to the mechanics of the game. The rest of the research presented here is intended to bridge that slight gap.

Bridging the Gap

As with the Game Object Model (GOM) the Mechanics Dynamics Aesthetics (MDA) model provides a framework for developers to create games. What it lacks are the strong linkages between game mechanics and learning modalities needed for a serious game as established in the Learning Mechanics Game Mechanics (LM-GM) model.

According to MDA, games build behaviors and aesthetics are the desired responses evoked in the player of the game (Hunicke, et al., 2004). In the case of education, learning objectives are the desired responses that educators want to evoke in students. Therefore, when using the MDA model, the aesthetics portion of a serious game should be the intended learning objectives.

Bloom's taxonomy is a classification system for the levels of cognitive learning that educators set for their students (Buchanan, et al., 2009). Using these cognitive learning levels teachers can plan out courses by setting lesson objectives for each session. Each objective targeting specific behaviors with the intent of working students up the pyramid of cognitive learning (Fig. 0-4. Bloom's Cognitive Levels (Buchanan, et al., 2009).).
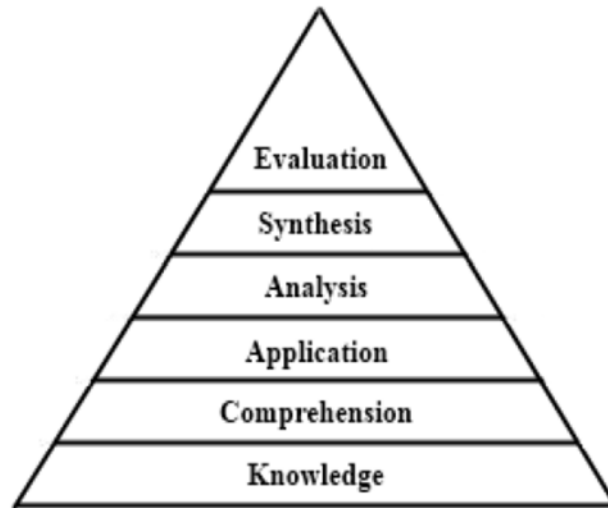
Fig. 0-4. Bloom's Cognitive Levels (Buchanan, et al., 2009).

Furthermore, each level has predetermined action verbs, called "key terms", associated with them that describe the actions students should be able to perform while in that cognitive level to meet the learning objective (Lorin & Krathwohl, 2001).

Summary

While traditional games have been around for millennia, the field of serious games is not even half a century old. With this comes a level of variability when it comes to defining a basic term like game mechanics, how those mechanics are categorized, and even the differences in distinguishing a mechanic from a rule. For this reason, this paper will define game mechanics as "methods invoked by agents designed to interact with the game

state" (Sicart, 2008) and separate them into five categories; Physics, Economy, Progression, Tactical Maneuvering, and Social Interaction (Adams & Dormans, 2012).

During its tenure, serious games has focused primarily on the evaluation of a game's educational potential. This focus accounts for a lack of systems used to design serious games and several systems that can be used to evaluate existing games. The Game Object Model (GOM) is one of the few systems designed to support serious game creation and while it helps breaks up the game logically to help designers fulfill their requirements, it does not adequately show how a games component links to learning objectives so it can be easily evaluated from an educator's perspective. In contrast to GOM, Learning Mechanics-Game Mechanics (LM-GM) enumerates the linkages between selected game mechanics and their comparative learning modalities to directly assist with an educator's evaluation, but from a designer's perspective it does not frame how those components fit together to form a cohesive game.

Designed for commercial game production the Mechanics Dynamics Aesthetics (MDA) methodology breaks up game design into three distinct levels each of which can be described as a different perspective on the game. Game mechanics make up and drive a game's dynamics. Interactions between dynamics make up and support a game's aesthetics. This provides the designer with an inherent traceability from a game's mechanics through its aesthetics. Aesthetics are the behaviors and experiences game designers want players to consume and find value in. Focusing on a player's perspective assists designers in determining what game features best supports the experience they want the player to have and in effect lead to better designs (Hunicke, et al., 2004).

Translating MDA's aesthetics into something a serious game designer can use requires understanding learning objectives. Bloom's taxonomy is a framework that educators use to design curricula and coursework in a way that moves students through the levels of cognitive learning. Educators use key terms to help guide the setting and execution of lesson objectives needed to be covered during a course period. In this manner lesson objectives are the behaviors and experiences educators intend to impart to students at the completion of a class activity much as aesthetics are treated by game designers in MDA.

III. Game Design

This chapter presents a utilization of the Mechanics Dynamics Aesthetics (MDA) methodology and features of Bloom's taxonomy to design a serious game from learning objectives. The learning objectives for the game are from the Air Force Institute of Technology (AFIT) Introduction to Cyber Warfare class's curriculum in order to produce a serious cyber game. A case study performed on the game created using the described process can then be used to evaluate it against learning objectives and entertainment goals which will either prove or disprove the hypothesis of this thesis.

This chapter first presents lesson objectives selection and conversion into aesthetic goals using MDA. It then demonstrates how to convert an aesthetic goal into a dynamic informed using key terms from Bloom's taxonomy. Finally, it describes a few of the mechanics of CyComEx and how they support the highlighted dynamic thus demonstrating the traceability from lesson objective to game mechanic inherent in the presented methodology.

CyComEx Lesson Objectives

The classroom that is used for examining the use of MDA and Bloom's taxonomy is the Air Force Institute of Technology's (AFIT) Introduction to Cyber Warfare class. The Introduction to Cyber Warfare class has the following six lesson objectives pulled from the 2017 course syllabus:

1. Students are expected to complete the course with a working knowledge and understanding of cyber operations and their impact on warfare and national security.
2. Students will possess a foundational understanding of cyber security principles and methods and technologies for defending systems and networks.

3. Students will understand the relationship between vulnerabilities, exploits and threats, as well as a framework for assessing risk.
4. Students will understand the current legal framework governing cyber operations.
5. Students will understand cyber-physical and cyber-operational linkages to include industrial control systems.
6. Students are expected to demonstrate critical thinking and communication through graded deliverables and class participation.

Obviously, the resulting game is not intended to cover all of the above learning objectives for the class nor should it attempt to (Bellotti, et al., 2010) and so the game CyComEx was designed to focus on classroom lesson objective one. The scope for the game was further narrowed so that it serviced a working knowledge of cyber operations and it's impacts on national security within the more constrained context of cyber security, mission execution, and the impact of policies. This produced six game specific learning objectives:

1. Students will identify trade-offs between cyber security and mission execution
2. Students will explain how policies impact different cyber mission areas: (Offensive Cyber Operations, Defensive Cyber Operations, and Network Operations)
3. Students will experience the separate cyber mission areas
4. Students will craft policies impacting cyber mission areas
5. Students will evaluate effectiveness of crafted policies
6. Student will learn real cyber policies

From this list it was determined that many of the lesson objectives could be captured within a few of the others. It was also identified that designing to a greater number of lesson objectives had a greater chance for causing the game to be more complex than it needed or could be because of time considerations. The decision was made to focus on learning objectives one and two.

In addition to the lesson objectives, entertainment is an important goal to incorporate in the design of a game. Simply playing a game does not ensure that its players

remain interested with its content. A game must be entertaining enough to engage players intellectually while challenging their decisions and actions, a state called transformational play (Barab, Gresalfi, & Arici, 2009). Through transformational play students become immersed in a role that requires them to use the knowledge, skills, and concepts taught in a course's curricula to solve fictional problems. The benefit of this is higher engagement, increased intrinsic motivation, and retaining the learned concepts longer versus using traditional instruction methods alone (Barab, et al., 2009).

To ensure that the game produced would encourage transformational play the lesson objectives were mapped to MDA's traditional aesthetics goals. The two lesson objectives fall into the fantasy, sensation, challenge, and narrative while an emphasis on a cooperation and competition covers fellowship and challenge. The lesson objectives were then taken to the class instructors and presented for any feedback they might have as to whether they were appropriate for their current curriculum.

CyComEx Dynamics

Once lesson objectives were selected and since they were constructed using Bloom's taxonomy their key terms provide the core dynamics of the game. The first lesson objective states that "Students will identify trade-offs between cyber security and mission execution." The key term used here is "identify" it falls within the knowledge and comprehension levels of cognitive learning for Bloom's taxonomy (Lorin & Krathwohl, 2001). This action must apply to trade-offs made within the game and those tradeoffs must be between cyber security and mission execution.

The second lesson objective states that "Students will explain how policies impact different cyber mission areas." The key term here is "explain" and it falls within the comprehension, synthesis, and evaluation cognitive levels for Bloom's Taxonomy (Lorin & Krathwohl, 2001). This action must apply to the use of policies within the game and how they directly impact operating within the game's defined mission areas.

Focusing on the key terms within the objectives provides the designer with the actions that define the relationships between components of the game in order to support those objectives. The designer must then select an appropriate dynamic provided by the categories Physics, Internal Economy, Progression Mechanisms, Tactical Maneuvering, and Social Interaction which bring about the actions described.

As an example, with the first lesson objective students must identify the tradeoffs between cyber security and mission execution. A tradeoff implies a natural tension that exists between these two components of the game. In order to identify this tension within the context of the game, there must be a method tied to these components that a player can directly interact with, manipulate, and experience an affect upon. This can be used to determine which dynamic category is most appropriate to express and convey the aesthetic goal.

