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Use of Serious Games to Incorporate Security Awareness Programs with Skills Training

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Abstract

The purpose of this study is to determine the possibility of addressing the shortcoming of Security Awareness training in providing Skills training. The study will also determine if it is possible to create a Serious Game that will provide Skills training. There is a constant increase in cybersecurity attacks. Now, security training is limited to Security Awareness training, which does not provide Skills training. Security Awareness training also lacks motivation elements that can make training more palatable and engaging for individuals. This study will also investigate if Serious Games can help target training towards organizational goals. Most Security Awareness training is administered annually and cannot be changed to meet specific organizational requirements or emerging security threats.

This study begins with the introduction Information Security and the problems that organizations face regarding addressing security threats. Justification for the study is also addressed. The theories and components that will be included in the Serious Game will be included in the Background chapter. The Related work chapter will investigate other resources, how they address the challenges in security risk and game theory and what can be done to address the limitations that were faced in those studies. The Methodology chapter describes the requirements and steps necessary to produce a Serious Game artifact that conveys Information Security concepts and skills in an engaging manner. The Artifact chapter describes the artifact that is the result of the Methodology and a description of what the Serious Game consists of.

There has been progress with Security Awareness training, but little that involves Skills training. There has been little progress with motivating individuals to engage in security training. Further, evaluating the effectiveness of Security Awareness training is limited to post-training tests that only require memorizing parts of the training. These evaluations do not test the effectiveness of the training. The training is not adaptable to organizational needs, which also renders the training less effective. The evaluation of the Serious Game showed that it was effective in providing Skills training and in motivating players. Serious Game can be employed to teach skills and motivate individuals to engage in training. The game can also be adapted to organizational goals and updated as required by an organization.

Keywords

- Serious Games
- Fogg's Behavior Model
- Bloom's Taxonomy

- Flow
- Scaffolding
- M-D-A

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Chapter 1
Introduction

1.1 Topic covered by the project

We are told that Information Security is part of everyone's job. With the mean time to infection of an unprotected computer being five minutes [NASJ12], an organization's ability to secure information is critical to that organization's security posture. Information Security is typically addressed by annual End-user Security Awareness training. Only 5% of training sticks without reinforcement [Rit04]. While Security Awareness training is important because it describes the various vulnerabilities and attacks that an organization faces, the type of training that would be more advantageous would be Security Skills training. Security Skills training addresses the skills that are necessary to provide the individual with the ability to address and mitigate the threats identified by the Security Awareness training. This is because the ability of the individual to address and mitigate security threats is critical in reducing an organization's exposure to security risks, Security Skills training can be viewed as a logical training goal after Security Awareness training.

Proper Security Skills training must also address gaps in training skills that individuals identify. There are many levels and types of security breaches. Many companies spend as much as $3.7 million dollars a year preventing phishing and spear phishing attacks [WC18], where spear phishing attacks alone can cost an estimated $16 million *per incident* [WC18]. Some require simple mitigation steps while others may require more sophisticated training to mitigate. Mitigation skills must be learned that will specifically address each type of threat that may be faced. Security Skills training must be able to address the gaps in training that each individual faces and reports. Typical training steps can be outlined by using Bloom's Taxonomy, which explains the various learning levels and what level of expertise we can expect from individuals based on applied training methods.

Motivating individuals to learn security mitigation skills has always been a challenge. In 2013, Human Vulnerabilities account for 80% of vulnerabilities exploited by attacks

[AM15]. It is essential to address this challenge. The feeling of vulnerability can be a significant indicator of motivation to take precautions on social networks [LeF12]. Individuals are motivated to learn skills that are closely connected to their line of work, but extended job responsibilities can be neglected or completely ignored. This can lead to collateral security incidents or incidents that can happen outside of primary work responsibilities. Serious Games have been a method to motivate individuals to engage in training. Although most people view Serious Games as a method for introducing fun into training, it has more specifically added game aspects to security training to make training more engaging. Motivation to learn and its connection to effective Skills Training will be introduced by the Serious Game-style training. The game will be aligned with aspects of Fogg's Behavior Method.

1.2 Problem Description

Information Security has become more important in recent years for organizations. There is a constant increase in cyber-attacks worldwide, an estimate of $106 Billion was recorded for cyber hacks in the united states in 2016 alone [AC] and there is a constant increase in the estimated losses from cyber espionage and cyber-crime which results to billions every year [Cen13]. According to Gartner, the global information security market is forecasted to reach $170.4 billion in 2022 [KE18]. It is important for individuals to acquire the skills to address security challenges that are aligned with the goals of an organization. Now security training is limited to Security Awareness training, which provides an overview to individuals of general security threats and vulnerabilities that may not be specific to the requirements of the organization in question. Security Awareness training that does not address organizational needs or goals is insufficient in providing the skills necessary to address the security threats that arise and that will increase in the future [ASS20]. This can lead to the organizational security inadequacies, and subsequently, mistrust by customers and partnership organizations. There are also economic costs and fines that can be incurred when security breaches are not properly handled. For example, it is estimated that the Norsk Hydro breach that occurred in March of 2019 will cost an estimated 75 million dollars not including collateral damages [Ash19].

New training methods must be used to convey Information Security concepts and skills. The training must also be engaging so that individuals will use it in their day-to-day routines. Security Awareness Training is not effective in addressing security threats because training engagement time by the user is too limited [Rit04]. Serious Games have shown promise in stimulating motivation towards training, but have not been directed towards the specific gaps in Security Awareness training. Training solutions also lack the flexibility to address the varying skill levels and requirements of the individuals, and thus, the organization. Evaluating Serious Games using Bloom Taxonomy, a multi-tiered model of classifying thinking according to six cognitive levels

of complexity [For11], can be used to help identify the differences between learning levels and the subsequent lacking in some training levels that many individuals experience with conventional training methods. Bloom Taxonomy can also identify areas where providing a more immersive environment for security training will be beneficial to individual based on the type of training required at that level. Coupled with pre-evaluation of the individuals, a Serious Game can further assist in focusing the necessary level of training on each individual by evaluating the individual's skill-level and training engagement time to track progress of the individuals training.

Using Serious Games to help motivate individuals to continue training can be enhanced by applying Fogg's Behavior Model to the training method. Creating a game that uses Fogg's Behavior Model will incorporate techniques that motivate the individuals to increase the amount of training time. This will result in the individual learning more skills, which can be applied to mitigating security threats and vulnerabilities. The increase of skills learned from training allows individuals to address and mitigate security issues and, in turn, increase the security posture of the organization. Increased motivation may also assist in identifying whether individuals lack the attitude towards learn security skills as opposed to ability to do so. Identifying these challenges can assist in providing the appropriate training.

1.3 Justification, Motivation and Benefits

Most organizations address Information Security by providing annual Security Awareness training. The major benefit of the training is to make individuals aware of the threats that exist and that may be encountered while using an information system. Generally, the training is presented through statements regarding security risks, scenarios of people experiencing questionable security situations or who perform questionable security practices. They adopt a general approach instead rather than emphasizing the different manipulation techniques generally adopted by attacker [ASS20]. The training is concluded with an exam that requires a pre-determined passing grade.

This project proposes the use of Serious Games concepts to develop Security training to teach the skills necessary for an individual to address security threats. Security training should include elements that will allow the individual to learn mitigation skills and procedures to follow, which will limit the effects of vulnerabilities and attacks. Serious Games concepts can also assist in motivating the individual to perform game tasks that will lead to the individuals learning to mitigate security threats. These concepts are identified in Fogg's Behavior Model. B. J. Fogg theorizes that changes in behavior are connected to increased ability to perform [Fog09], in this case, security mitigation tasks. Increased ability is achieved by motivating and triggering the individual into action, or **(B=MAT)**. The game will use these

identified factors from Fogg's Model to change how the individual behaves in security situations. Individuals will benefit from the increased ability to secure information and the organization will be able to increase security posture based on these acquired skills.

The project will also attempt to confirm the idea that Serious Games can be used as a tool to motivate individuals into skills-learning instead of being viewed as a tool that simply makes learning more palatable by simply adding fun to the training. The game elements will be used in connection with training elements with the expectation that they can continually motivate the individual to progress past gaps in individual motivation towards training. Further, the project will attempt to confirm that Serious Games concepts can be applied to the problematic training areas that make it difficult to address training goals required by organizations. The training gaps and the approach to address the gaps will be identified using Bloom's Taxonomy to identify expected learning expectations at the various levels.

1.4 Research Questions

Although Serious Games have shown promising results in the areas of immersion and motivation during training, there is still a lacking regarding influencing behavior changes. Further, adding gaming aspects to a system does not necessarily address the fundamental problem of providing individuals with the ability to address Information Security vulnerabilities and attacks. Individuals should understand what to protect, why they should protect it, how the organization can help them with this and how successes and mistakes can be used as opportunities to learn and improve [BAD+15]. Most individuals do not know how to mitigate potential attacks or recognize attacks in progress because Security Awareness activities do not address Security skills training. Individuals need to adapt better skills to help create and effective Information Security Management System(ISMS) that aligns with organizational goals and improves security posture. As such, this project will attempt to answer the following questions.

1. *How can Serious Games be used to address the shortcomings of traditional Security Awareness Training?*

   How can Serious Game elements be used for Skills training?

   How can the appropriate levels of skills training be adapted to address individual requirements?

   How can Serious Games assist in aligning Security training with organizational goals?

2. *How can Serious Games be used to increase the motivation of individuals to learn security skills?*

Which Serious Game components will be effective in motivating the learning of Security mitigation skills?

How can game components be used to motivate the individual to use the game continually?

How can skills training motivate individuals to change security behavior?

3. *How can we evaluate the effectiveness of the training*

   What improvement criteria must be measured and against which training areas or standards?

   What methods will be effective in collecting these measurements?

1.5 Planned Contributions

A Serious Game or applied game is a game designed for a primary purpose other than pure entertainment [Mic05]. In this game the primary purpose for that game will be to teach Security skill to individuals. Security Awareness training provides knowledge in security threats and vulnerabilities. What conventional Security Awareness training lacks is the focus on skills training. The study focuses on providing skills training based on Bloom's Taxonomy, which separates learning levels into learning focus areas. This will be complimented by including motivational methods based on Fogg's Behavior Model, which describes motivation as a balance between ability and proper triggering.

Chapter 2
Background

This chapter will outline the background areas that are the basis of this thesis. Section 2.1.1 discusses the challenges faced by Security Awareness Training. Section 2.1.2 introduces Bloom Taxonomy and how it can be used to identify learning levels and evaluate learning effectiveness. Section 2.1.3 discusses Fogg's Behavior Model and how it factors into training motivation, various training methods and factors that can be used in the development of a game. Section 2.1.4 will discuss Game Design Framework that will outline the game development. Section 2.1.5 is a summary of this section.

2.1 Purpose

The sections in the background chapter provide an overview of the areas that will be addressed and the components that can be included in the development of a Serious Game. Assessment of current evaluation methods used in an effort for training will also be conducted. These include education and training theories, development methods and learning evaluation methods. This chapter will also discuss the various challenges regarding creating a game prototype and the limitations that are experienced when attempting to provide security training and how these limitations may be addressed by using different training and motivation methods.

2.1.1 Security Awareness training

A challenge with traditional Security Awareness training is that it does not teach the skills needed to decrease the number of security breaches that an organization experiences. Individuals are often ill-equipped to handle security related issues [TKK15]. This includes fundamental skills, for example, strong password creation [AFSP16]. It is important to address the various shortcomings in typical Security Awareness training with the addition of appropriate Skills training. Effective Skills training will help to ensure that individuals will acquire the methods to face security threats and challenges. Further, there must be a method to evaluate whether

these skills have been learned by the individual receiving the training. Training evaluation will help identify shortcomings in training methods and content. The feedback received from pilot testing will be used to improve the game and the training elements to better match individual expectations and to meet organizational goals.

Security Awareness training traditionally lacks the ability to be adaptive. Typical Security training is conducted in a narrative form once a year and is not interactive. Threats change and increase rapidly and typical training cannot adapt to those changes. most Security Awareness training does not address threats that are specific to an organization. Providing interactive training allows the training to address specific real-world problems [AFSP16]. Further, the ability to change the training allows an organization to help its individuals to adapt to the changing threat environment. Training should be adapted to meet defined individual needs [SBO98]. Adaptive training can also be tailored to meet organizational goals in a timetable that is commensurate with the requirements and resources of that organization.

2.1.2 Bloom's Taxonomy and Evaluation Methods

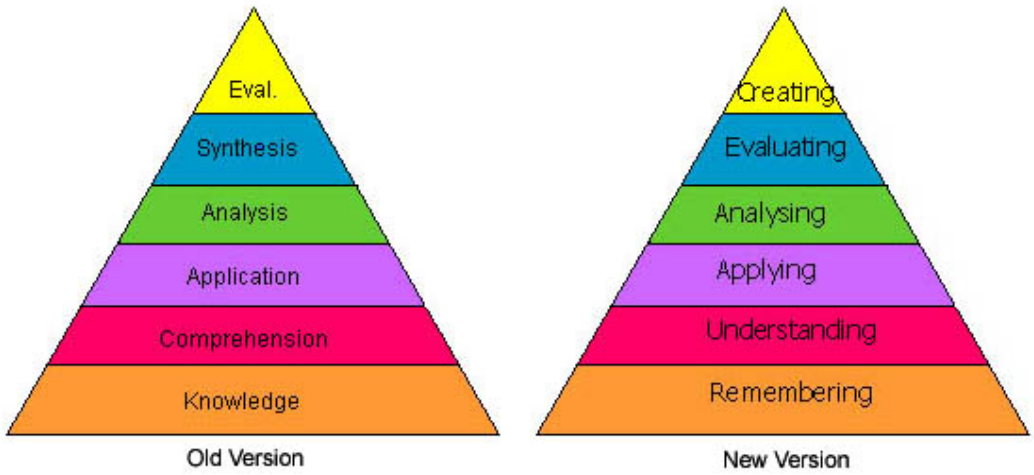

Figure 2.1: Bloom Taxonomy Illustration [For11]

To create effective Skills training, it is necessary to understand how people learn and what methods are helpful in teaching individuals to reach the desired level of training. Measuring the individual's achieved level of training also helps us to evaluate how effective the training has been. Gaps in training can be addressed by comparing an achieved level of individual skills after training to an established baseline level of skill acquired through evaluation prior to training. The evaluation can also assess

the appropriateness of the training for each expected learning outcome. Using the Bloom Taxonomy will assist in identifying levels of training and the various skills that are expected at each level. The extended Bloom Taxonomy Will be used so that action words can be incorporated in outlining the training questions [Kra10]. As such, there are four areas that the Bloom Taxonomy may help address:

- *Effectiveness of Training* The main components of the game.

