SERIOUS GAME DEVELOPMENT METHODOLOGY WITH SYSTEM AND HUMAN ORIENTED APPROACH

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ABSTRACT

SERIOUS GAME DEVELOPMENT METHODOLOGY WITH SYSTEM AND HUMAN ORIENTED APPROACH

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Serious games are on the rise as a new and motivating education and training method. This rise is being supported by serious games' ability to address individuals of all ages from many sectors. Although the game and education industries have established standards based on lessons learned, this is lacking for serious games. Considering the hybrid nature, it can be seen that there are many possible approaches for designing and developing serious games. It is possible to take elements form both simulation as well as game development approach. When available resources on development are examined, an invisible divide can be observed between design approaches. While one side of this division follows a functional system approach, the other side adopts a human motivational oriented approach. This study is designed around the research question if these two approaches can be combined. In order to answer this question, best practices and expert opinions are evaluated, similarities and differences between them are analysed by presenting different approaches. Aim of this thesis is to introduce a new serious game development methodology that covers game, system and people-oriented approaches. In order to understand the real life application of this methodology case studies were used for verification and validation. In addition, this study aims to provide a guide for serious game developers, which includes definitions, best practices, common problems and development processes. This study will be a significant endeavour to provide critical

guidance for serious game developers and provide methods of improvements to a growing sector's development process.

Keywords: Serious Game Design, Development Methodology, Human Oriented Design, System Design Approach.

ÖZ

SİSTEM YAKLAŞIMLI VE İNSAN ODAKLI CİDDİ OYUN GELİŞTİRME METODOLOJİSİ

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Bir yandan oyun tasarım yaklaşımı izlerken diğer yandan simülasyon yaklaşımı izlemek mümkündür. Ancak salt ciddi oyun yaklaşımı hala yabancı bir kavramdır. Ciddi oyun geliştirme üzerine mevcut kaynaklar incelendiğinde, tasarım yaklaşımları arasında "görünmeyen bir bölünme" ile karşılaşılmaktadır. Bu bölünmenin bir tarafı fonksiyonel sistem yaklaşımı izlerken diğer tarafı insan motivasyonları odaklı bir yaklaşım benimsemektedir. Bu çalışma kapsamında en iyi uygulamalar ve uzman görüşleri değerlendirilmekte, mevcut farklı yaklaşımlar ortaya konarak, aralarındaki benzerlikler ve farklılıklar analiz edilmektedir. Bu tez, oyun tasarımı, sistem ve insan odaklı yaklaşımları kapsayan yeni bir ciddi oyun geliştirme metodolojisi ortaya koymaktadır. Bu tezin amacı, oyun tasarımını, sistem ve insan odaklı yaklaşımları kapsayan yeni bir ciddi oyun geliştirme metodolojisi sunmaktır. Metodolojinin gerçek hayattaki uygulamamasının daha iyi anlaşılması için vaka çalışmaları ile geliştirilen metodolojinin doğrulama ve geçerlemesi yapılmıştır. Bu çalışma, ciddi oyun geliştiricileri için ciddi oyun tanımlarını, en iyi uygulamaları, ortak geliştirme sorunlarını ve geliştirme süreçlerini içeren bir rehber sunmayı amaçlamaktadır. Bu çalışma, ciddi oyun geliştiricileri için kritik rehberlik sağlamak ve büyümekte olan bir sektörün gelişim sürecine iyileştirme yöntemleri sağlamak için önemli bir çaba olacaktır.

Anahtar Kelimeler: Ciddi Oyunlar, Geliştirme Metodolojisi, İnsan ve Sistem Odaklı Geliştirme

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LIST OF ABBREVIATIONS

AAA	Blockbuster Video Game
ARR	After Action Review
C-IED	Counter Improvised Explosive Device
DTTC	Defense and Technology Training Centre
FOMO	Fear of Losing Out
GDD	Game Design Document
IED	Improvised Explosive Device
ILS	Integrated Logistic Support
LAN	Local Area Network
MoD	Ministry of Defense
NATO	North Atlantic Treaty Organization
SAS	System Analysis and Studies Panel
SAS	Systems Analysis and Studies
SG	Serious Game
SME	Subject Matter Expert
STO	Science and Technology Organization
UI	User Interface
USDP	Unified Software Development Process
USGDM	Unified Serious Game Development Methodology
USP	Unique Selling Point
VR	Virtual Reality