A physics dynamic is inappropriate because inherently it is a dynamic that players are not meant to manipulate directly. Manipulation of a progression mechanism is not ideal because any manipulation directly impacts player progression which then incentivizes conservative play and hinders any experimentation. A social interaction dynamic is not viable because the sensation should come more from players affecting game components than affecting other players. Likewise, while a tactical maneuvering dynamic can cause

tension, that tension would be directed towards other players and not between game components. Lastly, being concerned with how game components interrelate with each other, an internal economies dynamic can provide the kind of tension necessary between game components that cause tradeoffs to be made. Since these dynamics are also meant to be manipulated by players an internal economy supports experimentation which allows players to identify these tradeoffs more readily which directly supports the aesthetic goal of identifying tradeoffs between cyber security and mission execution.

CyComEx Mechanics

In CyComEx there are 3-4 players, each acting in the role of an operational level leader of a cyber unit. In the real world these leaders must utilize all the resources at their disposal to complete objectives assigned to them by their leadership and they bear the responsibility for the success or failure these units earn under their tenure. These leaders are intimately aware of how dependent their personal success is on their unit's successful completion of the missions assigned to them and competition amongst these leaders to become the best among equals is natural. However, success for the organization also depends upon the cooperation of operational level leaders working together to fulfill the greater organization's strategic objectives and failure to do so by some could cause negative implications for everyone.

Appropriately executing this narrative and assisting players in imagining themselves as operational level leaders within CyComEx requires the use of social interaction and Physics dynamics. For example, stating that CyComEx's players are assuming the mantle of operational level leaders by playing the game is a physics dynamic since players cannot within the context of the game choose to play some other role with

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greater or less responsibility. However, by itself the previous statement does not entirely execute the aesthetic goal. What it does is act as the foundation for future social interaction mechanics by asserting that the player has the agency to act on their own or consult with other players about the possible impacts of their actions as it pertains to their own priorities. In this manner the role of cyber leader supports both lesson objectives equally.

Each player tracks the state of their game using a personal game mat (Fig. 0-1). This mat lets other players know what their funding and security levels are, their current resources, and the number of missions they have or have yet to complete.
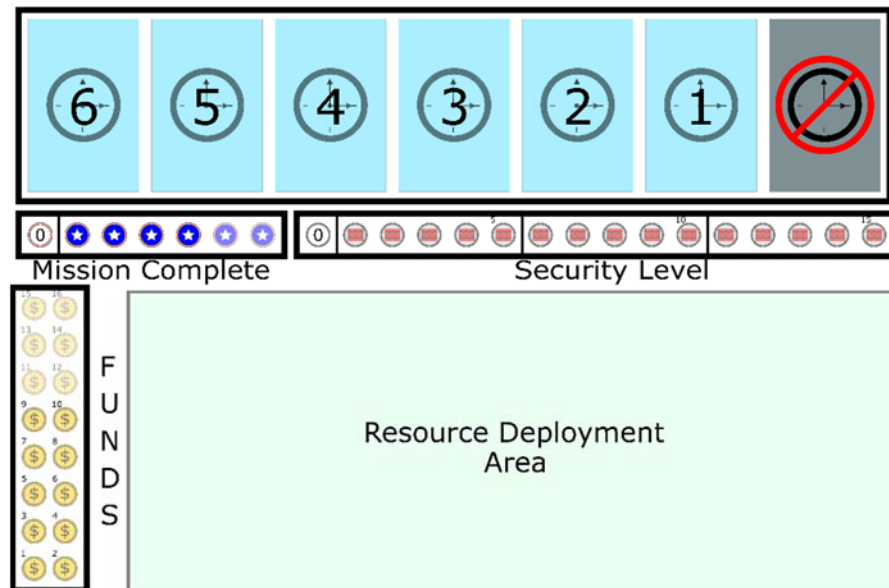
Fig. 0-1. CyComEx Playmat.

Each round players receive a certain amount of funding that can be used to perform actions or to pay certain mission costs. This mechanic is an expression of an internal economy and is related to the first lesson objective because players must compare and contrast where best to spend their funds on actions that support cyber security or mission execution which helps them to identify this natural tradeoff.

During six rounds players collect and trade resources to complete time limited missions, these resources become a nested internal economy that supports mission execution. The time limited missions impose urgency upon the player to complete them, perhaps sacrificing funding they could use to increase security. Players can also enact policies to gain capabilities or to protect against security driven incidents. A player's security level is a progression mechanic that places players beyond the negative impacts of incidents, which are random and negatively affect a player's ability to complete missions. This mechanic drives players to maintain a level of security and perhaps make some missions harder to complete (learning objective one). Players may also utilize maneuvers to either get ahead of or aid other players. This social interaction mechanic is aimed at driving the kind of cooperation and competition experienced within the cyber battlespace and impacts both learning objectives. An example of each card described is shown in Fig. 0-2.
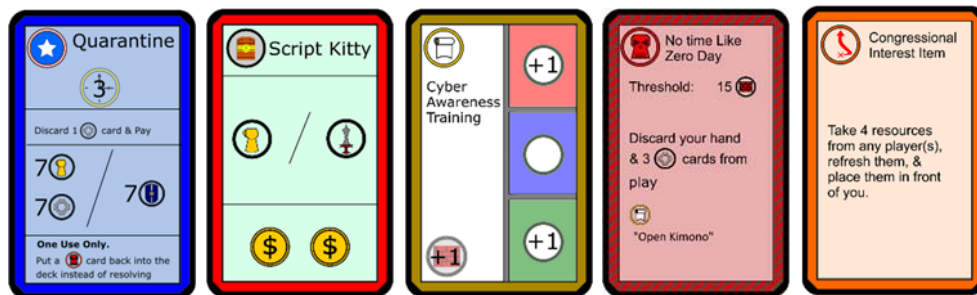
Fig. 0-2. Card Examples: Mission, Resource, Policy, Incident, Maneuver.

At the end of the game each player must meet a minimum number of completed missions or everyone fails. If everyone succeeds, a first among equals title is conferred upon the player that completed the most missions. These social interaction mechanics are used to provide the tension and urgency experienced by real life cyber leaders in the

execution of their missions to players of CyComEx and support the first lesson objective. They also force players to look closely at other players' motives or relate to a player's inability to complete their assigned missions. A complete set of rules can be found in Appendix A: The Rules.

CyComEx Playtesting

After a prototype game was produced playtesting was conducted to determine how game mechanics interacted and whether their interaction supported the dynamics they were intended to. Simultaneously, the dynamics of the game were judged by how well they supported learning objectives. It was at this point that game length was assessed against the hour long maximum. This process naturally generated change recommendations by play-testers, recommendations were then considered in context of whether they supported the learning objectives and/or reduced the length of time it took to play the game. Those that met learning objectives and reduced the game length were incorporated into the game through the design process. The game was then re-prototyped to reflect the changes and finally play-tested.

Summary

The Mechanics Dynamics Aesthetics methodology for game design informed by Bloom's taxonomy was used to design CyComEx. The process started by focusing on defining learning objectives and other aesthetics of the game needed to meet course objectives for Introduction to Cyber Warfare. It then progressed to defining what dynamics were needed to support the desired learning objectives. This was primarily informed through analysis of the learning objectives using Bloom's taxonomy. This analysis guided

design of mechanics to support the desired dynamics. The design was then iteratively prototyped, play-tested, and redesigned until it was deemed suitable for evaluation by students. A table summarizing the mapping between aesthetic goals, dynamics, and mechanics for CyComEx can be found in Appendix E: MDA Mapping.

IV. Methodology

This chapter presents the experimental evaluation of CyComEx in meeting the learning objectives and its potential entertainment value. The case study conducted was an observational study using student surveys to evaluate the games in areas of interest. Survey questions were designed specifically to either evaluate the game's effectiveness at conveying the learning objectives used to design the game or factors affecting or indicating its entertainment value. Each survey question had associated answers the students could pick from that were assigned values on a one to five scale. Averages and a standard deviation were then calculated from this data to make evaluations of CyComEx.

Objectives

The primary objective of the case study was to characterize the effectiveness of CyComEx regarding the following learning objectives:

1. Students will identify trade-offs between cyber security and mission execution
2. Students will explain how policies impact different cyber mission areas

Execution

The demographics selected to evaluate CyComEx as a part of this case study consisted of thirteen participants in AFIT's Introduction to Cyber Warfare class, a graduate level course on cyber. Evaluation of the game was accomplished at a point in the quarter after materials pertaining to CyComEx's learning objectives had been covered as a part of the course. Participants were initially given an in-class demonstration of the game and were provided a set of rules for familiarization. Participants were also provided access to an online introduction video covering the same material. During the following class period,

participants played a full game of CyComEx with their colleagues. After completing the game, they were asked to fill out questionnaires to rate their observations of the game with respect to specific areas related to the Lesson Objectives, the course they are taking, and the balance of specific game mechanics.

Survey Questions

The survey questions used a Likert scale asking participants to select which response they most agree with. The survey questions answered by the participants can be found in Appendix B: CyComEx Survey Questions. Survey questions were designed to directly assess CyComEx's ability to convey learning objectives or its entertainment value. Questions 1.a, 1.c, 5 and 6 were targeted to measure factors within the game that supported both learning objectives. Question 2 was targeted specifically towards learning objective one, question 3 to learning objective two, questions 1.b and 4 to CyComEx's entertainment value.