  Are effective results achieved?

- *Evaluation of Format* Allowing the player to assist in improving the game through feedback.

  Is the training fit for purpose?

- *Adaptability*

  Can the training fit a specific purpose, group or requirement?

- *Portability of Training* Is the game appropriate for other scenarios?

  Can the training be transferred to other cultures, contexts or industries? [BDLS19]

The method of evaluating training will be based on success criteria establish in alignment with general security goals and specific organizational goals.

- *Questionnaires* - Pre and Post -training
- *Game feedback* - Between game trials, during and Post -training
- *Game results* - During and post -training

We must determine which level of training will be necessary to allow the individuals to achieve the skills that are necessary to mitigate security risks. We must also determine how we will evaluate the level of training achieved based on the same standard. We would like level *3a* in the Bloom Taxonomy illustration, **Figure 2.1** Application/Applying. This level aligns with the ability for individuals to apply the information that they have learned.

Establishing training effectiveness is an important reason for using Bloom's Taxonomy. Bloom's Taxonomy can assist in focusing the evaluation on specific training levels and training outcomes. Focusing on Skills that are aligned with roles and responsibilities of an individual can improve job performance. Evaluation of training will help ensure that the skills training can transfer effectively to job tasks and be

aligned with organizational goals [BDLS19].

Evaluation Design types - It is important to disregard all other factors, outside of the actual training factors, that may influence the training outcome. What must be considered are the factors from the training that should be the focus of the evaluation. Distractions, for example use of technology, must be separated from evaluation factors. Factors that are important to include for effective training: [BDLS19]

- *Proximity to job tasks* - How close to this task to the individual's job?
- *Repetition of tasks/information* - Is the training re-enforced?
- *Individual feedback* - Can the training be adjusted using information from individuals?
- *Training categories* - Which areas are identified and reached?
- *Spacing of training material* - How much is an individual expected to absorb at one time?

These factors ensure that the training is fit for task and that there is an appropriate amount of reinforcement that will help provide clarity, understanding and that will sharpen the skills of the individual. These items also align the training to meet goals and policies set by the organization.

2.1.3 Fogg's Behavior Model

Interaction in training is an important element to motivating individuals. Security breaches are frequently a product of low motivation among individuals [GGBF17]. Generic scenarios may not help individuals easily relate to the real-world situations they may face. Immersion in a game environment can help motivate individuals when those techniques can be used to show various consequences to their actions and how those actions would have similar real-world consequences [AFSP16]. Connecting the scenarios to organizational goals can engage the individual by making a connection to authentic work tasks. Connecting the scenarios to feedback can help to reinforce desired behavior [AWW17].

Changing the behavior of individuals can be accomplished by use of motivational tactics. Serious Games increase motivation and learning outcomes [GGBF17], while personalized security training content makes training relevant, easier to understand and leads to improved security behavior [RFE16]. Changing an individual's behavior changes the individual's attitude regarding security and results in change of an

organization's security culture [RFE16]. Creating a stronger security culture provides sustainable effects that will help an organization to remain secure. To create a Serious Game using effective methods, it is important to understand the various factors that motivate or demotivate various individuals to learn. Individuals that perceive the security risk as low may be less likely to follow security policies [SMP14]. An organization must also consider its security goals and resources when creating a training plan. A cost/benefit analysis of compliance and work impediment can help to determine what is too much security and how much security will be a hindrance to workflow [GGBF17]. Understanding what level of security is necessary to achieve organizational goals that mitigate risks is an element of the security program that must be assessed before it can be included in the Serious Game. This level of security must be balanced with a level of security that is affordable for the organization. Affordability must include the cost of time and effort in addition to price of the security solution.

There are also factors that may cause individuals to doubt their abilities to effectively discover, avoid or mitigate security attacks or breaches. Lacking self-efficacy, the feeling that the individual is equipped to handle situations, may not only prevent an individual from discovering attacks or breaches. The individual may not act against attacks or breaches that have been discovered. There are psychological factors involved in security that must be addressed [TKK15]. These psychological factors will have an influence over how a Serious Game can be developed. They will also have influence over how effective the artifact of a Serious Game will be in teaching the individual the mitigation skills necessary to limit the effects of security breaches since these psychological will have to be incorporated in the Serious Game if they are to address those issues.

Fogg's Behavioral Model will assist in creating a Serious Game artifact by addressing the factors that hinder an individual's ability to learn. As the Figure 2.2 shows, Fogg's Behavioural Model will address three areas that influence behavior [Fog09]:

- *Motivation(Motivator pairs)*

  Pleasure/Pain - Response on a primitive level

  Hope/Fear - Anticipation of an event

  Social Acceptance/Rejection - Behavior

- *Ability*

  Time - How much is available

  Money - Financial resources available for use

  Physical Effort - Simplicity vs Complexity of efforts.

Brain Cycles - Mental efforts required

Social Deviance - How much will norms be abandoned.

Non.-Routine - Outside of "comfort zone".

– *Triggers*

Spark - Used to motivate people

Facilitator - Used to support lacking of ability

Signal - A simple reminder to those with both motivation and ability.

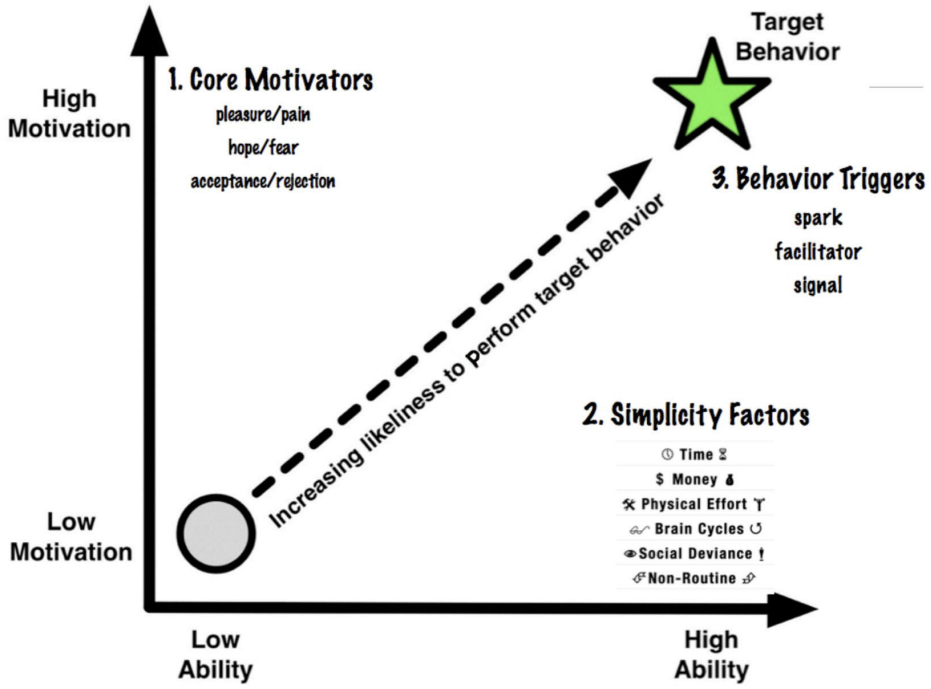

Figure 2: All three factors in the Fogg Behavior Model have subcomponents.

Source: A Behavior Model for Persuasive Design (Foggs BJ, 2009)

Figure 2.2: All three factors in the Fogg Behavior Model have subcomponents

Methods of Motivation: Subcomponents [Fog09]

- Creating urgency and consequences to motivate
  - Using a clock or a time limiter
  - Not allowing the player to go backward in the process
- Create a balance between high ability and low ability tasks
  - Ensuring that training is not so easy as to cause boredom
  - Ensuring that training is not so difficult as to cause frustration.
- Providing triggers that initiate learning and new behaviors
  - Making training interactive to incite motivation.
  - Creating prompts to guide the player game.
- Adding game components to the Serious Game
  - Creating a immersed environment for the player
  - Fulfilling the sensory expectation of a game

Using Fogg's Behavioral Model in a Serious Game will help ensure that the individual attempts training in an environment where the individual is comfortable. The interactive environment will create an atmosphere that motivates the individual by using game components as a spark to call the individual to action. Prompts, alarms or other facilitator actions will guide the individual over rougher areas helping with game simplicity. These factors will lead to habits aimed at changing the individual's behavior while maintaining the necessary balance between motivation and ability.

2.1.4 Game Design Framework

There are several Serious Game components that must be included to ensure that the individual receives the proper game experience during training. These components help ensure that an authentic game scenario is created and that the scenario created is appropriate for the individual. This includes individual tasks and individual-required levels of knowledge. The components also ensure the individual is immersed in the training environment. Security Awareness training has various challenges, but one of the more difficult challenges to address is how to make the individual engage in the training in a way that becomes more personal to the individual. Most of what the organization hopes to protect is abstract and difficult to explain clearly to most individuals. In most cases, the inner-workings of an Information Technology (IT) systems are never explained to individuals at all. Learning the additional tasks important to the protection of a system invites a greater level of difficulty that must be addressed by targeted training methods. It is important to create an environment where the game components add a level of concreteness and clarity to the Serious

Game environment so that it can easily be applied to actual job situations. These concrete situations that the organization experiences can be transferred from the abstract concepts using Serious Games. There are several components that can be used for these purposes:

- *Game Design Components* [RBLW17]
- The object and feel of the game. Many games start with a background story. This sets the game environment and allows the individual to understand the where the game scenario takes place. It is important that the setting immerses the individual so that the individual remains involved in the game.

- *Mechanics-Dynamics-Aesthetics* [Sil]

- *Mechanics* - Describes the particular components of the game, at the level of data representation and algorithm. The main components of the game [HLZ04]. Mechanics are the various actions, behaviors and control mechanisms afforded to the player within a game context. Together with the game content (levels, assets and so on) the mechanics support overall gameplay dynamics [HLZ04]. Game mechanics such rules, algorithms, data structures, etc. that are included in the game to support the game environment.
- *Dynamics* - Describes the runtime behaviour of the mechanics acting on player inputs and each others' outputs over time [HLZ04]. Progression of the game's backstory or plot [RBLW17].What the player of the game sees. They are the inputs and the reaction to the inputs of the game. Dynamics add to the immersive experience of the game. They are included in the game to help motivate the individual to use the game. The goal of immersion is to encourage user time with the game in an effort to help the user retain what is learned.
- *Aesthetics* - Describes the desirable emotional responses evoked in the player, when she interacts with the game system. The attempts to portray realism in the game [HLZ04]. They can also help ensure that the user will stay engaged in the game by creating an interactive environment to attract the user and keep the user involved.

- *Game Setting:* Scenario items that can contribute to immersion

  Story - Game background

  Sets the scenario, environment, goals characters, etc. In this case, the setting can ostensibly be a business office where each is being introduced to the company for the first time. Each employee has the same role. The module chosen will

determine which questions the player is asked and which tasks the player must perform. **see Appendix A**

Game Environment - Area where the game will be played [AC].

One-player, Two-player, Multi-player - Multi-player can help create competitive environment.

Simulation - Creation of an immersive environment

Hands-on - Learning through experience

Roles - Characters of the game

Objective - Goal of the characters

- *Game Mechanics:* The main components of the game. Progress to the goal [CGWM17].

  Points - Method of measuring incremental progress

  Levels - Method of showing complexity and/or advancement.

  Missions - Method to diversify learning. Modularity of topics.

  Leader-boards - Method of showing major progress, status or accomplishments.

- *Game Prompts:* Helping the player to push the game forward. Important triggers that help to continue the game. Assistance to bridge learning gaps.

  Unlocks - Methods to assist with progress

  Event - Warning of new activities

  Notifications - Information to assist with progress

  Tips - Shortcuts to assist with progress.

- *Learning Environment:* There are several elements that will be included in the Learning Environment. These elements will make the Serious Game experience amenable to the players. They also allow the players to learn in an environment where they can not cause harm to IT systems.

  Immersion - The game will create a learning environment that immerses the player.

  Repetitive - The game will cycle through questions. Question theme will also traverse levels.

  Success/Setbacks - Answering questions incorrectly causes the player to lose a turn. Correct answer allows the player to continue. Answering prize questions gives the player a token

  Adaptability - Questions can be changed to address changing situations or organizational targets. Changes can be made quickly.

Competition - Strategy can be used to place the player at an advantage against other players. Observing other players can help the player gain knowledge that is useful in the game.

These components can set and create the Serious Game environment. The components are chosen to ensure that the individual is immersed in the gaming experience. Choices must be made in order to create the best game for purpose and to ensure that the game can progress to address future challenges and organizational goals.