Question 1.a characterizes the games utility as an instructional aid for Introduction to Cyber Warfare. It maps to both lesson objectives because they were derived from the course's curricula. A low score here would indicate that the game detracts from the overall educational thrust of the course and a high score indicates the opposite.

Question 1.b characterizes how fun the game is, a low score indicates that the game is only useful as an instructional aid and a high score shows that it might also be successful outside an educational setting. This question maps to CyComEx's entertainment value which is important in catalyzing the players learning experience (Bellotti, et al., 2010) and supporting transformational play (Barab, et al., 2009).

Question 1.c characterizes how well the game conveys the different cyber mission areas. This question supports both lesson objectives because an understanding of these areas is necessary to mission execution and how played policies impact mission areas. A low score here indicates the game is not approachable enough for introductory cyber professionals while a high score suggests that is approachable.

Question 2 directly characterizes how well the game links to the first lesson objective. A high or low score on this would indicate that the balance intended to be maintained between mission execution and security needs to be rebalanced. In this case, the question is directly assessing which way the game is skewed (towards security or mission execution) from the viewpoint of the players.

Question 3 directly characterizes how well the game tracks to the second lesson objective. This score gives an indication as to how impactful the policies are upon completing missions. A high score may indicate that the polices are too impactful while a low score would indicate the policies need revision.

Question 4 characterizes the maneuver game mechanic. The maneuver mechanic is intended to spur cooperation and/or competition between players and is a feature that relates to the game's entertainment value by acting as a challenge to other players. A low or high score here would indicate the cards need to be rebalanced to insure game enjoyability is not negatively impacted.

Question 5 characterizes how much interaction is needed between players to fulfill the game objectives. A low score indicates that the game interactivity mechanics need to be revised as the game is meant to spur conversation. Question 6 characterizes how dependent the game's win conditions are on player cooperation. As the game is intended

to balance player cooperative and adversarial natures to provide a more realistic environment that would be experience by operational cyber leaders either a high or low score would indicate the game needs rebalancing along those lines

Questions 5 and 6 are linked to both lesson objectives because both are aided through player interaction and a social game aesthetic. For the first objective, players should be encouraged to interact with other players when taking actions such as drawing or moving resources around. The potential for drawing an incident card and impacting everyone negatively if the security level of all players is low grows with each card drawn and is a tradeoff between mission execution and security that should be identified. For the second objective, since policies impact everyone and in some circumstances limit their ability to complete missions, players are encouraged to explain their deployment and their potential impacts on each other's missions.

Summary

The purpose of this chapter was to present the methodology behind the case study conducted to evaluate CyComEx's ability to convey its lesson objectives. A study was conducted with thirteen participants from a graduate level cyber class to evaluate the game in areas of interest. After the material for lesson objectives were covered, the game was introduced thoroughly with an in-class presentation and supporting video given to the participants prior to a CyComEx playthrough. After playing a game of CyComEx, the participants completed optional surveys with questions designed using the Likert scale to convert objective assessments into numerical data for the purposes of analysis.

V. Analysis and Results

This chapter presents the analysis and results of the case study conducted to evaluate CyComEx's ability to convey its lesson objectives. Completed surveys from thirteen participants from the Introduction to Cyber Warfare class were collected after participants played a full game. Survey responses were then consolidated, and the sample mean and standard deviation for each question calculated. Typically, these values would be used to perform one-sample t-tests for statistical significance in order to better to support the results but thirteen samples are not enough to establish statistical significance.

Deployment and Execution

Introduction and deployment of the game to participants went extremely well. Before the use of CyComEx the learning objectives would have been addressed by assigning readings in conjunction with a writing prompt to force students to think critically about the content. Student engagement would then be spurred by classroom group discussions about the assigned readings with the level of engagement corresponding directly to whether the students had performed the assigned readings.

In the case of CyComEx, most students were actively engaged in asking questions about its gameplay during the initial thirty-minute introduction period. During the period of gameplay participants were given 50 minutes to play. After that period expired four groups had completed all six rounds and the last group had just finished round five. All eligible participants completed and returned surveys evaluating CyComEx. Finally, after all surveys had been turned in students were briefed on the game's lesson objectives and

encouraged to participate in a group discussion about the game and how it did or could better achieve those objectives.

Results of Survey

The results of the survey are consolidated in Table 1. The case study data matrix shows the number of responses received for each numerical bin (1, 2, 3, 4, or 5) as well as the calculated mean and standard deviation for each question.

Table 1. Case Study Data Matrix.

Question Number	Total # of 1s	Total # of 2s	Total # of 3s	Total # of 4s	Total # of 5s	Sample Mean	Observed Standard Deviation
1.A	0	0	3	6	4	4.077	0.760
1.B	0	0	3	8	2	3.923	0.641
1.C	0	0	2	7	4	4.154	0.689
2	0	0	6	6	1	3.615	0.650
3	0	0	2	7	4	4.154	0.689
4	0	7	4	2	0	2.615	0.768
5	0	0	3	10	0	3.769	0.439
6	0	5	4	3	1	3.000	1.000

Question 1.A Analysis

A histogram of the results for question 1.A is provided in Fig. 0-1. What it shows is that most of the responses to the question corresponded to "Agree." The calculated average value for this question is 4.077 with a standard deviation of 0.760 when mapped to the possible responses this indicates that most participants responded somewhere between "Neutral" and "Strongly Agree" with "Agree" being the most likely response. This is evidence that during this case study CyComEx succeeded at supporting the content covered in the Introduction to Cyber Warfare class. Since the material covered in class

supports the classes lesson objectives support of that material is also an indication that

playing CyComEx supports the lesson objective it was derived from.

Fig. 0-1. Histogram of Question 1.A Data.

Question 1.B Analysis

A histogram of the results for question 1.B is provided in Fig. 0-2. This question

assesses participants comfort levels with teaching or playing the game outside of class.

What it shows is that most of the responses to the question corresponded to "Agree." The

calculated average value for this question is 3.923 with a standard deviation of 0.641 when
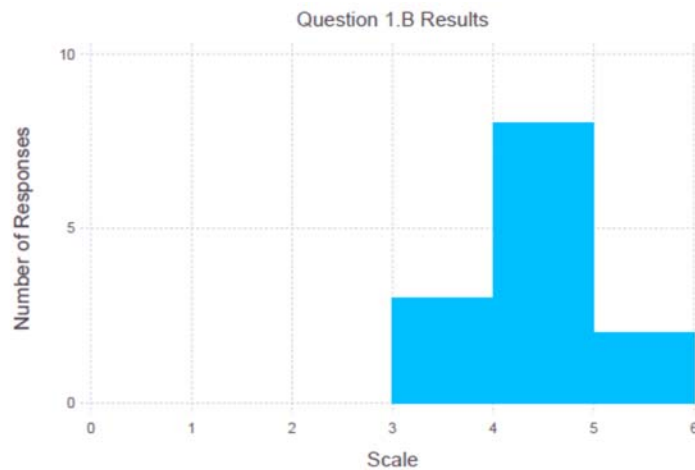
Fig. 0-2. Histogram of Question 1.B Data.

mapped to the possible responses this indicates that most participants responded somewhere between "Neutral" and "Strongly Agree" with "Agree" being the most likely response. This is evidence that the game was entertaining enough that participants were willing to teach or play the game outside of class.

Question 1.C Analysis

A histogram of the results for question 1.C is provided in Fig. 0-3. This question assessed whether participants felt the game was a good primer for cyber and its mission areas to novices. What it shows is that most of the responses to the question corresponded to "Agree." The calculated average value for this question is 4.154 with a standard deviation of 0.689 when mapped to the possible responses this indicates that most participants responded somewhere between "Neutral" and "Strongly Agree" with "Agree" being the most likely response. It indicates that participants supported the idea that CyComEx could be used as an introduction for others to cyber and its mission areas. This also means that the contextual background for cyber and its mission areas was established sufficiently enough to support the game's learning objectives.
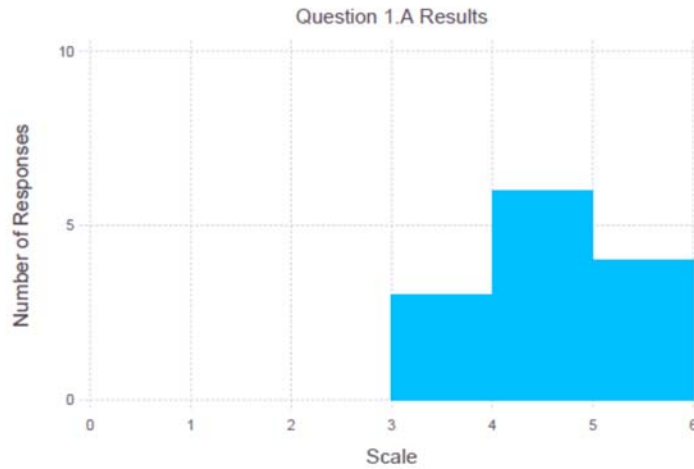

Fig. 0-3. Histogram of Question 1.C Data.

Question 2 Analysis

A histogram of the results for question 2 is provided in Fig. 0-4. What it shows is that most of the participants either assessed the game to have a slight emphasis on mission execution over cyber security or was fairly balanced between the two. The calculated average value for this question is 3.615 with a standard deviation of 0.650. This shows that CyComEx has a slightly higher emphasis on mission execution over cyber security which fulfills the need of the game's first learning objective.

Fig. 0-4. Histogram of Question 2 Data.

Question 3 Analysis

A histogram of the results for question 3 is provided in Fig. 0-5. This question assessed whether policies had a significant impact upon mission execution within the game. Data shows that most of the participants felt that playing policies had a significant impact upon mission accomplishment. The calculated average value for this question is 4.154 with a standard deviation of 0.689. This means that participants believed that playing policies either had some or too much impact on mission completion, with the average tending towards somewhere in the middle. This is direct evidence that policies impact mission completion as intended within the game and that CyComEx supports its second learning objective.
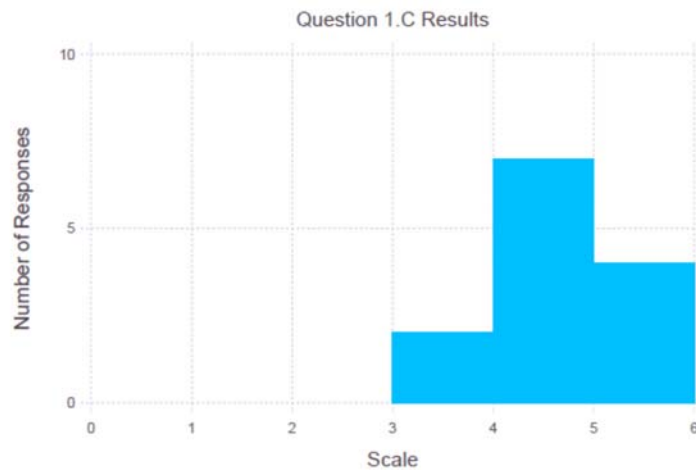

Fig. 0-5. Histogram of Question 3 Data.

Question 4 Analysis

A histogram of the results for question 4 is provided in Fig. 0-6. This question assessed whether playing maneuver cards had an unbalancing impact upon a player's win condition within the game. Data shows that more participants felt that playing maneuver

cards made attaining their win condition easier than not. The calculated average value for this question is 2.615 with a standard deviation of 0.768. This covers a range that could be problematic as it shows that the mechanic is slightly unbalanced and makes it easier for players to win if they play maneuvers than it should be. An unbalanced mechanic can negatively impact the challenge aesthetic that this mechanic is meant to support and undermine the entertainment value of the game. This information indicates that re-balancing maneuver cards might be needed.
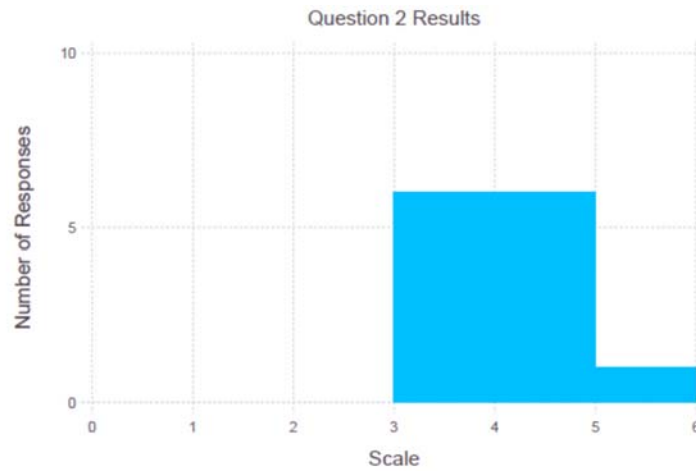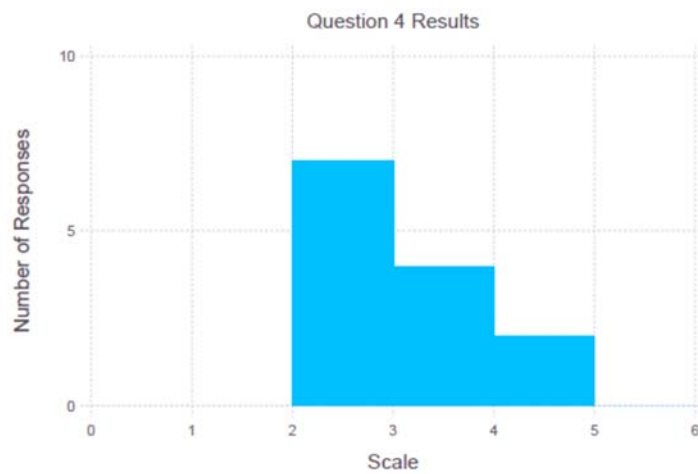

Fig. 0-6. Histogram of Question 4 Data.

Question 5 Analysis

A histogram of the results for question 5 is provided in Fig. 0-7. This question assessed the level of player interaction necessary to play the game. Data shows that most of the participants felt the game required a significant amount of player interaction. The calculated average value for this question is 3.769 with a standard deviation of 0.439. This

shows that CyComEx required between some to a significant amount of social interaction to play.
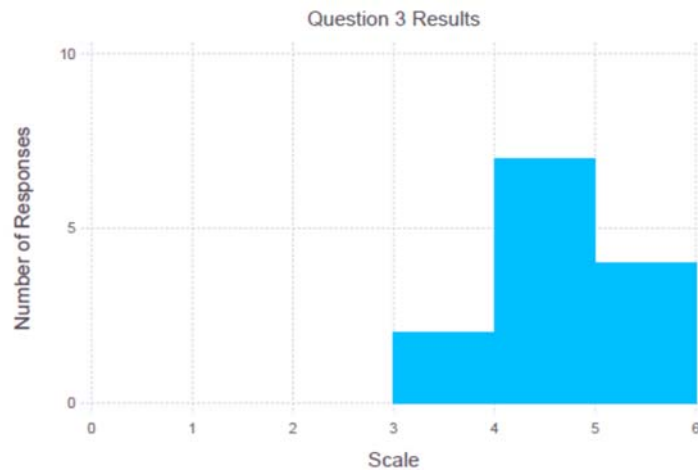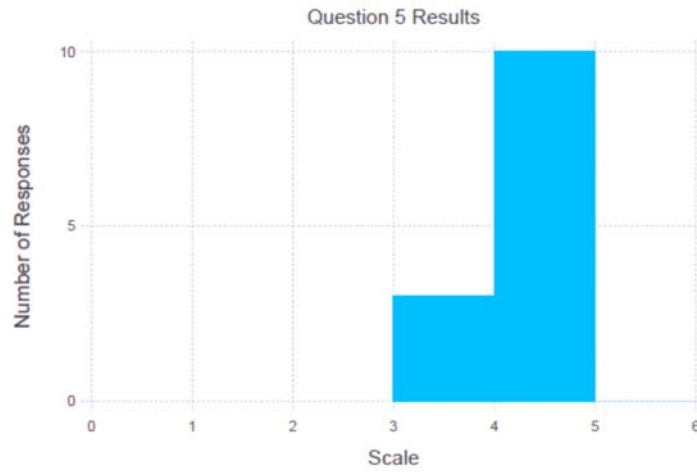

Fig. 0-7. Histogram of Question 5 Data.

Question 6 Analysis

A histogram of the results for question 6 is provided in Fig. 0-8. This question assessed the level of cooperation needed to play CyComEx. Data shows that most of the participants felt that the game was more cooperative than it was competitive. The calculated average value for this question is 3.000 with a standard deviation of 1.000. This
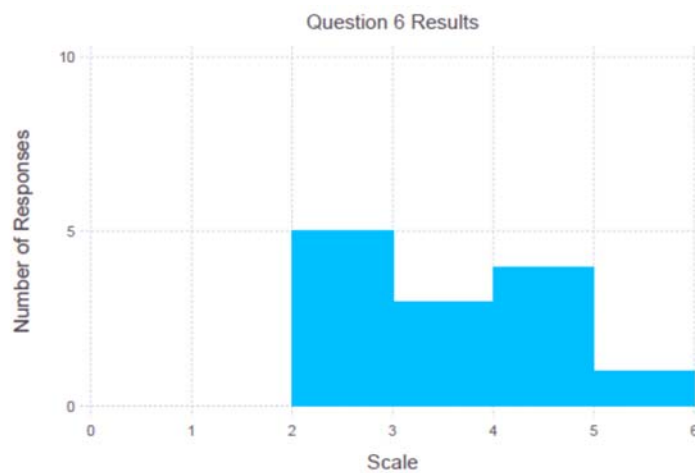
Fig. 0-8. Histogram of Question 6 Data.

covers a spectrum that includes semi-competitive to semi-cooperative play evenly. This result supports both learning objectives as the interplay between cooperation and competition drives player interaction and game engagement.

Summary

Excepting the small sample group, deployment and execution of the case study was successful. Analysis of data gathered from the case study provided results that CyComEx supports the two learning objectives it was designed to under the Aesthetics portion of the modified MDA methodology. The responses to this case study regarding CyComEx's learning objectives indicate a positive impact to AFIT's Introduction to Cyber Warfare's objective for creating an understanding of cyber operations. Furthermore, CyComEx has been assessed by the participants of the case study to be an entertaining game which points to its possible utility outside of the academic environment. Finally, pursuant to game improvements, analysis indicates that the maneuver mechanic should be monitored closely to insure it does not become unbalanced and negatively impact the entertainment level of the games balance.

VI. Conclusions and Recommendations

The cyber battlespace needs tools that can be used to communicate battlefield strategies to contemporaries and serious games can provide useful abstraction tools to do so. Unfortunately, the field of serious games does not have a reliable process for mapping useful behaviors, known as lesson objectives in the academic community, to game mechanics in a manner that is readily usable by both game design and pedological communities. This thesis presents a solution as well as offers data on some initial findings pursuant to that proposed game design process.