2.1.5 Summary

The challenge of creating a game that contains all the game components and aspects is difficult. Creating an online video game is ideal for this task, but not practical regarding cost and timetable. For the purposed of this research the prototype of the game will transfer the elements of the online game to a board game. While the game components and elements will be reduced, there will be a level of adaptability that will be available using the board game that would take a great deal of time and effort to change on an online game. There will also be an ability to observe the tests and receive instant feedback during testing. Adjustments can also be made during the testing, if necessary. The artifact will facilitate the creation of an online game at a later time by providing a more appropriate training template by using feedback from pilot testing of the prototype.

Chapter 3
Related Work

The focus of this study is to determine if a Serious Game can be developed to teach Security mitigation skills to individuals in an organization. This study also focuses on the effects of a Serious Game on the ability to motivate individuals to continue engagement with Security training. This chapter is a review of related work assessed that may be extended to create the Serious Game. This review will help us to identify limitations with existing security training methods to address those challenges.

3.1 Addressing Skills training

The article *Cybersecurity Skills Training: An Attacker-Centric Approach* [AM15] takes an attacker-based approach at teaching security concepts. The approach is an attempt to provide skills training by conveying to the individual how an attacker plans and achieves and attack. Attacker-centric training is viewed as a cost-effective approach to provide skills training. The article also points out that taking responsibility for security is necessary to avoid successful attacks [Her14]. This is true for all levels of an organization from employees to leadership. This this approach lacked the evidence from any evaluation method that this type of training would be effective in teaching security mitigation skills.

Mases et al. proposed a ten-step process for evaluating individual skills for simulation training. The goal of their research is to introduce a developed model that includes an integrated competency assessment. The Stenmap achieves this by mapping the various skills into sets where an appropriate scale can be used to measure those skills. The Stenmap was effective in evaluating cyber/technical skills in a game environment. The taxonomy used must be one that can measure more general skills or must be able to be adapted to the skills that are required by the training provider.

Wash and Cooper [WC18] describe an experiment conducted to identify better

ways to train users to more secure decisions. The premise is to provide a story that encompasses all of the lessons that one may find in "facts-and-advice" based training. Individuals must be persuaded to change their behavior and the experiment proposes training to teach the individual on how to make more secure decisions. The experiment also hopes to identify new methods to motivate individuals to make more secure decisions and to help them to understand the decisions they make. This experiment ended inconclusively regarding whether stories or facts were superior in mitigating security breaches. The experiment had an alternate conclusion: Experts had a greater influence of the effectiveness of training that how the information was transferred. This influence could be positive or negative based on the the medium used.

3.2 The use of Motivation in Training

In [GGBF17], it is attempted to apply Serious Games to individuals with low motivation or that lack Security Awareness. The goal is to personalize the security training by introducing practical exercises to improve security behavior [RFE16]. This is in the form of exercises that individuals can use. The article considers how Serious Games can be used to add game concepts to motivate individuals. The study depended on the individuals to already be motivated to learn the subject matter and were close to the same level of knowledge.

Retention is also an important factor in training. To help individuals to retain information, it is important to understand that different individuals require different types of training. The article *Navigating the Great Learning Barrier Reef: Active Training Ideas to Make Learning Fun!* proposes that active training models may make training engaging [BDLS19]. The theory is that if there is more engagement in training, there will be more retention from the training. Making the training "active" is intended to make the individuals motivated to attend and participate in training. The active participation is the key to training retention. This training does explain how active training elements can be used to create training, the design is not used to create a Serious Game.

The article *Sleeping With Their Eyes Open: A Guide to Student Staff Training* [Rit04] attempts to use the concept of active training, training that requires engagement and interaction from the recipient, to create training for a dynamic group of individuals. The two challenges to address were to provide more practical training through hands-on training and to provide training that was engaging to keep individuals motivated to train. The training needed to have a "learner focus" instead of

focusing on completing a curriculum. This design improved the training environment, but it is a challenge to adapt the training to the topics that they individuals would use in the future. This training also not offered as a Serious Game.

In the article *Evaluating Contemporary Digital Awareness Programs for Future Applications within the Cyber Security Social Engineering Domain* reviews various studies that identify that interactive training is superior to traditional training sessions [ASS20]. The review cites the major problem with traditional awareness training is that it is not interactive and dynamic. Further, it adopts a generalized approach to training instead of identifying specific problems individuals face. There are also problem with conducting training in a formal setting. This results in a lack of individual engagement [AH19]. The review finds that traditional training methods fail in tackling real situations. This is a result of the inability for traditional training methods to engage the individual during training.

The chapter *Evaluating Serious Game Trainings* from the book *Serious Games for Enhancing Law Enforcement* suggests that appropriate success criteria must be established beforehand to quantify the acquisition of improvement of knowledge, skills, attitudes or behaviours. The premise is to show the necessary steps that lead to meaningful evaluations and the potential challenges that must considered [BDLS19]. Evaluation elements such as training validation (getting the expected results), comparative evaluations (comparing learning outcomes from different situations), training transferability (can the training be used in various situation and settings) and long-term viability (how long can the training be used before it must be changed) must be considered in evaluations. This training evaluation had positive results, but there were aspects of the training platform that distracted the individuals. This can demotivate an individual towards training.

3.3 Adaptability of Training

In the article *A Review of Using Gaming Technology for Cyber-Security Awareness*, it is stated that the goal is to target awareness training towards user needs [AFSP16]. The belief is that understanding the importance of awareness training, in this case cyber security and information on cyber measures, are limited. Gamification or Serious Games can be employed to support keys areas in Security Awareness training and learning. Serious Games can also be used to evaluate the impact of training. However, issue specific games are not typically found and few of the games art targeted towards the requirements of professional organizations.

The article *Overview of Learning Cybersecurity Through Game Based Systems* attempts to address the challenge of providing skills to individuals from diverse backgrounds [AC]. The paper evaluates various game based learning to identify the strengths and weaknesses of game systems. The goal is to improve the game systems to create an immersive learning experience that provides effective awareness training. The study determines that the game that have multi-player games have the most immersive effects because of their ability to create a competitive atmosphere. Unfortunately, the games lacked the flexibility to satisfy user needs. These games were also limited in their ability to change the subject matter to achieve specific training goals.

The objective of the research in the article *Exploring Game Design for Cybersecurity Training* is to teach individuals cybersecurity skills through gaming beyond the current state of practice [NASJ12]. This means extending security training from its current state to a state where additional topics can be taught to individuals. The premise is that Serious Games can be used to provide an engaging interface that enhances training, entices individuals to train, and simulates training scenarios. This change will help to train the current generation to change the workforce and the next generation to learn the skills necessary to provide the highest level of security and defense against attacks. The game CYberNEXS provided positive results in training, but it was a limited scope of the training it could provide. There was little adaptability to other training topics.

The article *Training and learning for crisis management using a virtual simulation/gaming environment* attempts to design a Crisis Management System (CMS) simulation game. The CMS will create a realistic environment to training Crisis Management professionals in an environment using scenarios and gaming [WGA11]. The simulated environment will bridge the gap between classroom and live simulation. The training will also allow for different training scenarios to be created and for exercises to be run. These scenarios can be run in a safe environment where mistakes can be made without negative consequences. The scenarios must also be tailored to the individuals that will be trained. Less knowledgeable individuals will require higher levels of training. The expense of these games limits the number of scenarios that can be run. There are also concerns with the inability to run the scenarios if a system is not available.

3.4 Summary

There are varying challenges that are planned to be addressed by creating a Serious Game. Our Serious Game will use require skills training to reach the correct level of training that will provide an organization with its requirements. The Serious Game will also match the needs of the individual to perform security tasks aligned with job tasks. Addressing organizational goals will be accomplished by creating a game that is scalable and that is flexible so that the content can be changed or adjusted. The Serious Game must be motivating to the individual without containing elements that may distract the individual from engaging in or continuing the training.

Chapter 4
Methodology

The Methodology chapter explains the steps taken to create a Serious Game artifact using the Design Science Research Method(DSRM). The Design Science Research Method was chosen because it outlines the steps necessary to create an artifact. Each level in the DSRM will explain what each step entailed and what information was included at each step to create the game. The chapter will conclude with a summary of the DSRM process as it was performed.

4.1 Development of a Serious Game to extend Security Awareness Training to Security Skills training

Serious Games have shown promise in stimulating motivation towards training, but have not been directed towards the specific gaps that Security Awareness training has regarding addressing Skills training. Evaluating Serious Games using Bloom Taxonomy, a multi-tiered model of classifying thinking according to six cognitive levels of complexity [For11], can be used to help identify the gaps between learning levels and the subsequent mismatches in training levels and training techniques that many individuals experience with conventional training methods. Bloom Taxonomy can also identify areas where providing a more immersive environment for security training will be beneficial to individuals based on the type of training required at that level. A Serious Game can assist in focusing the necessary level of training that an individual requires by evaluating the individual's skill-level before the training. The Serious Game can also be adjusted by evaluating the individual's training progress towards established organizational goals after the training is completed.

Design Science Research Method framework will be used to outline the activities during the methodology development. This method addresses solving a problem by creating an artifact, in this case a Serious Game, that addresses that problem of Security Skills training. The main purpose of Design Science Research is achieving knowledge and understanding of a problem domain by building and application of a

designed artifact [HMPR04]. The requirement for Security Skills training along with an effective delivery system for the training is the focus of how this development method will be used. *Figure 4.1* shows the steps of the Design Science Research Method. It also shows the goals, inputs and outputs of each step of the process. Each step of the process is dependent on the previous step and provides information required for the subsequent step. The tools used to provide inputs for each step are also provided in the illustration.

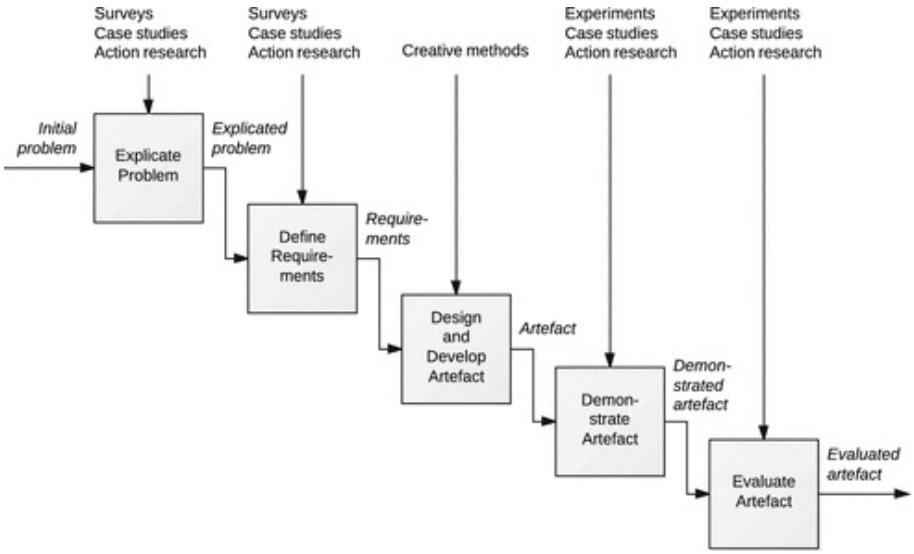

Figure 4.1: Design Science Research Method Illustration

Explicate Problem: The purpose of this step is to state a problem in terms such that it can be solved by establishing requirements that will do so.

Individuals require the skills to address security challenges that are aligned with the goals of an organization. According to research of articles regarding Security Awareness training, this problem is exacerbated by individuals lacking motivation to train. It is clear that typical Security Awareness training does not always address organizational needs or goals. Security Awareness training is also insufficient in providing the skills necessary to address the security threats that arise. These threats will increase in the future. Poor training can lead to organizational security inadequacies, a less then optimal security posture, and subsequently, mistrust by customers and partnership organizations. The goal is to improve Security training to focus on teaching skills targeted to achieve security requirements.

Explicated Problem: Security Training lacks skills training and elements of motivation that will entice individuals to train effectively.

4.2 Define Requirements

The goal of this step is to establish requirements that will be used to create Serious Games mechanics that will enhance Skills training. The Serious Game will teach security mitigation skills and methods. The explicated problem is that security training needs to provide Skills training to individuals and provide motivational components that the training so that individual will train more often. The inflexibility of standard Security Awareness training to adapt to the requirements of the organization will also be addressed. Creating a Serious Game that contains skills components to teach individuals mitigation skills will create a more effective training environment. Involving game aspects that will motivate the individual to engage in the game can motivate individuals to change their attitude towards training engagement time. Increased training can help individuals reach the goals of the organization.
These goals can be achieved by using game dynamics. The challenge is to create a game that will bridge the training gaps between simple security awareness and Security Skills training which teaches security threat mitigation by teaching methods that will mitigate security threats. The Serious Game should also overcome the challenge of creating an environment that motivates the individuals to re-engage in training. This may result in the individual learning additional skills and re-enforcing those skills so that they can be continually applied to mitigating security threats and addressing vulnerabilities.

Defined Requirements - The Serious Game will include four elements: The first element is a *Game Platform*. This is the environment where the game will be played. Game elements that explain the game environment will also be included. There will also be *Game Components* that that will create a game feel in the game environment that will assist in motivating the user to play the game. The game will contain *Training Level goals* so that the training is aligned with the learning levels of Bloom's Taxonomy. Finally, *Organizational goals* will be included in the game in the form of categories and subcategories of training questions to ensure that organizational goals are met.