Conclusions of Research

The Mechanics Dynamics Aesthetics methodology supplemented by Bloom's Taxonomy provides a path to serious game design. This modified methodology guided creation of CyComEx. The game was designed to support two lesson objectives based upon the materials for Introduction to Cyber Warfare. A case study was performed using participants from the Introduction to Cyber Warfare class. Analysis of participant survey results show that CyComEx successfully conveyed the two learning objectives as was intended.

Results also showed that CyComEx was entertaining enough to play outside of an academic environment. This is important because it supports the possibility that the game can reach audiences outside of the graduate level cyber professional audience from which the participants of this case study came from. The maneuver card mechanics was assessed to be a potential area of issue as it is slightly imbalanced. The level of imbalance is not

cause for a complete rework but does highlight that more consideration and balancing needs to go into the creation of those cards so that it supports the aesthetic goal sufficiently.

Significance of Research

CyComEx's successful conveyance of learning objectives to participants proves the concept for using an MDA process modified by Bloom's taxonomy for the creation of serious games. The game's recognized potential for introducing others to cyber and its mission areas shows serious games can be used as tools to help others step into the highly specialized compartment that is the cyber domain. Bringing different perspectives and backgrounds together drives the innovative ideas and decisions necessary to keep an organization at the forefront of its domain.

Recommendations for Action

The modified MDA process outlined above is certainly not perfect and one case study is not enough data to show that the process is proved to be effective. To prove it out more data needs to be collected both in scope and depth. To provide depth more a greater number of participants need to evaluate the games produced. For CyComEx, this would mean including the game within the curricula unchanged for at least two or three more classes so that the sample size reaches something that can produces statistically significant results. To provide scope more serious games need to be created using the modified MDA/Bloom's Taxonomy process. This should be accomplished in many different areas of academia using a wide variety of game media, so it can be shown the process remains agnostic from both the material and game medium.

Specific design changes that should be made for a later version of CyComEx would be the addition of flavor text to the cards. At least one of the participants identified an interest in the cards providing a bit more technical depth to place it in better context with cyber. Without reworking the game and its mechanics entirely this can be accomplished by adding flavor text to each card.

Flavor text was originally intended to be incorporated into the design of Policy cards for CyComEx. Unfortunately, the need to prototype quickly and a general inexperience with graphic design meant that these references could not be incorporated in a way that didn't distract from the core goals of the game. Policies which provide benefits to the Defensive Cyber Operations (DCO) and Network Operations (NetOps) mission areas have real world references in best practices or public policies and these references would have been the content of their flavor text.

For the other card types, flavor text may provide related and insightful bits of information to players. Maneuver card flavor text would cite possible events that have called for their use. Incident cards would reference real world cases or their consequences. Resource card flavor text could provide specific examples of the kinds of technology used or the certifications and qualifications one might look for in personnel of that level. The only card that would not be advisable to put flavor text on for OPSEC reasons would be Mission cards.

Once CyComEx is mature enough to be accepted into the curricula of multiple cyber courses, designers should then consider creating expansions. The purpose of these expansions would be to incorporate facets from the other battlespace domains into the context of the game. Much as with the creation of CyComEx, these expansions would need

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to continue servicing the two original learning objectives but must also consider incorporating learning objectives targeted towards cyber's interaction with that battlespace.

Recommendations for Future Research

During the game design for CyComEx it became apparent that the greatest limitation on the game was not necessarily the process but the time constraints for gameplay. Research that provides results on the optimum or maximum number of game mechanics that can be fit into a game of defined length would help to set boundaries for designers.

A deeper study of the mapping from Bloom's key terms to the dynamic categories and from the dynamic categories to game mechanics is needed to move the modified MDA process towards a more algorithmic approach to serious game design. Such a mapping provides the designers a more defined path than exists in the current process.

Summary

CyComEx successfully supported and conveyed its two learning objectives. This limited success proves the concept for continued study into using the modified MDA process for serious game design. The game was also assessed by its participants as entertaining enough to teach or play outside of class and with people not familiar with cyber mission areas. The case study showed that the Maneuver mechanic needs to be monitored carefully to insure it does not become unbalanced over further iterations of the game.

Looking forward, more study needs to be completed using the modified MDA process to create serious games to insure the process is consistent. More evaluation of

CyComEx also needs to be completed until results become more statistically significant. Adding more descriptive flavor text and designing domain specific expansions are suggested future improvements to CyComEx. The prior would increase the games technical depth without adding more complexity. While the latter would help to expand the game into the areas where cyber overlaps the other battlespace domains which is a region the original CyComEx does not cover. To rely less upon artisan level knowledge in mechanic selection necessitates determining the relationship between game length versus the number of mechanics and a more defined mapping between dynamics and Bloom's key terms.

Introduction:

Congratulations! You've all elected to lead the nation's cyber elite, but it's not all popping boxes, pwning newbs, and petting the cute but devious kitties of script. Someone must direct it all and you've been selected to lead your cyber unit to greatness. Can you show yourself to be the best among equals all while insuring your nation's infrastructure doesn't become some giant zombie botnet for the Enemy?

Player Tableau:

Below is a description of the parts to the suggested layout for playing CYCOMEX depicted
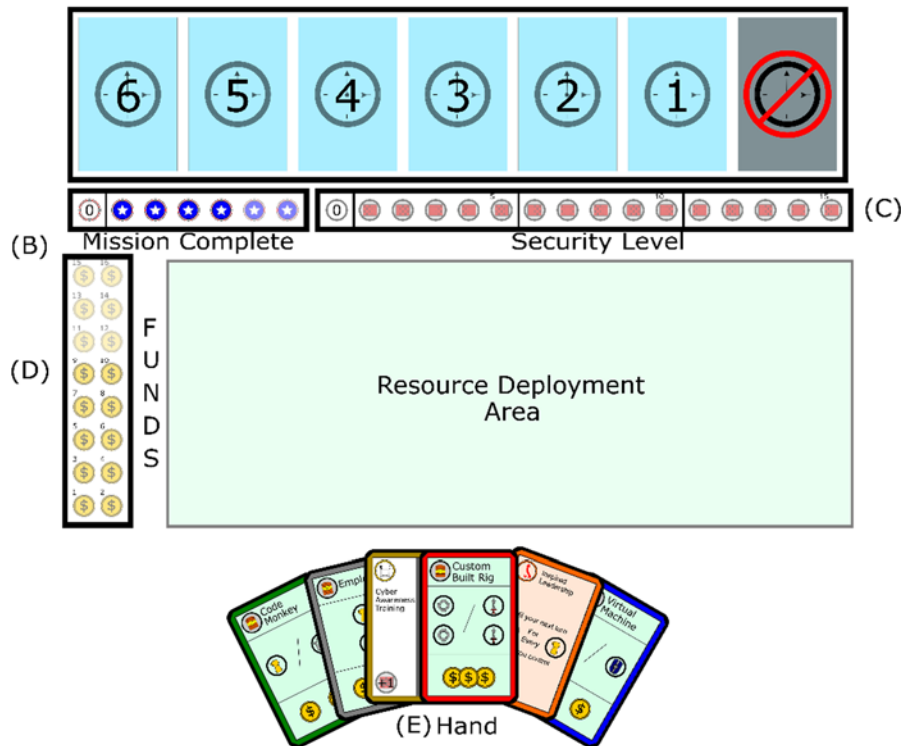
above:

A. This is the priority queue. It is there to help track the life of your missions. When a mission card is drawn place it on its matching time slot. At the end of every round move each mission in the queue one place to the right. When a mission moves off the priority queue position marked with a "1" it is considered "Failed" and should be stacked to the right of the "1" position. Any player may ask to inspect another player's failed mission pile during the game.

B. This tracks how many missions you've completed during the game.

C. This is used to keep track of your current security level (⬛). Players start the game with a security level of 0. Security can only range from 0 to 15.

D. This is used to keep track of the Funds () you've used during a round. Unless otherwise stated, a player has 5 Funds to spend at the start of every round.

E. This is your hand. Unless otherwise stated, each player has a hand limit of 6 cards. If at the end of your turn you have more than 6 cards in hand you must discard cards from your hand until you have 6.

Card Types:

1. ⭐ **Missions**: Drawn from the Mission deck, these cards are the tasks you've been handed from higher headquarters to complete.

   - Specialization: The color around the border of the card indicates what mission area the mission belongs to and what specialized resources are best suited to meet the mission's requirements. Red for Offensive Cyberspace Operations (OCO), Blue for Defensive Cyberspace Operations (DCO), and Green for Network Operations (NetOps).
   - Time Limit: Located under the title of the card, this indicates the number of rounds you must complete the Mission in before it is considered "Failed". Note: Any missions left uncompleted by the end of the game are also considered "Failed"
   - Requirements: The two sections in the middle of the card are what it takes to complete the Mission. The top portion outlines any special requirements associated with the completion of this mission. If the top portion describes the multiplier X the minimum value for X is always 1. The bottom portion indicates the resources necessary to complete the mission. A "/" symbol indicates that, in conjunction with the special requirements, you may use either a combination of resources on the left or right of the "/" to complete the mission.
   - Reward: Located at the bottom of the card, this is what you get for completing the Mission

2. 🎴 **Resource**: Drawn from the Deck, these cards are the people and infrastructure you need to accomplish your missions. When "Exhausted" (turned on their side) they produce the designated amount of resource indicated in the middle area of the card. A "/" symbol indicates that this resource can produce either the amount of resources on the left or the resources on the right when Exhausted.