4.3 Design and Development of the Prototype

The proposed artifact is Serious Game prototype that addresses the shortcomings of Security Awareness training. The artifact has the following requirements explained above:

- Game platform
- Game components
- Training Level goals
- Organizational goals

Serious Games can benefit from being online. The interactive and immersive effects that can be included in online games are superior to that of a board game. Board games create a challenge for introducing some game components to the game. The game will include Mechanics-Dynamics-Aesthetics(M-D-A) elements that explain the game environment mentioned earlier in section 2.1.4. There will also be a challenge in creating the appropriate training levels that an online game could present. The artifact will be developed to reflect aspects of Bloom's Taxonomy to address the Skills training required for the game to advance from awareness towards Skills training. This will be accomplished by including different training levels to the game. The Bloom Taxonomy will also be used to help evaluate the training by identifying the focus areas for evaluation. The artifact will employ Fogg's Model, which will address the challenges of helping motivate individuals towards training. This will be accomplished by increasing training engagement time. Game components will be incorporated into the game to entice the individual by immersing the individual in the game environment. The result is a board game that asks questions at various levels that reflect organizational training goals.

Designed and Developed Serious Game Prototype *Game aspects* will lead to the method how the players will experience the game. The choice of game will be important in determining which game components and characteristics can be included in the game. The choice of a game will also determine the skills and security categories that can be taught and how they can be presented to a player.

The *Platform type* of the game will be a physical game. It will be a *Board game* that has quiz-style questions that can be matched to various skill-training levels. Question categories are connected to organizational security goals. Creating a physical game will also make it possible to access the game without having to be online. This can facilitate using the game more often than traditional awareness training normally allows. This can motivate players to use the game more and expose themselves to more learning opportunities.

4.4 Demonstration of the Serious Game Prototype

As mentioned earlier, the Trivia Board Game is created using Bloom's Taxonomy to address training levels and Fogg's Behavior Model to address motivational factors

connected to the use of the game components in the game environment. The game will be demonstrated and evaluated by functional testing the prototype in a live playing environment. Implementation of the prototype will be performed by running two pilot rounds of the game, which contains game components listed earlier. The Serious Game will reflect the security requirements of an organization based on industry standards. They will reflect the standards for Information Security in the form of the questions created specifically for the game. Elements will be included, where possible, to create an immersive environment for Skills training. The feedback will be received from the players who pilot test the prototype. The pilot test will provide the functional tests that will ensure the game can be evaluated by individuals and that other issues will not interfere with playing the game during the evaluation process. This will result in a artifact that can be evaluated by a second focus group.

Functional Testing of Prototype - The functionality of the game must be pilot tested to ensure that there are no issues with the game components or the flow of the game. Issue with the functionality of the game must be addressed to ensure that there are no obstacles to the player experience. It is important to avoid potential distractions so that the learning experience is not interrupted or disturbed.

Effectiveness of Training: Game Characteristics Testing the main components of the game will be performed through *Functional testing* Functional testing will test the game in a controlled environment to assess functionality and to identify defects. The test will ensure that the game can be played without interruptions and will identify areas for game adjustment.

The Functional testing focus group will include the following test subjects and consist of the following steps:

- Mixture of IT People and Admin people (3-6)
- Functional Testing Steps:
    1. Play game.
    2. Feedback from participants. Separate form.
    3. Game changes and adaptation
    4. Play game for the second time
    5. Game changes to produce Artifact
    6. Results.

The result of the functional testing will be an artifact that is fit for task and Usability testing. Any changes that are necessary to accomplish this goal will be done at the completion of the functional test using feedback from the test subjects.

4.5 Evaluate Artifact

Once the game has gone through Functional testing, it must be tested to ensure that it meets the requirements for providing Skills training to the players. It must also display game characteristics that will motivate the player. *Game testing* will test the game to ensure that it will fulfill the training objectives and to test if the issues that may hinder the training objectives can be identified and addressed. Like Functional testing , the Pilot testing will be performed by playing the game in a controlled environment to ensure the proper use of the game and to address issues that may occur while playing the game.

Evaluating game effectiveness - Once the Functional tests are completed and all functional issues are addressed and corrected as much as possible, an artifact is produced. To test the game to ensure that it meets its objectives, a focus group consisting of a cross-section of individuals will pilot test the artifact in a controlled environment. Each player will be given the opportunity, during the game, to provide feedback regarding how the effectiveness of the training elements can be improved. Each player will also receive an evaluation prior to and after testing the artifact. This information will be used to measure the effects of playing the game for Skills training The evaluation will also be used to evaluate the motivational effects of the game and to determine if the player feels that the game can be used to achieve organizational goals.

Usability testing the game - The artifact is the result of the prototype that has been functional tested by a testing group. A second testing group will evaluate the Serious Game to determine the effectiveness of the artifact with regard to the intended training goals. The Usability testing will include the following test subjects and consist of the following steps:

- Mixture of IT People and Admin people (3-6)
- Usability Testing Process Steps:
    1. Pre-evaluation of Second group of participants
    2. Play game.
    3. Game changes to produce Artifact
    4. Post-evaluation of Second group of participants (3-6)
    5. Feedback from participants. Separate form.

6. Results.

The result of the Usability testing will be an artifact that can be used effectively for Skills training objectives. Each player from the testing group will be evaluated before and after testing the game. The pre-evaluation will be used as a baseline of comparison for the post-evaluation. These two sources will be used to assess the effectiveness of each evaluation area included in the questionnaire.

Evaluation Areas - Under Evaluation Areas, we attempt to answer the following questions: *1) What questions must be asked to determine the game's functionality?* What feedback must be provided by players to determine if the prototype can function as a game. The game must have an objective and rules. It must have a logical consistence so that players can develop a coherent strategy. Player feedback must answer questions regarding demotivating or distracting elements of the game. this will make it possible for those elements to be adjusted or removed from the game. The game components cannot impede on the training process. The game should help facilitate the Skills training process to create the optimal learning environment. *2) Evaluation of Game Usability* This evaluation must answer questions that will help measure if the game provides effective training. The topics of the questions must inquire about effectiveness of the game to teach skills and to motivate the player. Evaluation questions should also inquire whether the game has distracting elements and if the game reaches organizational goals. Receiving information from individual players will help to evaluate the effectiveness of the game to deliver Skills training. The evaluation must ensure that the game questions are clear and appropriate for the level of the information they are meant to convey. The question must also have a balance where they do not cause boredom or frustration. This is a state of immersion that is called Flow. Flow occurs is when high skill level matches high challenge level [Csi14] creating a state where the individuals feel they can react to whatever is presented to them [Nak14]. *3) Is the training fit for purpose for various roles/scenarios?* The game must provide training for individuals from various departments and from various educational backgrounds. It is also important to determine if the game can be used in different training scenarios and continue to be useful for players. The ability to use the game in other training situations would be valuable for an organization because the same format can be leveraged for different situations. This is a more cost-effective method to train individuals. The accessibility of the game is also important to increase game engagement. this level of portability also includes the ability for the game to be used by other industries, cultures and contexts.

Collection of Evaluation Data The evaluation is performed by collecting information from the players. This must be done in a consistent matter so that the information is reliable. There are three methods that will be used to collect and

record data from the players: 1) Questionnaires: the collection of data before(Pre-evaluation) and after(Post-evaluation) playing game will be done using questionnaires. The questionnaires will be collected electronically. The questionnaires will be anonymous. This will help ensure that the players are comfortable answering the questions honestly. 2) Game feedback: the feedback will be collected during the game by taking notes of the questions that are asked by the players. The Game feedback may be used to adjust the game to ensure it provides the best learning experience. Feedback will also be collected through *Talk Aloud Protocol [Lew82]*, which is a method in collecting spontaneous feedback from players as they play the game. Player comments will be noted while the game is played and, when appropriate, used to make adjustments to the game. 3) Game results: the game results and progress during the game will also provide information for evaluating the efficacy of the players to complete the game. Player strategy during the game and the results of the game will also provide information on how the training was received and what results may be expected by using the game for training.

Evaluation results The results of the evaluation tests will show what the effectiveness of the game with respect to the experiences of the individual players. The effectiveness will be measured using methods stated in the Evaluation Areas section and displayed in a manner that will make them clear to an outside observer by interpreting the collected information. Care will be taken to ensure that the surveys measure what is intended and that the measurements are consistent and repeatable. The questions asked of the players are consistent with the research questions that have been asked in this thesis. The measurements will help determine if the Serious Game can be used in the manner intended and can perform the tasks that it is intended to perform with regards to Skills training and providing motivation to train for the individuals involved in the training.

4.6 Summary

The Methodology chapter explains the reason for using Design Science Research Method (DSRM) and what actions were taken during each step to result in the artifact. Each step is necessary in the process of creating, testing and evaluating the Serious Game concept through the design, development and evaluation stages. Each step aligned activities with the game that is proposed. To reach the goal of each step, the proper inputs were made available so that the outputs were produced. This ensured that inputs for each subsequent step is produced. Each step of the methodology connected inputs and outputs contiguously throughout the process to produce the desired goal.

Chapter 5
Artifact: Design, Development and Evaluation

The Artifact chapter explains the motivation behind creating a Serious Game. Section 5.2 discusses Game Features and the various theories and components that contribute to the design and development of the game. Section 5.3 discusses the Description of the game and rules, goals and challenges of the game. This section will also show how the game will be played. Section 5.4 discusses the various parts, roles and physical aspects of the game. Physical components and the design of the game will be included in this section. In section 5.5, we discuss methods used to acquire feedback from Functional testing and evaluation methods used to acquire information from Usability testing. This will help to assess the effectiveness of the training by conducting evaluations during the Usability testing phase. A summary of the chapter is in section 5.6.

5.1 Artifact

The result of the Design Science Research Method(DSRM) will be an artifact that has been Functionality tested and Usability tested. The resulting artifact will contain the game features and other contributions to the game. The motivation for their inclusion will also be discussed. Results of the game and what they mean to the assessment process will be examined.

Motivation As was mentioned in the Introduction chapter, section 1.3, Information Security has become more important in recent years for organizations. There is a constant increase in cyber-attacks all over the world and an increase of losses that they can result in. It is important for individuals to acquire the skills to address security challenges aligned with the goals of an organization. Now security training is limited to Security Awareness training, which provides an overview to individuals of general security threats and vulnerabilities. In many cases, these threats and vulnerabilities may not be specific to security goals or reach the security goals of the organization in question. Security Awareness training that is not adaptable or

that does not address organizational requirements or goals is insufficient in providing the methods and skills necessary to address the security threats that arise and that will continue to increase in the future. This can lead to the organizational security inadequacies, and subsequently, mistrust by customers and partnership organizations. There are also economic costs and fines that can be incurred when security breaches are not properly handled.

5.2 Game Features

The Game Features will contribute to how the game will be designed, how the game will be developed and how the game will be evaluated. They include Serious Games features and how training and evaluation can be accomplished. Components of the game and how the game is played are part of the features of the game. Results of the game and the possible contribution to training must also be examined.

Motivation for creating the game, as discussed in the Introduction chapter, section 1.3, leads to features that are required to reach Skill training goals which align with organizational goals. To address the issues regarding learning gaps organizations experience using conventional Security Awareness training, the Game Features must address the following areas:

The lacking of Security Skills training The game provides a method to provide the player with skills that are difficult to learn with conventional Security Awareness training. *Organizational goals in Security training* The training categories and question categories and subcategories are aligned with organizational goals and industry standards. These categories and subcategories can be changed to meet the needs of the players and to accommodate the changing requirements of an organization. *Training motivation* The game contains components and other game characteristics based on Fogg's Behavior Model that balance the motivation and ability of the player and allow for motivation in the players to be properly triggered. *Adaptability to changing trends in Security* The game allows for the questions to be changed and updated as appropriate. Different subjects and categories can also be included in the game to meet changing requirements. *Evaluating the effectiveness of Skills training* To ensure that the game delivers in the various areas that it is to address, the game effectiveness must be measured and evaluated. This will be achieved by acquiring information from the players in the form of questionnaires before and after playing the game. There will also be formal and informal feedback acquired during and after playing the game.

The proposed solution for addressing motivation is a Serious Game that is a quiz-based journey game. The game will be broken into three levels, each matching the

first three levels of Bloom's Taxonomy. The player can demonstrate knowledge, understanding and application of Security concepts, which align with the first three levels of the Bloom Taxonomy in a game environment. The game will consist of six categories that match organizational security goals. Each category will contain questions that parallel the first three levels of Bloom's Taxonomy. Advancing in the game requires answering questions correctly. Incorrect answers will halt players' advancement during the game. Answering questions at the third level of each topic gives the player a prize. Answering third level questions from each of the topics plus one third level question of the players choice wins the game. While the game can be designed as an online game **see Appendix B**, the proposed artifact for this thesis will be a board game. The board game will address similar game mechanics as the online game:

- Questions must be answered to advance
- Penalties are incurred for answering questions incorrectly
- Prizes are awarded for answering third level questions at the end of each topic
- Collect a prize from each topic to win the game.

Using questions inspired by Bloom's Taxonomy The Bloom Taxonomy will be use to advance the training objectives from simply providing information about security , or awareness, to providing understand and context and finally providing application and skills. The first level of questions (L1) ask questions that test knowledge. These questions will be in the form of "What is" or "True/False" regarding security facts and information. The second level of questions (L2) will challenge the players understanding by using comparisons or understanding the use of tools and devices.The third level of question (L3) will test the player on how the security information can be applied to real-world situation by identifying steps of a process or by identifying proper actions that the player should take.

Fogg's Model game incentive and triggers Motivation of the players is important to the success of the Serious Game. Fogg's Behavior Model suggest that behavior change is a function of motivation, ability and triggers. Since, in some cases, ability and motivation may be lacking, it is important to ensure that the trigger is appropriate to influence the change of behavior. In this case, the trigger will be the game. It will offer the spirit of competition that may both motivate learning and motivate continued use of the game. The game will also be continually triggered by providing the answers to each question as the game continues. Providing answers to the questions will ensure all individuals receive the benefit of the Skills training.

The repetitive nature of the questions in each level and among the various topics will facilitate the player in answering questions as the game continues.
Fogg's Behavior Model contains various means of motivating and triggering motivation based on the ability of the individual. While there are different motivation levels, ability levels and effective triggers, the ones below will be included in the game with the aim of changing the individual behavior. These were mentioned in the Background Chapter, section 2.1.3:

Three Components of Fogg's Behavior Model [Fog09]:

Behavior = Motivation - Ability - Triggers or ***B=(MAT)***

- **Motivation(Motivator pairs)** - *Social Acceptance/Rejection - Behavior* - The players play the game in the spirit of competition.

- **Ability** - *Brain Cycles - Mental efforts required* - The questions are easier at Level 1 than at Level 2 or Level 3. This should allow the player to advance without being bored or overwhelmed by the question level. The Facilitator will also add a level of scaffolding by asking and answering the questions with explanations when necessary.

- **Triggers** - *Triggering* initiates the use of the game and helps to continue the use or reuse of the game. There will be three methods employed.

  Spark - Used to initiate action - Initiating the game

  Competition - Used to stimulate action - The game will set up a competitive atmosphere for the players.

  Facilitator - Used to support lacking of ability - Quiz-master will assist players in strategy and in understanding quiz questions. This allows the facilitator to employ a level of Scaffolding. Scaffolding consists of the controlling elements of the task that are essentially beyond the learner's capacity, thus permitting the him to concentrate upon and complete only those elements that are within his range of competence [Woo76].

Evaluation Methods Evaluating the artifact is essential in determining the effectiveness of the artifact on Skills training. The artifact must also be evaluated for its potential for motivating the individuals that play the game. In addition, adaptability to organizational goals and the potential for adjusting to shifts in security threats and vulnerabilities will be discussed. It is also important to understand how effective

using a Serious Game can be to administer Skills training.
The following methods will be incorporated in the evaluation of the artifact:

- *Effectiveness of Training:* Evaluating the main components of the prototype-/artifact.
- Pre- and Post-test design - A design that has an initial assessment to establish a baseline of information in the form of questionnaires. Allows for direct comparisons between two identical measurements to show any improvement that has occurred by use of the artifact [BDLS19].
- Feedback: Survey - The feedback form received from the players are free-form and request information regarding problems the players encountered with the game and potential improvements that can be made to the game.
- Feedback: Participant observation - Feedback can also be collected during the game. This feedback will be presented in accordance with the Think aloud protocol [Lew82]

Expected Outcomes The Serious Game artifact has been created for two reasons: The first is to create a tool that will train skills that will mitigate security threats. This will be accomplished by creating game questions that build the player's knowledge. The game also uses questions to test the player's existing knowledge. The second reason is to create a game that will motivate the player to continue to play the game. This will be accomplished through the game components that create an immersive environment for the player. The game also includes competitive element that will help trigger the player into continuing the game. The competitive nature may also compel the player to play the game on more occasions. Increased play of the game will lead to increased learning opportunities and can reinforce learned skills.

5.3 Game Components

The *Game Components* are the goals, rules, challenges and interactivity of the game. This game is a board game that has a quiz-component as the challenge to the game. Advancing in the game requires rolling a die, answering questions and collecting pieces. Strategy for collecting pieces faster than the opponent players is also part of the challenge.

Question Categories and sub-categories The types of questions that will be tested in the prototype will be taken from categories that organizations target for

Table 5.1: Security Categories and Sub-categories

Examples: Security Categories and Sub-categories	
Security Category	Security Sub-category
Access	Passwords
Attacks	Phishing
Resilience	Back-up/Storage
Malware	Virus Recognition
Peripherals	External Drives
Physical Security	Assets Protection

Table 1

Table 5.2: Question Levels

Question Levels		
Level 1 Questions: Knowledge	Level 2 Questions: Understanding	Level 3 Questions: Application
Name and Identify	Comparison	Show/Identify steps
Describe Item	Rank Items	Describe Method
Choose from a list	Identify use of Item	Describe proper action

Table 2

inclusion in Security Awareness training. These areas are chosen because they are important to organizational security goals. The questions will be aligned with the learning levels in Bloom's Taxonomy. This will address the progression of learning that is represented by the Bloom Taxonomy hierarchy.

Sample Module Categories and sub-categories. Table 1 shows Example Security categories and sub-categories that can be used in the Serious Game. There can be various sub-categories under each category. Here, one sub-category is represented.

Question Levels - The learning levels represent the first three levels of Bloom's Taxonomy. Each level in **Table 2** shows various security question types for that level. These questions types will represent the respective Security sub-categories that will be part of the Serious Games.

Table 5.3: Example Questions

Example Questions		
Sub-categories	Question Level	Example Questions
Passwords	Level 1	Identity elements of a good password?
	Level 2	What makes a strong password?
	Level 3	Which methods can be used to protect passwords?
Phishing	Level 1	What is the most popular Social Engineering attack?
	Level 2	How does Social Engineering to phishing
	Level 3	Which methods mitigate a phishing attack
Back-up/Storage	Level 1	Name a back-up solution
	Level 2	Compare back-up solutions
	Level 3	How would you use back-up information?
Virus Recognition	Level 1	What do viruses do to a computer
	Level 2	What is the difference between a worm and trojan?
	Level 3	How can you recognize a virus is on your system?
External Drives/Devices	Level 1	What can an external hard drive be used for?
	Level 2	How can you secure an external hard drive?
	Level 3	What can you do to protect and external hard drive
Asset Protection	Level 1	Name a surveillance method
	Level 2	What can you use to secure a laptop in a public place?
	Level 3	What method can be used to secure a server room?

Table 3

Example Questions. Table 3 shows example question from each of the Security sub-categories. Each of the six sub-categories has a question represents each level of Bloom's Taxonomy. listed at each level of Bloom's Taxonomy. These questions will be represented in the Serious Game prototype.

Mechanics-Dynamics-Aesthetics(M-D-A) of the game M-D-A places emphasis on the designer's selection of mechanics to drive the dynamics and aesthetics that are created [PO19].

- *Mechanics*: The main components of the game. Player interaction of the game [HLZ04]. Game mechanics such rules, algorithms, data structures, etc. that are included in the game to support the game environment.
  - Board game - Quiz format
  - Roll die, choose direction to advance
  - Answer questions to collect pieces
  - Collect all the pieces to win the game
- *Dynamics*: Runtime behaviour of the game. Progression of the game's backstory or plot [HLZ04]. What the player of the game sees. They are the inputs and the

reaction to the inputs of the game. Dynamics add to the immersive experience of the game. They are included in the game to help motivate the player to use the game. The goal of immersion is to encourage player time with the game in an effort to help the player retain what is learned.

- The game requires movement
- The game provides a mechanism to control moves(chance)
- The game requires collecting pieces to win
- The game rewards success/penalizes mistakes
- The game allows for interaction between players.

– *Aesthetics*: The desirable emotional responses of the player. The attempts to portray realism in the game [HLZ04]. They can also help ensure that the player will stay engaged in the game by creating an interactive environment to attract the player and keep the player involved [20110].

- The game provides an action the player must take
- The game requires strategy
- The game includes a head-to-head competitive atmosphere

5.4 Game Description

The Game Description explains the type of game, the roles and all mechanisms involved in playing the game. Physical aspects of the game and how to achieve the objective of the game are discussed. The illustrations of the game will also be displayed.

Game Story - Trivia Chase: A learning journey The original plot of the game has the player going on a quest to find a crown. In this version, the player will fill a pie tin by answering questions to acquire pie pieces. Each pie piece represents a Security Knowledge area. Answering one final question correctly wins the game. The question types represent three levels of difficulty represented in Bloom's Taxonomy. The board is traversed by rolling a die, landing on spaces and answering questions represented by the color category and level of the space. Answering questions correctly allow the player to continue rolling the die with additional opportunities for answering questions. Inability of a play to answer a question allows the next player to roll the die to answer a question.

Mechanics/Rules Each player begins on the board on the color that represents his game piece. The order that the players role the die is determined by rolling a die at the beginning of the game and then each player rolls, in turn, starting clockwise from

the first player. The player can move in any direction that he finds advantageous to collecting pie pieces. Questions around the perimeter of the board are Level One(L1) questions with the exception of pie questions. The questions leading to the center of the board are Level Two(L2) questions. All pie questions and the question to win the game is are Level Three(L3). Inability to answer questions passes the die to the next player. Each pie question represents a topic. The last question is from the topic of the players choice.

Game type The game will be played on a physical platform as a board game. There will be 3-6 players competing against each other. The game is a quiz game where answering question correctly will earn the player game pieces that symbolize the player making progress in the game. The game will also be facilitated by a Quiz Master that will ask and answer the questions represented by the space the players land on or choose. The game will be able to be played at any time that players can meet to play the game.

Game board The Game board is split into three levels, each that represents a level of Bloom's Taxonomy. As the player moves around the board, the questions that are asked are chosen by the various levels on the board. **see Figure 5.1**

Each color on the Game board represents a different topic in Information Security. The topics are based on organizational goals for Information Security. **see Figure 5.2**

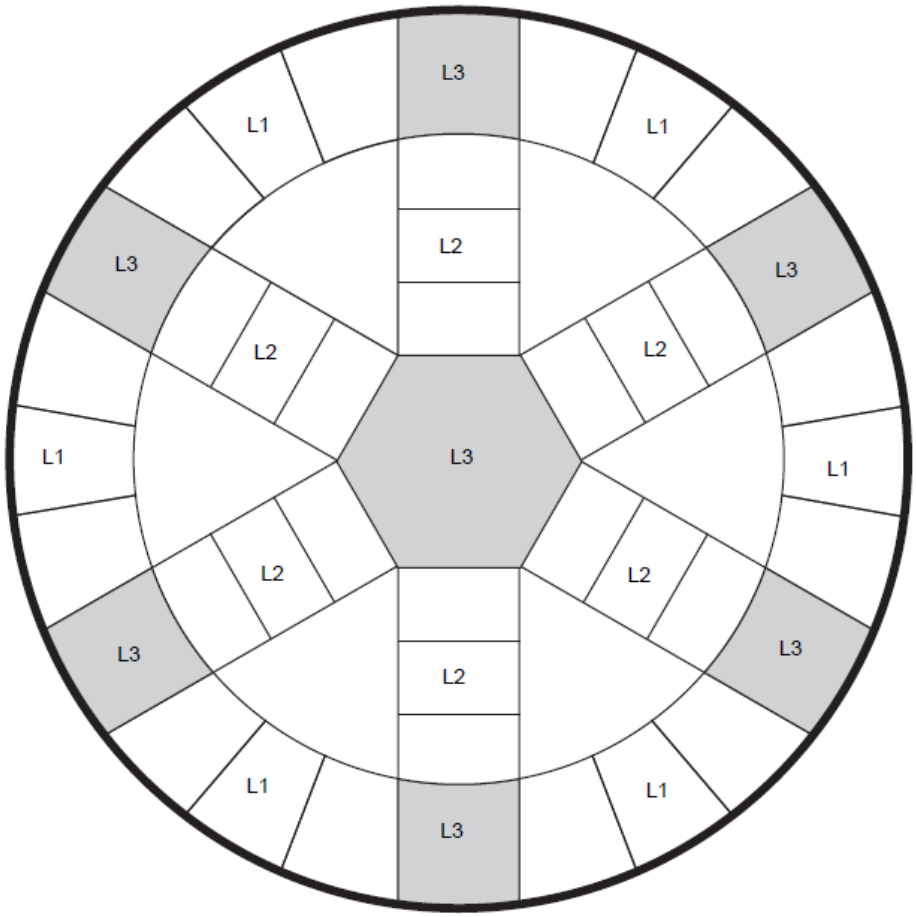

Figure 5.1: Trivia Chase Game Levels

Figure 5.2: Trivia Chase Game Board

5.5 Game Evaluation

The evaluation method used involves asking pre-game evaluation questions, using the artifact and asking post-game evaluation questions. The evaluation will be accomplished by testing in a small group under observation of a facilitator and describing the outcome of the testing.

Functionality Testing - Piloting the Prototype Functionality testing is performed to provide feedback from the players that will be used to adjust the flow of the game. Proper flow ensures that the player will be immersed in the game. It is important that the game components work as intended so that they do not interfere with the Skills training aspects of the game. There are three forms of feedback that will be collected during pilot testing:

- *Formal feedback* - The use of forms to provide information from the players.
- *Informal feedback* - This is provided by direct player feedback during the game.
- *Game results* - How people progress during the game. Game strategy may also provide information regarding the flow of the game.

Artifact Testing Artifact testing is performed to provide feedback from the players that will be used to evaluate the effectiveness of the game in providing the required training. It is important that the game provides the proper Skills training so that organizational training goals are met. There are three forms of feedback that will be collected during Artifact testing:

Pre-evaluation - In addition to background information about the individuals, each individual will be asked questions regarding how effective the current training is, how motivating current training is and how skill the individual is at mitigating security threats.

Game feedback - Information provided by the players during the game. This feedback comes in the form of comments, questions, and strategic moves. The game results will also be used as feedback.

Post-evaluation - After testing the artifact, each individual will be asked questions regarding how effective the game was at providing Security skills training. Each individual will be asked about the effectiveness of the training and how motivated the individual was to continue the training. The individuals will also be asked whether or not they have increased mitigation skills as a result of playing the game. There are three methods to collect data during the Artifact testing phase:

- *Questionnaires* - Pre- and Post game evaluations. Formal evaluations collected electronically and anonymously.
- *Game feedback* - Feedback from players during the game. This includes instructions to the players and comments and game strategy from the players.
- *Game results* Overall feel for the training style and game results for each player. How each player advances can be considered a de facto test. If learning objectives are aligned with game goals, game performance can play a role to assess player learning [HS15].