   - Specialization: The color of the boarder indicates what this Resource is specialized in. Red for OCO, Blue for DCO, or Green for NETOPS. Resources with gray boarders are not specialized.
   - Production: Located in the center of the card, this is how much Tech ⚙ or Manpower ♟ this resource produces when Exhausted. All resource cards will at the very least produce either the Manpower or Tech basic resources. The basic resource a resource card produces determines whether it is a Tech or Manpower card. Specialized cards produce special resources associated with their specializations. ⚔ for OCO, 🛡 for DCO, & 🏛 for NETOPS that can be used to fulfill Mission requirements of the same specialization.
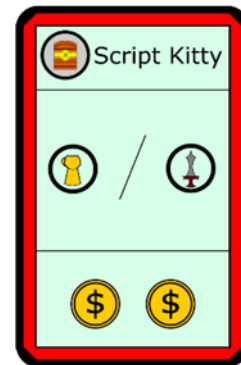
- Cost: Located at the bottom of the card, this is how many Funds it costs to play this resource from your hand.

3. **Maneuver**: Drawn from the Deck these cards give a player the ability to perform unique actions with temporary effects during their turn. To perform the action described on the card play it using your Funds, resolve its effects, and then place it in the discard pile.
   - Effect: Located in the center of the card, this describes the action to take when you play this card using your Funds.

4. **Policy**: These cards affect all players once played and are cumulative. These cards are split into a left and right side
   - Left side: This side of the card contains the name of the policy. It also describes the impacts of playing this policy. (i.e., the "Cyber Awareness Training" Policy increases the security level of all players by 1)
   - Right side: This side is split into three different areas signifying the mission areas of the game (Red for OCO, Blue for DCO, and Green for NETOPS). If a number appears in these areas it means that missions of that specialization must add or subtract an amount of resources (commander's discretion as to the type of resource) equal to the number indicated to or from the total cost of the mission. (i.e., the "Cyber Awareness Training" Policy increases the cost of all OCO & NETOPS missions by 1 resource)
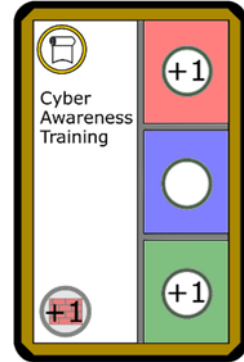
5. **Incident**: When you draw one of these cards from the deck, play it immediately (does not cost Funds), resolve its effects against all players, place it in a separate "Incident" discard pile, and then draw another card.
   - Threshold: Compare this number to each player's current security level. Unless otherwise mitigated, if that player does not meet or exceed the threshold value needed they are affected by the consequence portion of the Incident card.
   - Consequence: Located in the middle of the card underneath the Threshold value, this describes the impact to players who did not meet the security threshold or otherwise mitigate the incident's consequences.
   - Applicable Policies: Located at the bottom of the card, this is a list of policies that can be played by any player (provided they've the funds remaining) for that player to ignore the consequence portion of this card.

Set Up:

1. Prepare the Mission Deck, Game Deck, and player's initial hands.
    1. Shuffle the Mission cards, count off the top 6N (where N is the number of players), and set them aside. This is the Mission Deck. Any additional Mission cards are not used.
    2. Remove all Incident cards from the Game Deck.
    3. Shuffle the Deck and deal out 8 cards to each player.
    4. Players choose 6 cards for their starting hand and discard the rest.
    5. For a standard game, search through the Game Deck for the "Cyber Awareness Training" and "Two Person Integrity" policy cards and put them into play. For an advanced game, draw cards from the top of the deck until two policy cards have been revealed, put the policies into play, and put the rest of the cards into the discard pile.
    6. Shuffle all Incident and discarded cards back into the Deck.
    7. Give the Distinguished Gamer (DG) the "Start Player Marker." If there is no DG then give the youngest player the "Start player marker"

2. Prepare Player Tableaus
    *   Initial funds are 10
    *   Initial security level is 0

Gameplay:

*   **Round Start:**
    1. Reset each player's funds, and resources.
        *   Unless cards in the player's tableau have changed this value, reset Funds to 10. All resources in players' tableaus are Refreshed by putting them right side up, as shown on the right.

    2. Assign new missions
        *   Each player draws one mission from the mission deck.
        *   Players then place their missions in their priority queues in the spot matching its time limit.

    3. Begin player turns
        *   Turns proceed clockwise from the player who has the "Start player marker".
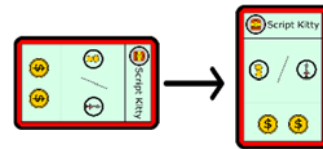
- **Actions**
  1. On a player's turn, they may:
     - ▷ **Play**: Spend one Fund and play a card from their hand. In addition to this, player's must spend funds equal to a resource card's cost to deploy it to their tableau. If a player has insufficient funds remaining, they cannot play the resource card.
     - ⬇ **Draw**: Spend one Fund and draw a card from the game deck. If the card is an Incident, immediately resolve the Incident and then draw another card. Players cannot have more than 6 cards in their hand **at end of their turn**.
     - **Complete a mission:**
       - A mission's requirements must be fully satisfied during a player's turn for the mission to be completed. Resources or funds spent on a mission do not carry over.
       - To use a resource to complete a mission Exhaust it by turning it sideways as shown on the left. Unless otherwise specified, a resource cannot be Exhausted towards a mission's requirements again until it is Refreshed (either at the start of a new round or by playing a maneuver).
       - Funds used to satisfy a mission are spent.
  2. ⬆ **Move**: On any player's turn, a player may spend one Fund to move a resource or Mission from their tableau to another player's tableau.

- **Round End:**
  1. Each player slides all missions currently in their tableau one space to the right. Any missions that were in the Time 1 space are placed in the player's failed mission stack.
  2. Move "Start player marker" to the right of the current player.

End of Game:

- The game consists of 6 rounds and has a mission completion target of 4
- If all players have completed the mission completion target at the end of 6 rounds all players Win. Otherwise all players lose. The nation does not reward "go-it-alone" leaders.
- The player with the most completed missions receives the Distinguished Gamer (DG) designation for the next subsequent game (if any are played). In case of a tie, the player with the most Resource Cards receives the DG tag.

FAQ:

1. If an incident tells you to discard cards and you can't, what happens?
   - If an incident requires that you discard cards, whether in play or in your hand, that you do not possess nothing happens.

2. Do Policy adjustments (Manpower/Tech/Funds) affect mission requirements if DCO/OCO/NETOPS icons are used?
   - Yes, policy adjustments affect mission requirements regardless of whether specialized resources (DCO/OCO/NETOPS) are used to fulfill base mission requirements as they are an additional cost needed to fulfill missions of the designated areas.

3. What happens when there are no more cards in the game deck?
   - Shuffle all discarded cards and place them face down. They are now the game deck

Iconography:

Below is a legend of all the Icons featured in CYCOMEX. Many cards will use these icons when referring to cards, resources, or mechanic

Legend

Resources	Cards	Actions	Misc
DCO	Mission Cards	Move	Security
OCO	Resource Cards	Draw	Time
INO	Policy Cards	Play	
Manpower	Incident Cards		
Tech	Maneuver Cards		
Funds			

Appendix B: CyComEx Survey Questions

1. On a scale of 1 to 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree,

    5 = Strongly Agree) rate the following statements:

    a. The game supported content covered in class

    b. I would feel comfortable playing/teaching this game outside of class

    c. The game could be used to familiarize people with cyber and its mission

       areas

2. To win the game, players had to focus:

    a. 1 – Solely on Security Level

    b. 2 – Mostly on Security Level and partially on Completing Missions

    c. 3 – On both Security Level and on Completing Missions

    d. 4 –Mostly on Completing Missions and partially on Security Level

    e. 5 – Solely on Completing Missions

3. Playing Policies:

    a. 1 – Had no impact on Completing Missions

    b. 2 – Had little impact on Completing Missions

    c. 3 – Had some impact on Completing Missions

    d. 4 – Had a significant impact on Completing Missions

    e. 5 – Had a lot of impact on Completing Missions

4. Playing Maneuvers:

    a. 1 – Made my win condition too easy

    b. 2 – Made my win condition easier

    c. 3 – Had no effect on win conditions overall

    d. 4 – Made other player's win conditions easier

    e. 5 – Made other player's win conditions too easy

5. How much interaction with other players did the game require?

    a. 1 – No interaction

    b. 2 – Little interaction

    c. 3 – Some interaction

    d. 4 – A significant amount of interaction

    e. 5 – Too much interaction

6. Of the below options, I would describe the game as:

    a. 1 – Fully competitive (Players are generally adversarial and the primary obstacle to winning)

    b. 2 – Semi competitive (Players are adversarial but not the primary obstacle to winning)

    c. 3 – Balanced between competitive and cooperative

    d. 4 – Semi cooperative (Players are non-adversarial but cooperation is not needed to win)

    e. 5 – Fully cooperative (Players must cooperate to win the game)

Appendix C: Internal Review Board Waiver

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (AETC)

19 Oct 2018
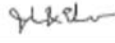
MEMORANDUM FOR Dr. Gilbert Peterson

FROM: John J. Elshaw, Ph.D.
          AFIT IRB Research Reviewer
          2950 Hobson Way
          Wright-Patterson AFB, OH 45433-7765

SUBJECT: Approval for exemption request from human experimentation requirements (32 CFR 219, DoDD 3216.2 and AFI 40-402) for Serious Game Design Survey.