5.6 Summary

This chapter explained the motivation behind creating a Serious Game to address gaps in Security Training. We also discussed how theories and components contributed to the design and the development of a Serious Game that can be used for Skills training. The Serious Game is described along with the rules, goals and challenges of the game. This chapter also explained how the game is played. In addition, the various parts, roles and physical aspects of the game are described. The design of the game was also described in this section. Finally, methods used to acquire feedback from functional testing and methods used to acquire information for assessing the effectiveness of the training through Usability testing were discussed.

Chapter 6
Results

In this chapter the Research Questions are answered using the results of the Functional testing of the prototype, Usability testing of the artifact and the results of playing the game. Observation of the testing will also be used as feedback to answer the Research Questions. Changes to the prototype and artifact during the course of testing and the results of those changes will be discussed.

Section 6.1 will show the results of the feedback and player evaluations that are the outcome of Functional testing and Usability testing the game. Formal and informal game feedback and game results are also discussed. Section 6.2 revisits the research questions and to what extent they are answered by feedback and evaluations of playing the game.

6.1 Results

This section shows the results of both the Functional testing and the Usability testing of the game. Feedback will be collected during and after the game is tested and evaluated. The outcome of the game will be used to evaluate the effectiveness of the game.

Functional testing feedback -The first focus group of players were asked to list the changes that should be made to make the game more functional. While the feedback mentions that the game was "fun" and "good" there are some areas where the players thought the game should be adjusted to add a game show dynamic. Much of the feedback concerned the question content and how the questions were asked during the game. The actual game aesthetics and dynamics received little criticism.

- *Expansion of question areas* - Handling of Security incidents was mentioned as one of the areas that should have been included. Sadly, the game does contain

that type of Skills training, but it was reached only once during the rounds of this particular test.

- *Making questions more context specific* - The questions are meant not to be generic, but they can only be so specific. The questions can be tailored to be specific to each organization. Two different organizations were used for the testing. Adjustments were made to align the game with the organization that performed the Usability testing.
- *Question simplicity* - Requests were made to make the questions less difficult. One feedback suggestion was to employ more multiple choice questions. This would make the questions easier, but would defeat the purpose of the questions that are meant to teach skills and methods. There was also feedback regarding some of the lower level questions not being able to be applied to some of the higher level areas areas. The game is designed to do so, but playing limited rounds of the game will not provide that effect. Achieving that request could be done by limiting the topics or by playing the game more often.

Usability testing results -The Evaluation testers were asked to list the changes that should be made to make the learning elements of the game more effective. Evaluations were distributed to this focus group both before and after playing the game. The feedback mentions that the game was "fun" and "enjoyable" and there were some areas where the players thought the game should be adjusted. much of the feedback concerned the questions asked during the game. The actual game aesthetics and dynamics received little criticism.

- *Usability testing Pre-questionnaire* - The Pre-questionnaire begins with personal information of the player. These include three questions. **Figure 6.1** depicts the Age Group of the players. Two of the players were between 45-54 years old. Only one player was above age 54. **Figure 6.2**, the technical knowledge of the players is charted. No players had technical backgrounds. **Figure 6.3** displays how many of the players have had on-line security training. Each of the players have had on-line security training. Each of the personal information questions had a pull-down menu where the answer/answer range could be chosen. The remaining Pre-evaluation questions regard the effectiveness of Security training in its present form. Motivation towards training and ability to handle threats are also asked. The final question regards the player's attitude towards Games. Gaming and Gamification. We used Likert Scale (1 to 10) to measure ... Each question has a 1-10 rating: 1 is worst, 10 is best. **Table 6.1** contains these eight questions and each of their ratings.
- *Game feedback* - Feedback during the game came in the form of Think aloud protocol [Lew82].

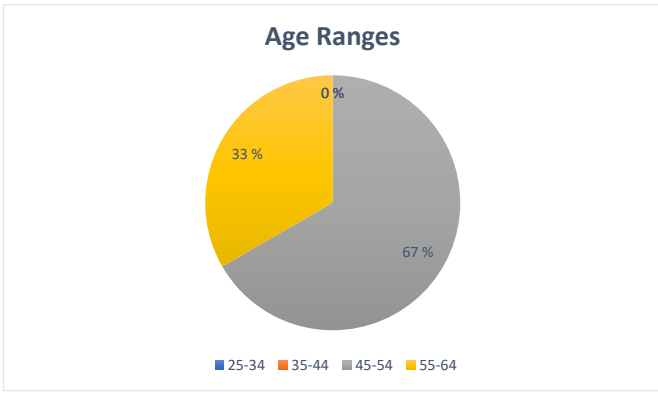

Figure 6.1: Age Ranges of players

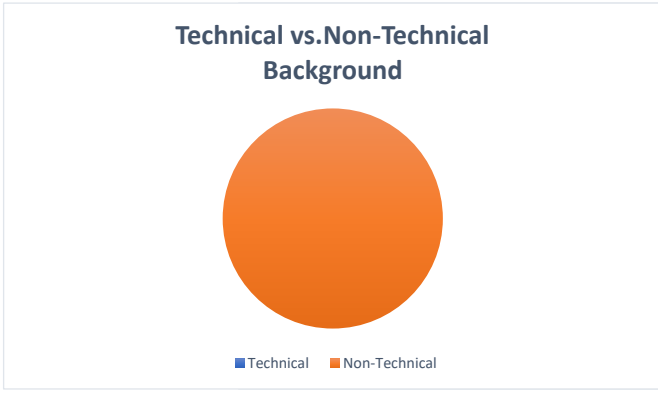

Figure 6.2: Technical vs. Non-Technical Background

Figure 6.3: Online Training vs. No Online Training

Pre-Evaluation Questions	Score									
	1	2	3	4	5	6	7	8	9	10
Rate the overall effectiveness of Security Awareness} training.		1			2					
Rate how effective Awareness training is on providing Security Information.					2		1			
Rate how effective Awareness training is on providing tools for handling Security threats.		1		1	1					
Rate how motivated you are to take part in Security Awareness training.	1	1	1							
Rate how motivated you are to complete Security Awareness training.	1		2							
Rate your knowledge of Information Security.	1				1	1				
Rate your ability to handle Security threats.		1	1	1						
What is your attitude towards Games/Gaming/Gamification?		2						8	9	

Table 6.1 Likert Scale

- **Think aloud protocol** - Think aloud protocol was employed to capture the comment of the players to have live feedback during the game. This information is supplemented by the game results. The comments were recorded and are displayed in **Figure 6.4**.

  Many of the comments are positive towards the game. Others stated what players didn't know or wanted to know in the future. A few comments mentioned the game dynamics and how the players were affected. Still other comments regarded game strategy and what should be done to have the best chance to win the game. Most players agreed that there were areas that were important to learn more about regarding security.

– *Game results* - The Evaluation testers played rounds of the game until completion. The winner of the game answered six Level 3 questions plus an additional

Figure 6.4: Talk aloud protocol responses

question of choice. At the end of each game, none of the other players had answered fewer than three Level 3 questions. Although previous knowledge of security assisted the player in winning, player strategy and chance kept the game competitive.

– *Usability testing Post-questionnaire* - The Post-questionnaire begins with the six questions in **Table 6.2**, which rate the effectiveness of the game for providing information and skills training. These question are rated on a Likert Scale from 1 - 10. **Table 6.3** contains questions regarding the how the game affected player motivation and how well the game affected learning. These question provided pre-determined choices for the player. **Table 6.4** has six questions. Three questions are concerned with the game environment and the effects on the player. The final three question regard adaptability of the game for organizational goals and other training situations. There is also a question

Post-Evaluation Questions	Score									
	1	2	3	4	5	6	7	8	9	10
Rate how effective the game was in providing knowledge of Security facts.								1	1	1
Rate how effective the game was in providing knowledge of Security methods.									2	1
Rate how effective the game was in teaching skills to handle Security events.								2	1	
Rate your knowledge of Information Security after playing the game.							2	1		
Rate how your ability to handle Security threats after playing the game.							1	1	1	
Rate how effective the game was in motivating you to learn.							1	1	1	

Table 6.2 Likert Scale

Post-Evaluation Questions	Choices			
	Game Questions	Game Competition	Game Mechanics	Other
Which components in the game did you find motivating?	2	3	0	1
Which components in the game did you find demotivating?	0	0	0	0
Which elements of the game did you find most effective to learning?	2	0	1	1
Which elements of the game did you find least effective to learning?	0	0	1	0

Table 6.3

Post-Evaluation Questions	Choices	
	Yes	No
Did you have a positive experience with the game?	3	0
Did you find the game environment immersive?	2	0
Did you find the game components a distraction?	0	3
Do you feel that this game will meet organizational goals	3	0
Do you believe that the game is adaptable to other situations?	3	0
Would you invite others to play this game?	3	0

Table 6.4

regarding the player's desire to play the game again.

6.2 Research Questions

This sections discusses to what extent the Research Questions have been answered. The information from the feedback and evaluations will be used to determine if the components used in the prototype design result in an artifact that can address the questions that have been posed.

1. *How can Serious Games be used to address the shortcomings of traditional Security Awareness Training?*

   The Serious Game artifact provided questions and answers that addressed security mitigation methods. This is an extension of Security Awareness training where skills training is addressed. The categories of the game also aligned with

Security Awareness organizational standards. The Serious Game introduces three learning levels. The first level of questions require security awareness knowledge. It also provides scaffolding for the second level by providing security topics. The second level provides understanding of the security concepts. It also provides scaffolding to the third level by describing how security tools can be used. The third-level is Skills training that addresses security mitigation skills and methods. The security mitigation methods were fact-based and tailored to training requirements for the individual.

Based on the feedback from the Usability testing, most players believe that the game is appropriate for Skills training. The players rated the game in the top 90% in providing knowledge of security methods and in the top 80% in teaching skills for handling security events. This is compared to below 40% the players reported with conventional Security Awareness training.

The Usability testing also revealed that the game components contributed to Skills training. These game components Mechanics, Dynamics and Aesthetics create an environment that the individual experiences while playing the game. The Game Mechanics added to the game strategy and the competitive atmosphere of the game. Game Dynamics; rolling the die, moving around the board and collecting pieces helped to create an immersive atmosphere that motivated players to continue playing the game. The Aesthetics of the game; bright colors, use of a pie pieces and a pie tin to collect the pieces and using a three-sided die piqued interesting in the game which also lead to the immersive atmosphere of a game. Answering questions to progress in the game and the competitive nature of the game promoted player focus on Skills training. Individual training requirements are met by the game facilitator reading the questions and answers aloud to all players. The training is complemented by the repetitive nature of the questions throughout the categories. The categories could also be adjusted to meet the requirements of the organization.

The board game created for this experiment shows that Bloom's Taxonomy can be used to identify the Skills level required to mitigate threats. The extended Bloom Taxonomy provides action words to the learning levels. The action words were helpful in ensuring the correct type of question could be asked. They also ensured that the individual understood how to perform tasks and use proper mitigation methods. A Serious Game that uses this approach can be effective.

2. *How can Serious Games be used to increase the motivation of individuals to learn security skills?*

   The design of the Serious Game has been completed with game components included. The game components include motivation factors, ability factors and triggers. Motivation factors include the multi-player competitive nature of the game. Ability factors include the mental effort required to answer the questions of the game and to use the best strategy to collect pie pieces. Triggers such as having a facilitator ask questions, read answers, and explain the rules and strategy of the game initiated the play of the game and help with the continuation of the game. The game components create an immersive environment and the balance of motivation and ability create Flow, which enhances the learning environment. The individual does not require prior knowledge of security to learn security skills. These factors ensure that the game information will be accepted by individuals and that individuals will receive training that matches their ability level. This will reduce distractions caused by frustration.

   The feedback from the Usability testing suggests most players believe that the game is motivational. The players rated the game 100% in this area. This is compared to only 20% rating for motivation towards Security Awareness training. Just over 20% are motivated to complete Security Awareness training. The quiz-like style and the competitive nature of the game was also motivating for the players. The immersive nature of the game created a flow that helped to make players forget that they were in a training exercise.

   The Usability testing also revealed that particular game elements contributed to behavior changes in the players. Players had positive experiences with the game and would invite others to play. Effectiveness of the training and the game components have made using the game as a training tool more attractive to the players.

3. *How can we evaluate the effectiveness of the training*

   Evaluating Skills training, motivation and adaptability were important for testing the Serious Game. Questions had to be specific to the area that was investigated. The feedback during prototype testing was collected during and after the prototype testing rounds were completed. The prototype was adjusted according to that feedback. The evaluation investigated skills that the player gained while training, motivation the player experienced while playing and motivation to play the game at a future time. How well the game could meet other organizational goals and the adaptability and portability of the game

were also the focus of the evaluation.

There were two types of game evaluation that were used for the Serious Game: Functional testing and Usability testing. Functional testing tested the prototype to ensure that it was viable for use as game. This was necessary to ensure that using the game for training purposes was not hindered by the Mechanics, Dynamics or Aesthetics of the game (M-D-A). The feedback returned after the pilot testing was used to determine how the game was adjusted. Much of the adjustment was to the training portions of the game and not the actual game dynamics.

Usability testing was accomplished by using survey questionnaires to collect information about the players experience with the training. The information from the questionnaires helped determine if the game was effective in providing Skills training. The game components were evaluated to determine if they contributed or detracted from the learning experience. The game was also evaluated for how it could be used for and adapted to organizational requirements. The surveys were conducted online. They could have been conducted manually using paper questionnaires without any loss of integrity.

A pre-evaluation and post-evaluation of the Serious Game was used to gauge the player's learning progress. The Serious Game outcome also provided an indication of a player's progression. The pre- and post- evaluation questionnaires helped identify specific areas of interest regarding the success and failure of the Serious Game to achieve its goals. The evaluation questionnaires also made it possible to compare the individuals' knowledge and motivation before and after playing the game. This gave a clear indication of the improvements that were made in both areas.

6.3 Summation

The purpose of a Serious Game is to provide training, in this case, by using a quiz format based on security. The game components are meant to compel the player to continue playing by using motivational cues. The cues were identified using Fogg's Behavior Model. A game that incorporates competition, rewards and challenges helps to immerse the player in a game experience. Immersion in the game was the key to motivating the player to continue playing the game. Immersion also creates Flow, which helps with player confidence, and thus, player achievement. This game was successful in motivating players to continue to play the game. The players were also interested in playing the game at a later time and would invite others to play the game. *The Functional test*, the test of the prototype for game functionality,

was successful without making extensive changes to the game. The questions were adjusted for brevity and so more of them would allow for short answers, but the game functionality remained the same. *The Usability test* tested the effectiveness of the game. In-game feedback was recorded and the comment "we have a different process for this", which concerned incident reporting, stood out as the greatest critique. The adaptability of the game would make it possible to tailor the game to organization's policies.

The Pre- and Post game questionnaire were helpful to compare the knowledge, attitude and motivation towards training. The Pre-evaluation was used to create a baseline that the Post-evaluation could be measured against. The players evaluated the game as effective.

A Serious Game was successful in creating a learning environment that provided effective training and that motivated the individual to continue training. Progress in these areas was measured qualitatively by using pre-evaluation and post evaluation questionnaires to collect information. The players reported an increase in knowledge and skills. Feedback during the games was also useful towards refining the game to make it more effective for providing training.

Chapter 7
Discussion & Conclusion

7.1 Discussion

Security is a value to organizations. Protecting information and preserving reputation are among the most valuable outcomes of having sound security. Sadly, many individuals do not feel the same about their own private security. There are few individuals that have proper malware control on their private computers and fewer still that have a back-up solution. There is a disconnect between the values of the organization and the values of the individuals that are part of the organization. I have discovered that with the conflict in values between individuals and organizations, learning Security skills as a byproduct of other activities is beneficial to both the individual and the organization. In this case, the delivery system is a Serious Game. Learning can be the main objective without being the main focus. Individuals remember the game, but they benefit from the training portion of the game almost subconsciously. This can be attributed to the immersive aspects of the game.

Another outcome of the game was that individuals showed a great deal of prior knowledge regarding security. Organizational focus on security is already having an effect on individual behavior. There was also a high level of players sharing game strategy during the more competitive moments of the game. Players began to cheer for other players as the game progressed. There were some distractions regarding the game questions being in English for people that spoke English as a second language. This was corrected by explaining the questions more clearly. The game was designed so that many of the question from one level made it easier to answer questions from another level. It was not expected that this type of cross-referencing would result in effective cross-referencing across different categories. This included questions at various levels in the various categories.

There were issues with some of the game rules. One evaluation stated that too much of the strategy was determined by chance. I discovered that the introduction of chance to the game kept the game competitive for players that were not as familiar

with the subject matter. The game was effective as a Skills training tool and it motivated players to continue playing. Still, it was treated as a game with all of the expected competition that games provide. It was also clear that individuals realized that they required more security training based on the questions and answers they heard during the game. This level of self-assessment happened despite the individual not having been asked the question.

7.2 Conclusion

The Serious Game addressed the shortcomings of Security Awareness training to provide Skills training that help individuals mitigate security risks. These shortcomings also caused Security Awareness training to fail in meeting organizational security goals. The Serious Game addressed the challenges that Security Awareness training suffers in motivating individuals to learn and to continue training. Security Awareness training does not meet the specific needs of individuals to learn security skills that align with their responsibilities. The extent to which the game could be evaluated for functionality and effectiveness were also examined.

The purpose of the thesis was to create a Serious Game that could address the issues that typical Security Awareness training does not address. The Serious Game contained elements that address Skills training for the individual and motivation for the individual to continue training. Bloom's Taxonomy was incorporated in the game to identify the level of training require and how the training at that level could be addressed. Fogg's Behavior Model was employed to identify motivation aspects that are connected to game components. Motivation was identified as a function of attitude change, in this case, towards security and security training. Attitude change is an important factor that leads to behavior change. The evaluations showed that individuals exhibited an attitude change towards Security training because of the game.

The process of creating the Serious Game is presented in previous chapters. The research and theories that contributed to the game development are discussed and the methodology for development is presented in a structured format. The overview of the game and its components are discussed in detail and the results of testing the game are presented. A discussion of the game and findings, limitations an future work are also summarized

In this study, we examined if a Serious Game can be used to teach skills. A board game was used as the prototype . This changed the triggers and the manner by which facilitation of the game was accomplished. The players showed significant increases in skills and motivation to play the game. This was shown by comparisons between the pre- and post game evaluations. There were significant changes in player-attitude to security training. Competition between players and the game components made the game compelling for the players. The players felt that the game was effective in training and in motivating the players to continue playing.

It has been demonstrated that Skills training can be conducted by using a Serious Game. It has also been demonstrated that Serious Games motivate individuals to continue playing the game. The Serious Game provides additional opportunities for individuals to learn and the learning is more dynamic. The game would benefit from the addition of game elements. A board game contains some elements, but more "hands-on" opportunities, like completing a security task, could help the learning process. The game would improve by including additional audio and visual cues and prompts that could help the player. There is also room for more coordinated cross-referencing between question categories. This would give more depth to learning structure for the players.

Creating the Serious Game as an online adventure game, as originally conceived, would have allowed for more game components to be included in the game. This would have created a more dynamic game with more types of learning vectors. The board game simply allowed the player to answer questions, so the questions had to address the various teaching targets and training levels for the game. The examination of the prototype was run during the COVID-19 pandemic. This was problematic because of the limited resources available to test the game. Using more focus groups would have provided more data points to use in the evaluation of the prototype. The additional data may have been helpful in developing the game and the diversity of the data may have helped adapt the game to a wider range of players. The Functional testing was conducted over Zoom Video Communications technology. The game was successful, but some of the aesthetics of the game were lost.

This game can be used in real-world situations outside of learning security skills. There are other work situations where the game could help players learn about their jobs and tasks. There are also areas of education where this game would be helpful. A quiz game can be compared to using flash cards for studying. If there are different categories of the same general topics the game quickly lends itself to this scenario. The game can also be used to train people in managerial situations. Managerial training would call for the use of the higher levels of the Bloom Taxonomy. The game could be extended to include those levels or a new edition of the game could be created that only contain the levels that meet the target requirements.

7.3 Future Work

There are several areas where this examination of Serious Games can be expanded for Skills training, motivation and evaluation. An online experience will provide the opportunity to expand the reach of the game to a wider audience. A wider audience can provide more diverse access to feedback that will help continually improve the game. A wider audience can also help the game to be quickly adapted to organizational goals and requirements by providing more information for helping to adjust the focus of the topics.

An online game will also allow for more game components to be added to the game that cannot be added to a board game. Adding game components can add to a more immersive experience for the player. Online games can provide the player with increased opportunity to access to the game and allow for increased adaptability on how the game can be played and updated. This will allow a player access to the game when it is most convenient, and therefore, provide more opportunities to use the game.

The development of a Serious Game can also be expanded by extending it to more focus groups. Using more focus groups and collecting feedback from those groups makes it possible to understand the needs of the individual users across other job disciplines and backgrounds. Since the game is meant to be adaptive, using more focus groups will help to create a game that will address various organizational goals. These include related skill areas that may lay adjacent to Security Training. The feedback can also help create a better game experience for the players.

The use of more focus groups or expanding the size of the focus groups will also give the opportunity to use more quantitative methods to evaluate the game. Limitations with access to prototype and artifact testers made it necessary to take a qualitative approach to evaluations. Increasing the participants and extending the testing to an increased number of rounds over a longer period of time would have provided data for more quantitative techniques. In addition, there would have been an opportunity to test for information retention as part of the evaluation.

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Chapter A
Appendix A

Game Design Document Outline

A.1 Title Page

A.1.1 Game Name: Vision Quest: The Search for the Crown(s) of Knowledge

A.1.2 Game Overview:

The game begins in a town/tavern where the player answers questions in order to collect credits to go on the journey. The more credits that are collected, the easier the journey can be. There are several questions that need to be answered correctly for the player to advance. This means that the player may have to go back several times in order to collect enough points to embark on the quest. The prototype quest continues up a mountain. The easiest path to the top of the mountain is achieved by a series of test that are also different types of question formats. Finally, the quest ends in a castle where the crown can be found. Clues are revealed as a result of completing challenges. Find the crown and the player becomes the "king" of that challenge. The crown is a badge that the player keeps. There are different modules that will follow the same stages with question on a different discipline. All start from the Town/Tavern.
The character avatars can be different: Men, Women, etc. but all have the same power. Only a player's knowledge differentiates him from other players. Collecting crowns makes the player the master of the discipline. Collecting all crowns makes the player The Master of the Universe... of Vision Quest.
Each of the three levels of the quest represents a different level of knowledge. Questions on subsequent levels are worth more points. Score is kept for each player. Each level is self-contained, so failing in Level 3 does not send the player back to Level 1 right away.

A.1.3 Game Concept:

The game is intended for people who work using IT systems in their work or leisure to learn security mitigation skills.

A.1.4 Genre:

Serious Game, Survival Game

A.1.5 Target Audience:

The game is intended for people who work using IT systems in their work or leisure.

A.1.6 Pedagogical objective(s):

Teaching Information Security concepts and skills.

A.1.7 Game Flow Summary – Prototype

- First screen – Town/Tavern at a table where questions are asked to the player that is embarking on the quest. The questions are based on a security discipline for that module

  If the user answers 80% of the questions, he receives 80 credits. More correct answers, more credits.

  If the player does not answer 80% of the questions. He must begin with the questions again. There will be different questions each time, but the same level.

  Upon completion, the player leaves the tavern and heads to a mountain

- Second screen – Mountain climb: The player tries to find the safest passage by answer questions correctly.

  Correct answers take the player along the path of least resistance. The player uses fewer credits.

  It is possible to use credits to bypass questions, but this method is more expensive than answering the questions. It is not possible to bypass all questions with credits.

  The player must complete eight passage questions to reach the top of the mountain.

  The questions are timed. Excess time use costs credits.

If the player fails, the player can go back to the first level to earn more money or remain on the same level and try again with different level-appropriate questions.

Safe passage up the mountain leads the player to a castle at the top of the mountain. A crown can be found in the mountain. The goal of the quest.

If the player does not complete this level, player can choose to return to the beginning of the same level or return to the first level to earn more credits.

Two failures require the user to return to the first level.

– Third screen – Castle: While in the castle, the player is required to complete tasks that will test the player's skill level.

Completion of the tasks allow the user to go for room to room in search of the crown

Failure to complete the task requires a loss of credits.

Theplayer is required to complete 80% of the tasks in order to get to the crown room.

The tasks are timed. Excessive time costs credits.

The crown room has three doors. One has the crown. If t

he crown is found, the player earns the crown as a medal for that area.

If the player fails, like above, the player can go back to the beginning of the level.

Two failures require the player to return to the previous level.

A.1.8 Look and Feel

The look and feel should give the player that belief that the player is making physical progress. Movement, walking, climbing, etc. should be visible. Background music would be important. If the player pays for a "tip" at one of the levels, there should be a visible indicator to request a tip or to see what the tip is. The timer should be visible. Progress sounds and failure sounds should also be apparent.

A.1.9 How does the game insert itself in a pedagogical scenario?

The game will give the player knowledge of security in Level 1. Level 2 will test the understanding of that knowledge by asking question that only a player that understands underlying concepts can answer. The question will be presented in a style to test understanding of the concept. Level 3 will require the player to apply the knowledge and understanding of the concepts to perform specific tasks. These will require "hands-on" answering of questions. The layout can be simple, but the player must feel a level of immersion.

A.2 Gameplay and Mechanics

A.2.1 Gameplay

The plot of the game has the player going on a quest to find a crown. The method that the player uses to find the crown is by answering questions in various forms based on the game level to traverse the different areas of the quest. Answering questions correctly earns the player credits that can be used along the quest. Completing the three levels earns the player a medal. Inability to answer questions in a level sets the player back.

Mechanics The player game will answer questions and collect credits. In the first level, the player does not have to move. The player simply answers questions that assess knowledge. This level is the base of the various quests. Each quest represents a knowledge topic. The second and third levels require movement, for example up a mountain to a castle or a room search. The player will apply his knowledge to traverse the terrain in question. Inability to answer questions or perform tasks will set the player back to the beginning of levels or ultimately, to lose levels.

At each level there must be a method to cycle questions. This will make it possible for the player to go through the quest several times and answer questions that are similar, but not the same. Question types must be matched appropriately to the challenge where the question is asked. Example: If an option must be chosen, there could be a True/False question.

Although the prototype will only have one quest, the complete game will have as many as seven quests. Each of the quests will be related to a different security area. At the end of conquering all areas, the player will receive a reward. Examples of potential quests: Tavern Mountain Castle

- Tavern –> Boat –> Island
- Tavern –> Cave –> Treasure grotto
- Tavern –> Forest –> Clearing
- Tavern –> Desert –> Oasis
- Tavern –> Canyon –> Secret Sanctuary
- Tavern –> Wilderness –> Fort, etc.

A.2.2 Game Options

The primary game option is to answer questions to acquire credits. The credits will help the player traverse the obstacles in the quest. There are options to use credits in order to receive tips that will help answer questions, but the tips are more expensive than simply answering the questions. Eighty percent of the questions/tasks must be answered/performed for the player to advance at each level of the quest. The credits collected reflect the player's score.

A.2.3 Learning objective

The level of skills training that the game will provide is the primary objective. The game should also help to change security behavior by triggering a motivation to learn through actions in the game. Using the game to increase the contact time in the learning modules will assist with the change in attitude towards security training and lead to behavioral changes.