1. Your request was based on the Code of Federal Regulations, title 32, part 219, section 101, paragraph (b) (2) Research activities that involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior unless: (i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) Any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

2. Your study qualifies for this exemption because your research does not involve human subjects, you are not collecting sensitive data, which could reasonably damage the subjects' financial standing, employability, or reputation. Further, the data you are utilizing and the way that you plan to report it cannot realistically be expected to map a given response to a specific subject.

3. This determination pertains only to the Federal, Department of Defense, and Air Force regulations that govern the use of human subjects in research. Further, if a subject's future response reasonably places them at risk of criminal or civil liability or is damaging to their financial standing, employability, or reputation, you are required to file an adverse event report with this office immediately.

10/19/2018

X ~~signature~~

Signed by: ELSHAW.JOHN.J.1078680454
JOHN J. ELSHAW, PH.D.
AFIT Exempt Determination Official

Appendix D: The Cards

SDN Upgrade
-6-
8
8
2$
8
8
2$

Weaponize
-4-
X
X
One Use Only.
Take the last card from the discard pile

Check the Taps
-4-
2X / X
X is the number of resource cards you control
Upon Completion.
If there is a in the discard receive

White Listing
+1
+1 | | +1

Cyber Awareness Training
+1
+1 | | +1

No time Like Zero Day
Threshold: 15
"Open Kimono"

No Removable Media
+1
+1 | | +1

Two Factor Auth
+1
+1 | | +1

Gone Phishing
Threshold: 3
Discard 1 card from your hand or a card from play
"Cyber Awareness Training"

Stove-Piped Execution
+1
Players may no longer Move missions

Encryption At Rest
+2
+2 | | +2

You've got ... Worms
Threshold: 3
Discard 1 card from your hand or a card from play
"No Removable Media"

Mission Hegemony
Pay / for
Players may not spend funds on move actions but gain:

Two Person Integrity
+1
+1 | | +1

Moley, Moley, Moley, ...
Threshold: 5
Discard 3 cards from your hand & 3 cards from play
"No Removable Media"
"Two-person integrity"
"Cyber Awareness Training"

Open Kimono
+2
+2 | | +2

Entrance Validation
+1
+1 | | +1

Malicious Website
Threshold: 4
Discard 2 cards or a card from play
"White Listing"
"Cyber Awareness Training"

Spartans, & Trojans, & Backdoors ... Oh My!
Threshold: 5
Discard 5 minus your cards from play
"White Listing"
"Cyber Awareness Training"
"No Removable Media"

Tailgate Party!
Threshold: 4
If any player fails to meet Threshold shuffle all back into the deck
"Entrance Validation"
"Two-Factor Authentication"

Social Engineering
Threshold: 3
Discard from play a number of cards equal to the amount of players that failed to meet Threshold
"Cyber Awareness Training"
"Two-Factor Authentication"

Mission Cards

The Gloves Are Off — +3 / +3 / -3

GSA Approved — -2 / +1 / +1

Tech Refresh — -2 / -3

Keep it In House — -2 / -2

The Color Of Money — Players may only complete one type of Mission on their turns, but gain: Pay $ For $ / ◎

Turn about Is Fair Game — -1 / -1

Action Cards

Top Cover — Discard 2 [card] from play.

Micro Management — You may Exhaust resources up to 3 times this turn. If Exhausted more than twice, discard that resource.

Command Decision — Take 2 Resources from in front of a player if they control a mission with [icon] > Your Mission

Corporate Lobbying — Swap one of your unfinished missions with an unfinished mission in front of another player

Back Channels — Search through the deck for a [card] card & put it into play.

Inspired Leadership — Until your next turn For Every [icon] card you control [+1]

Change of Leadership — Discard all [card] from play.

Political Intrigue — Look at a player's hand & take a card

Re-Allocated Budget — During the next round you recieve [+1] per player & everyone else loses 1 $

Congressional Interest Item — Take 4 resources from any player(s), refresh them, & place them in front of you.

Rapid Acquisitions — Take all [◎] cards from the discard pile, choose one, put it into play, & shuffle the rest in to the deck.

Friends in High Places — Negate the effects of a [icon] card just played.

Surprise Inspection — Target Player adds the mission below to their priority queue. It does not count towards mission completion, but if failed cancels a successfully completed mission. [-3] X is total number of [card] cards you control   X◎/X◎

Personnel Change Cycle — Gather all [icon] cards in play shuffle them together and deal them out to each player starting with yourself.

Call in a Favor — Switch hands with another player

Cards

Intern — $ (×3 cards)

Standard Laptop — $

Employee — $ $

Employee — $ $

Standard Laptop — $

Standard Laptop — $

Desktop Computer — $ $

Desktop Computer — $ $

Virtual Machine — $ $

Snort Swine — $ $

Thin Client — $ $

Code Monkey — $ $

Specialized Laptop — $ $

Script Kitty — $ $

Gamplay

Round Start
1. Draw a ◆ card
2. Refresh all ▮ cards
3. Set players ● to 10
4. Begin player turns

Player Turns
1. Turn order proceeds clockwise from the Marker
2. Players may play cards from their hands during their turn.
3. Players can only fulfill ● card requirements during their turn.

Round End
1. Move ● cards to the right on the priority queue.
2. Move Marker to right of the current player

Quick Reference

Resources ◆
Tech Manpower Funds

⊙ OCO DCO NetOps

Security Level

Time Limit

Card Types
Mission Policy Incident
Manuever Resource

Basic Actions that cost 1 $

1. ⚠ Playing a card from your hand. Must normally be done during your turn.
2. ➔ Drawing a card from the game deck. Can only be done on your turn.
3. ➔ Moving a card from yourself to another player. Can be done at any time.

New Policy #1

See Variant Rules for New Policy Cards In Rule Book.

? ? ?

New Policy #2

See Variant Rules for New Policy Cards In Rule Book.

? ? ?

Presidential Priority — Refresh any number of resources once. You may use any player(s), resources as if they were your own.

Recruitment — Draw 6 cards. Put 2 cards into your hand & shuffle the rest back into the Deck

Hiring Surge — Take all cards from the discard pile, choose one, put it into play, & shuffle the rest in to the deck.

Cards:

- Snort Swine
- CIRT Lead
- Security Professional
- Virtual Machine
- CIRT LAB
- CIRT Workstation
- Code Monkey
- System Engineer
- Reverse Engineer
- Thin Client
- Unit Cloud
- Thick Client
- Script Kitty
- 1337 Hax0r
- Red Teamer
- Specialized Laptop
- Some Future Tech
- Custom Built Rig

Appendix E: MDA Mapping

Lesson Objectives or Aesthetic Goals - Sensation - Fantasy - Narrative - Challenge - Fellowship - Discovery - Expression - Submission	Dynamics: - Physics - Internal Economy - Progression Mechanism - Tactical Manuvering - Social Interaction	Mechanics	Reasoning
Students will explain how policies impact different cyber mission areas	Explain with Physics. Supports fantasy, sensation, and discovery.	Mission Deck: All Mission cards are shuffled together, the top 6N (where N is the number of players), are set aside as the Mission Deck. Any additional Mission cards are not used.	Randomizing the missions provides players an equal chance of being exposed to each mission area. Interaction with "Policies Benefits and Penalties" will force players to explain to other players how proposed policies might impact their missions
Students will explain how policies impact different cyber mission areas	Explain with Social Interaction. Supports narrative, expression, challenge, and fellowship.	Policy Benefits and Penalties: Policies provide a benefit to all players at the cost of either the removal of a current capability or increasing the generic costs of two mission types for all players.	Since impacts and benefits are global this mechanic should spur discussion among players and force them to explain why a policy should or should not be played
Students will explain how policies impact different cyber mission areas	Explain with Social Interaction. Supports narrative, expression, challenge, and fellowship.	Initial Policies: For a standard game, the "Cyber Awareness Training" and "Two Person Integrity" policy cards are put into play at the start of the game. For an advanced game, cards are drawn from the top of the deck until two policy cards are	Starting the game with two policies introduces players to their impacts from the start so they can better discuss impacts of later policy decisions
Students will explain how policies impact different cyber mission areas	Explain the Progression Mechanics. Supports narrative, expression, challenge, and fellowship.	Win Condition: All players must complete four of the six missions they are assigned or all players lose the game	Interaction with "Policies Benefits and Penalties" means that policies that prevent players from meeting the minimum causes everyone to not progress (i.e. Win)
Students will explain how policies impact different cyber mission areas	Explain with Physics. Supports fantasy, sensation, fellowship, and challenge.	The Mission Priority Queue: When a mission card is drawn it is placed on its matching time slot. At the end of every round each mission in the queue moves one place to the right. When a mission moves off the priority queue position marked with a "1" it is considered "Failed" and should be stacked to the right of the "1" position.	Mission expiration creates a sense of urgency. Interaction with "Policies Benefits and Penalties" give players reasons for or against specific policies and their impacts.