The primary problem is creating a game that will be immersive enough to keep the attention of the player. The player must believe the goals in the game to be valuable enough to continue. The player must also find that the game is challenging enough to be interesting, but not so challenging that if will cause frustration. The medals and prizes must also seem worthy enough to acquire.

4. Story, Setting and Character 4.1. Story and Narrative- The player is a traveler on a quest for a crown. The player does not have much to reach his goal other than what he can gain by using his knowledge and skills. The player will begin in a town/tavern where he chooses his quest. The player we be told that he can embark on a quest IFF he can answer the required amount of questions. Answering the proper amount of questions will allow the player to proceed with the quest and acquire credits for his travels. Each quest will have its own challenges. The quest will require the player to answer questions or perform tasks to continue. The player will acquire credits for correct answers, which can be used to further the quest. Failure to answer the question or perform tasks within the time limits will send the player back to the beginning of each level. Two failures on the same level will require the player to return to the previous level. Finding the crown completes the quest and the player earns in badge. If all of the badges are earned, the player receives a prize. 4.2. Game World – The game can be an adventure world. The player will be asked to climb mountains, brave seas, explore caves, etc. to reach each level, collect credits and to find the crown. Finding all crowns will result in a prize. Answering questions provides the solution to the challenges at each level.

A.3 Characters

While the avatars can be different, it is only the knowledge of the player, both previous and gained, separates him from other players. Any available avatar can be chosen. Although only one avatar can be chosen, teams are allowed.

A.4 Levels

A.4.1 Levels

Each level is a training level.

- **Level 1** for each quest begins in the Town/Tavern and branches into each quest; The nature of each quest is determined by the topic of the module.
- **Level 2** of each quest is usually a movement from the tavern to some end destination. For example, the prototype quest will be to climb a mountain to a castle. Answering questions allows the player safe passage up the mountain. The questions will be stated on each obstacle and the correct answer provides passage. Wrong answers are penalized with no passage. Eighty percent of questions must be answered within the allotted time. Tips can be bought with credits that will provide hints to answers.
- **Level 3** is in the castle at the top of the mountain. The player can check rooms and hiding places by performing tasks. Correct answers allow rooms and hiding places to be entered. Wrong answers lose credits. Each task has a time limit. Tips can be purchase. In each level, a failure requires the player to repeat a level. Three failures at the same level causes a player to go down a level.

A.4.2 Training Level

A.4.3 Level 1:

Questions to test knowledge. Question can take the form:

- Choose the correct answer from a list
- Choose several from a list
- Match items from one list to another
- True or False

A.4.4 Level 2:

Question to test understanding. Question take the form:

- Comparison of Items
- Ranking of items
- Describing the use/misuse of an item

A.4.5 Level 3:

Questions to test the ability to solve problems. Application. Questions take the form:

- Show/Identify steps
- Create and item
- Identify the proper action(s)
- Identify the proper process

A.5 Assessment

How are the knowledge/competencies developed in the game tested?

- Pre-testing of players before starting the game

  This can also be achieved in Level 1 of the game
- Reporting of the questions answer correctly during each level

  The amount of time used for each level can be used as a weight factor.

  The amount of points at the end of each level can also be assessed.
- Post-game testing

  This can also be achieved by using the final level score as the test criteria.

A.6 Interface

A.6.1 The characters and the quest areas and the information required for each screen should display all needed information. This includes:

- Narrative information regarding quest/quest choices

– Questions and question values/clock

– Indication of correct/incorrect answer and count

– Earned credits and any badges earned

– Level

– Leaderboards/Character name(optional)

Care should be taken not to make the screen appear too cluttered.

Control System

Player should be able to click on answers, tips, and any available menu. The ability to slide questions to answers or to order or reorder answer will also be helpful. Pausing the game or any decisions that need to be made about how to progress should also be command driven on-screen. Pausing the game should not be possible while a question is being timed.

A.6.2 Audio, music, sound effects

These elements should be included where possible:

– Pleasant background music

– Music that adds suspense for nearing a goal or time limit

– Appropriate sounds for correct/incorrect answers

– Success music for goal achievement

A.6.3 Help System

Frequently Asked Questions (FAQs) These can be developed as feedback from the prototype game is completed.

Chapter B
Appendix B

This chapter will describe the requirements for the creation of a Serious Game as a delivery method for skills training. The first section will define the game requirements. The second section will describe the components of the game and how they will contribute to the feel and goals of the game. The following section will incorporate the components of the game into the framework of the game prototype.

B.1 Game Layout and Creation

The levels of the game with be based on Bloom's Taxonomy. Each game level will reflect the ability that each player has. This will assist in evaluating each players skill level by testing they players knowledge at each level.

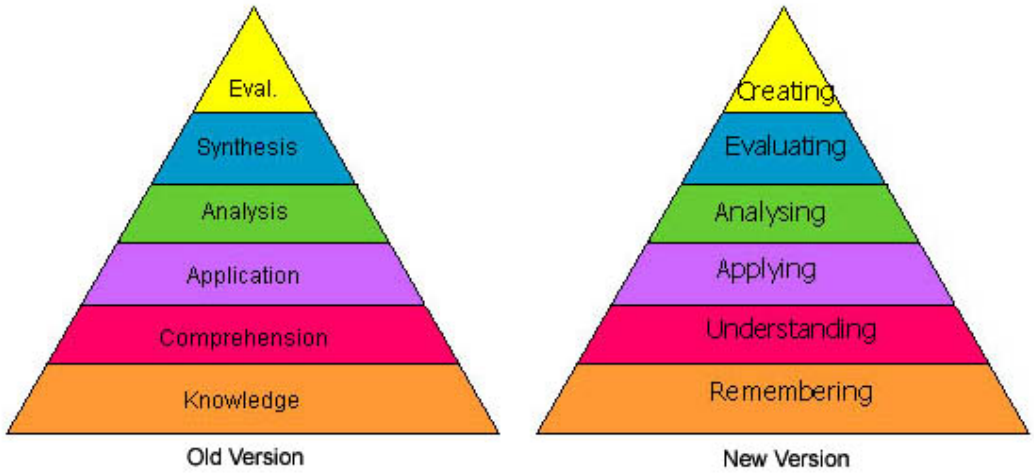

Figure B.1: Bloom Taxonomy Illustration

- *Level One - Knowledge* Basic information about security.

  Facts

  Categories

  Theories

  Ex: List security elements

- *Level Two - Comprehension* Understanding Security Elements.

  Comparison

  Interpretation

  Organization

  Ex. Show similarities between or differences between Security elements.

- *Level Three - Application* Problem-solving using security concepts.

  Rules

  Solutions

  Techniques

  Ex: Actions that will cause or prevent security events

- *Level Four - Analysis* Creating lists of steps or procedures for performing security tasks.

  Deconstruction

  Relationships

  Cause/Effect

  Ex: List methods for performing security tasks. Support the use of those methods.

- *Level Five - Synthesis* Combining elements to form one security concept.

  Comparison

  Interpretation

  Organization

  Ex. How would you mitigate a security breach? Explain your approach.

- *Level Six - Evaluation* Making judgments. Evaluations of decisions.

  Balancing

  Identifying

  Weighing

Ex: What is the best method of security mitigation for a specific event and why? [For11]

While all six levels in the Bloom Taxonomy is represented here, only the first three levels will be part of the game prototype. These will contain all of the basic skills that the end-user will be expected to perform.

B.2 Game Topics and Evaluation Questions

There are a number of questions that will be a part to the Serious Games. Similar question must also be in the pre- and post-evaluation to evaluate the effectiveness of the game. The questions will be broken down into topics where each topic will have a type of question asked based on the Bloom Taxonomy. Each topic will have questions that are consistent with the three levels to which the player can advance. Each topic will be expressed as a module.

Topic Areas - Areas of Security Focus

- *Access* - Entry to the system environment.
  - File access
  - Multi-factor Authentication
  - Password
  - User-types, Accounts
- *Attacks* - Exploitation of vulnerabilities.
  - Denial of Service
  - Phishing
  - Social Engineering
  - SPAM
- *Physical Security*
  - Access Cards
  - Asset Storage
  - Entryways
  - Locking Mechanisms
- *Security Mitigation* -
  - Encryption
  - Firewalls
  - Virtual Private Network
  - Virus Control
  - Updates

- *Computer/Connectivity* -
    - Backup and Storage
    - Connected Systems/Collateral Access
    - Hubs
    - Internet/Intranet/Clouds
    - Locking assets
    - Maintenance Systems
    - Public Plugin
    - Screen Protection
- *Peripherals*
    - Cards
    - Charging Devices
    - External Hard drives/Memory Sticks
    - Printers
- *Malware*
    - Crypto locker
    - Denial of Service
    - Trojan Horses
    - Worms
    - Locking assets
    - Maintenance Systems
    - Public Plugin
    - Screen Protection

Topics	Example	What is it	What it does	How to do it
Access	Passwords	Q-Level1	Q-Level2	Q-Level3
Attacks	Phishing	Q-Level1	Q-Level2	Q-Level3
Computers/Connectivity	Hubs	Q-Level1	Q-Level2	Q-Level3
Malware	Crypto-Locker	Q-Level1	Q-Level2	Q-Level3
Peripherals	Memory Sticks	Q-Level1	Q-Level2	Q-Level3
Physical Security	Doors	Q-Level1	Q-Level2	Q-Level3
Security Mitigation	VPN	Q-Level1	Q-Level2	Q-Level3

Creating a module for each topic and creating levels in each module will make a chain that leads from knowledge level of each topic to skill level in each topic. Since

not all areas of each topic has a skill component that must be taught to end-users, not all Information Security topics will be included in the game. We have chosen specific topics and skills below.

Topics	Example	Knowledge	Process	Actions
Access	Passwords	Q-Level1	Q-Level2	Q-Level3
Attacks	Social Engineering	Q-Level1	Q-Level2	Q-Level3
Computers/Connectivity	Back-up/Storage	Q-Level1	Q-Level2	Q-Level3
Malware	Crypto-Locker	Q-Level1	Q-Level2	Q-Level3
Peripherals	External Drives	Q-Level1	Q-Level2	Q-Level3
Physical Security	Asset Storage	Q-Level1	Q-Level2	Q-Level3
Security Mitigation	Virus Control	Q-Level1	Q-Level2	Q-Level3

Level1 Questions will be questions that test player knowledge of a topic. Level2 Questions will ask the player to identify a process connected to each topic, which builds on the knowledge of the topic. Level3 Questions will ask the player to perform a task that will either complete a task or avoid a task from being completed that may harm a system. Performance of each task will be evaluated. Each topic will contain an explanation of why each of the examples is important to the player to provide motivation for the user to learn the skills necessary to protect the example from each topic. These topics are aligned with Organizational Policies and security issues.

Sample Module Topics from Each Security Area

- *Access*

  Chosen Topic - Passwords

- *Attacks*

  Chosen Topic - Social Engineering Recognition

- *Computer/Connectivity*

  Chosen Topic - Back-up/Storage

- *Malware*

  Chosen Topic - Malware Recognition

– *Peripherals*

Chosen Topic - External Drives

– *Physical Security*

Chosen Topic - Asset Storage

– *Security Mitigation*

Chosen Topic - Virus Control

– **Sample Questions for Each Module type representing each training level**

– *Passwords*

Level1 - Identify elements of a good password?

Level2 - Which password of the following choices is best?

Level3 - How would you create a good password?

– *Social Engineering*

Level1 - Why is Social Engineering Successful

Level2 - How does Social Engineering compare to Phishing?

Level3 - How would you check for a Social Engineering attack?

– *Back-up/Storage*

Level1 - List reasons to back up information.

Level2 - Compare back-up solutions.

Level3 - How would you use backed up information to recover from a system crash.

– *Malware Recognition*

Level1 - What can malware do to a computer system?

Level2 - What is the difference between a worm and a Trojan.

Level3 - How can your recognize malware on your system?

– *External Drives*

Level1 - List the uses for external drives

Level2 - What are the risks of using external drives vs. system drives.

Level3 - What are the methods of an external drive?

– *Asset Storage*

Level1 - Which are the best methods to store a computer?

Level2 - When should a Kensington lock be used?

Level3 - What is the best method to store a computer that is left in an office?

– *Virus Control*

Level1 - What steps can you take to control viruses on your system?

Level2 - How could your organize your defense strategy for Defense in Depth?

Level3 - What steps can you take when you discover a virus on your computer?

Each topic above represents a module that will be a part of one of the seven Security areas. Each topic will be represented by three levels that are associated with Bloom's Taxonomy.

– **Question types** -the style of questions from each level

– *Level1 Question types* - Questions to test knowledge.

-Choose one from a list

-Choose several from a list

-Match items from one list to another

– *Level2 Question types* - Questions to test understanding.

-Comparison of items

-Ranking of items

-Describe the use of an item

– *Level3 Question types* - Questions that test the ability to solve problems using processes.

-Show/Identify steps

-Create an item

-Identify proper actions(s)

The various questions styles will be created to match the type and level of learning outcome expected at each of the classification levels

- **S-A-V-I Elements**[Rit04] [McR05]

- *Somatic* - Tactical Learning
  - "clickable" items
  - Movement options
  - Choices/Options for progress through modules
  - Activity-based learning
  - Physical manipulated components
  - Building models or processes
- *Auditory* - Learning by hearing and response
  - Spoken instructions
  - Spoken explanations
  - Background music, Toned correct/incorrect answers
  - Storytelling by digital means
  - Use of mnemonic devices
  - Group-work when possible
- *Visual* Learning through pictures, observing and notes.
  - Simulated environment
  - Animated questions and answers
  - Visual correct and incorrect answer indicators/results
  - Real-world examples
  - Analogies
  - Observations
- *Intellectual* - Learning by problem solving
  - Allow for construction of processes
  - Allow for problem-solving steps
  - Allow for the re-ordering of items

Applying new ideas to real life

Problem-solving exercises

Analysis