Lesson Objectives or Aesthetic Goals - Sensation - Fantasy - Narrative - Challenge - Fellowship - Discovery - Expression - Submission	Dynamics: - Physics - Internal Economy - Progression Mechanism - Tactical Manuvering - Social Interaction	Mechanics	Reasoning
Students will identify trade-offs between cyber security and mission execution	Identify with Physics. Supports fantasy, narrative, sensation, and discovery.	Cyber Specialization: Mission cards and Resource Cards are categorized into one of three specilaizations; Defensive Cyber Operations (DCO), Offensive Cyber Operations (OCO), or Network Operations (NetOps). Mission costs are cheaper when the same typed Resources are used to fulfill its requirements.	Specializing makes mission execution more efficient but interaction with "Policies Benefits and Penalties" that benefit security decreases that efficiency creating a tradespace to identify
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, sensation, discovery, and challenge.	Resource Production: Resources produce a type and amount of resources indicated above the cost portion of its card when it is exhausted towards a mission.	Interaction with "Mission Fulfillment" creates an internal economy. Interaction with "Policies Benefits and Penalties" that benefit security sets the tension between security and mission internal economies
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, narrative, sensation, and challenge.	Funds Tracker: At the beginning of every round players set their funding to 10 unless otherwise modified. When a player spends funds they place the marker on the level of their current funding after reducing it by the amount of funds spent.	Sets the basis for the games internal economy. Interaction with "Play a Card" forces players to make decisions based off of the tradeoffs they identify during the game
Students will identify trade-offs between cyber security and mission execution	Identify with Progression Mechanics. Supports fantasy, narrative, sensation, and challenge.	Security Level Tracker: Starts off at zero and cannot be increased beyond 15. The marker is placed on the space representing the sum of all modifieres to security level for that specific player	Interaction with "Play a card" for policies to increase security level also impacts mission execution for mission areas.
Students will identify trade-offs between cyber security and mission execution	Identify with Physics. Supports fantasy, narrative, sensation, and discovery.	Game Deck: Resource Cards, Incident Cards, Manuver Cards, and Policy Cards are shuffled to form the game deck	Randomness in the game deck creates a situation where interaction with "Draw a card" is needed to support mission execution but may also cause an Incident to be drawn.

Lesson Objectives or Aesthetic Goals - Sensation - Fantasy - Narrative - Challenge - Fellowship - Discovery - Expression - Submission	Dynamics: - Physics - Internal Economy - Progression Mechanism - Tactical Manuvering - Social Interaction	Mechanics	Reasoning
Students will identify trade-offs between cyber security and mission execution	Identify with Physics. Supports fantasy, narrative, sensation, and challenge.	Incident Resolution: When a player draws an Incident card from the deck, they must play it immediately for free. An incident's consequence resolves against all players whose security level do not meet or exceed its threshold. Afterwards the Incident is discarded and the original player draws another card.	The immeadiacy of unkown consequences from incidents drives the need to play policies which progress a players security level. All incidents impact a players ability to execute missions. This drives the internal economy for security.
Students will identify trade-offs between cyber security and mission execution	Identify with Social Interaction. Supports fantasy, narrative, challenge, and fellowship.	Policy/Incident Response: Any time an Incident is played a player may elect to play a Policy listed under the Policy symbol on the Incident card to make themselves immune from the consequence of the Incident being played.	Allowing players to play policies immeadiatly in response drives the security economy and could save other players as well. However this still comes at the cost of efficient mission execution.
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, narrative, sensation, and challenge.	Play a card: To play a resource card, players spend funds equal to a resource card's cost. For all other cards players spend one fund.	Interaction with Funds drives the game's internal economy. Playing cards is the expression of a players decisions after having identified and analyzed the tradeoffs inherent in making that decision.
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, narrative, sensation, and challenge.	Draw a card: Players spend one fund to draw a card from the game deck.	Interaction with Funds drives the game's internal economy. Drawing provides players access to new capabilities, resources, and policies that they must make decsions based upon.
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, narrative, sensation, and challenge.	Mission Fulfillment: A mission's requirements must be fully satisfied during a player's turn for the mission to be completed. Resources are exhausted and funds are spent. Resources spent on a mission can not carry over to fulfill other missions.	Interaction with Funds and Resource Exhaustion is the point of the mission execution economy and provides the context for identifying tradeoffs.

Lesson Objectives or Aesthetic Goals - Sensation - Fantasy - Narrative - Challenge - Fellowship - Discovery - Expression - Submission	Dynamics: - Physics - Internal Economy - Progression Mechanism - Tactical Manuvering - Social Interaction	Mechanics	Reasoning
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, sensation, narrative, and challenge.	Exhausting Resources: Players exhaust resources to fulfill a single mission's requirements by turning it sideways. Unless otherwise specified, a resource cannot be Exhausted towards a mission's requirements again until it is Refreshed (either at the start of a new round or by playing a maneuver).	Interaction with Mission Fulfillment drives the mission execution economy. Scarcity of resources drives the impacts of policies creating a tradespace to identify.
Students will identify trade-offs between cyber security and mission execution	Identify with Internal Economy. Supports fantasy, sensation, and narrative.	Refreshing Resources: Players refresh resources normally at the start of a Round by turning it right side up.	Interaction with Mission Fulfillment drives the mission execution economy. Scarcity of resources drives the impacts of policies creating a tradespace to identify.
Transformational Play	Social Interaction supporting fantasy and narrative.	Any player may ask to inspect another player's failed mission pile during the game.	Allowing players to inspect each others failed missions gives every player the opportunity to assess the benefit or detriment of assisting them and further immerses the player into the current game state.
Transformational Play	Physics supporting fantasy, sensation, and narrative.	Mission Tracker: When a player completes a Mission move the marker on the mission tracker to the right	Allows other players a quick reference for eachothers completed missions. Speeding up the game.
Transformational Play	Physics supporting fantasy, sensation, and narrative.	Mission Rewards: Completing a mission provides a capability to the player upon completion	Provides players further incentive to complete a mission and perhaps take risks for a particular reward.
Transformational Play	Social Interaction supporting fantasy and narrative.	Maneuver Cards: Maneuver cards provide players access to temporary capabilities that are used when the card is played	Immerses players further by forcing players to consider how these temporary capabilities can be applied for their benefit.
Transformational Play	Physics supporting sensation, and challenge.	Initial Hand: Players are initially dealt out 8 cards from the game deck. Any incidents are shuffled back into the game deck and replaced with new cards. Players then choose 6 cards for their starting hand and shuffle the rest back into the game deck.	This helps to start a players immersion into the game by forcing them to consider their options before the game actually starts

Lesson Objectives or Aesthetic Goals - Sensation - Fantasy - Narrative - Challenge - Fellowship - Discovery - Expression - Submission	Dynamics: - Physics - Internal Economy - Progression Mechanism - Tactical Manuvering - Social Interaction	Mechanics	Reasoning
Transformational Play	Physics supporting fantasy, sensation, and narrative.	First Player: The Distinguished Gamer (DG) recieves the "Start Player Marker" at the beginning of the game. If there is no DG then the youngest player recieves the "Start player marker"	The DG designation gives players a slight advantage for past performance and signals to new players a reason to shoot for excellence.
Transformational Play	Physics supporting challenge	Turn Order: During a round, turns proceed clockwise from the player who has the "Start player marker". Once the round is complete the "Start player marker" is moved counter-clockwise one player before the next round begins.	Players take their future turn order into consideration when making decision to insure they have the resources available at the right time to complete their missions.
Transformational Play	Physics supporting sensation, and challenge.	Hand Limit: Players cannot end their turn with more than 6 cards in their hand unless otherwise modified. Players will discard down to this limit at the end of their turn.	Provides a slight but necessary limit on the number of options players have to play on any given turn. This helps with immersion because in real life opportunities don't last forever.
Transformational Play	Social Interaction supporting narrative, fantasy, sensation, and challenge.	Move a card: Players spend on fund to move any card in their tableu to another player.	This capability allows for players to assist other players provided they have prepared to do so.
Transformational Play	Physics supporting fantasy, narrative, and challenge	Game Length: The game consists of six rounds	Limiting the game length places an importance on decsion making for all players.
Transformational Play	Progression Mechanisim supporting fantasy, sensation, and narrative.	Distinguished Gamer: The player with the most completed missions at the end of the game receives the Distinguished Gamer (DG) designation for the next subsequent game (if any are played). In case of a tie, the player with the most Resource Cards receives the DG tag.	This to a limited extent is meant to help immersion with providing players a reason to drive to be the best among equals.

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14. ABSTRACT
The field of Serious Games (SG) studies the use of games as a learning tool. The primary focus for the field has been designing systems to evaluate the educational efficacy of existing games. This translates to a lack of systems designed to aid in the creation of serious games. The rise in popularity of games has given rise to systems for commercial production which can be applied to SG creation. However, showing a clear linkage between a game's components and its learning objectives is a primary difficulty.

The Mechanics Dynamics Aesthetics (MDA) methodology is an understandable and robust construct for creating commercial games. However, an educational Serious Game (SG) must not only be fun, it must also convey the intended learning objectives to its players. This thesis explores utilizing the MDA methodology, with Bloom's taxonomy, to create and evaluate a game to meet two learning objectives for a Cyber focused class.

The created game CyComEx, was designed to teach cyber students to identify tradeoffs between security and mission execution, and to explain how policies can impact cyber mission areas. The game was evaluated to have conveyed these objectives during a playthrough and was enjoyable for participants of this case study. |

15. SUBJECT TERMS
Serious Games, Mechanics Dynamics Aesthetics, Bloom's Taxonomy, CyComEx,

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