CHAPTER 1

INTRODUCTION

- Game developers are the wizards of our age -

Games are as old as history of humanity. The oldest toy dates back 4,500 years ago. We have been playing games since we existed. Our earliest education starts in the form of childhood games. Games and toys help us learn the society, its culture, our roles and the use of our motor functions. Therefore, we can argue all games are educational. It is just we leave learning by playing in our childhood as we move towards formal education and on the job training in adulthood. Serious game concept argues the "gamer" in us never leaves us as well as the child inside us never dies. How else do we explain our irresistible attraction towards bubble wraps, silly pyjamas and the phenomena of adult cartoons. There aren't many differences between games and serious games. Serious games are educational tools that are very specifically defined for a target audience with clear learning objectives that incorporates a game. While games are systems of entertainment with a side effect of learning, serious game are learning tools that uses entarmient as a motivator. Serious games can be used for any subject and for any target audience, as long as they are developed correctly.

The success of the serious game resides in its design and a good design only works if its development is implemented correctly. Good game is simply a game that is entertaining. Good serious game is both entertaining and educational. Achieving this balance is no easy task and trying to build a framework around this concept is challenging to say the least. Games are only limited by imagination. Therefore, it is no surprise that there aren't many concrete development methodologies for game development. Most of the methodology tends to focus on the project development process. Nevertheless, serious games are not just limited with imagination; costs, time, space, target audience and learning outcomes poses design constraints on

serious games. While developing a serious game it is very easy to get lost in the game design, educational goals, system and/or target audience limitations.

There are two main ways to develop serious games. First way is the gamification method. In this method game requires nothing more than the mind of the person yet the imagination can be supported with boards, artworks, icons, tokens as well as miniature figures. Second way of development is the digitalized games. These are the games exist in the virtual realm and are intertwined with software development.

Serious games are on the rise as a new and motivating education and training method. This rise is being supported by serious games' ability to address individuals of all ages from many sectors. Although the game and education industries have established standards based on lessons learned, this is lacking for serious games. Considering the hybrid nature, it can be seen that there are many possible approaches for designing and developing serious games. It is possible to take elements form both simulation as well as game development approach. When available resources on development are examined, an invisible divide can be observed between design approaches. While one side of this division follows a functional system approach, the other side adopts a human motivational oriented approach. This thesis has six chapters. The first chapter focuses on literature review regarding game and serious game development. The second chapter focuses on identification and classification of serious games. Further, discussion about diffracting simulation, games and serious games will be made under this chapter. The third chapter focuses on understanding serious games. The chapter will start with the historical analysis of serious games thereafter serious game component will be analysed and discussion about diffracting simulation and games from serious games will be considered under this chapter. In the fourth chapter the thesis will put forth a unifed serious game development methodology. The proposed methodology relies on system engineering approach for functional design framework. While method uses behavioral economics approach to provide guidance for behavior oriented design. In addition, this chapter analyses quality measuring method for game aspect of serious game systems. The fifth chapter focuses on application case studies of the development methodology. One of the case studies analyses the application of small scale serious game in agile building approach while other case focuses on mammoth development approach for a larger

serious game project. In the final and sixth chapter the thesis will summarize and conclude the study.

CHAPTER 2

LITERATURE REVIEW

In order to understand serious game development, we have to start with analyzing game development. Serious games need to encompass a fully development game with all the entertainment qualities. Otherwise serious games miss it purpose of being entraining educational tool. This is why the literature review starts with game design and development process to set the foundation for serious game development methodology study.

2.1 Game Design Process

Before the software development process, game design document (Callele, 2005, 243) is prepared. Following the GDD functional, visual and audio media development plans are developed (Walfisz, 2006, 495). These plans are then subjugated to requirements analysis. Requirements are used to design the software architecture and software design document (Callele, 2005, 243). During this time post-development quality assurance plan and project plan, (Callele, 2005, 243) with delivery deadlines are planed (Walfisz, 2006, 496).

There are five main components of GDD. The framework sets the boundaries and scope of the game. While gameflow sets the pace or the rhythm of the game, control interface determines how the user interacts with the game. The story brings all the game elements together and creates a justifiable narrative around the game. Finally, the game character becomes the personification of the player in the game reality and establishes the connection between the player and the game. The goal of the design process is to create a harmonious and balanced interaction of all the components in a meaningful and creative way.

2.1.1 The Design Framework

The main purpose of the design document is to designate the boundaries for the designers. While the game is designed, tries to create content that can achieve immersion. When the results of the third Nordic conference on human and computer interaction are examined, it shows that when the user finds immersion in the game world, they emotionally surrender to the game and experience variety of feelings (Niklas et al., 2004, 342-343). The most important requirement of the game should be which emotional experience is planned for the player during the game (Callele, 2006, 299). A fun game is not necessary equal to the feeling of happiness. Similar to movies, genres like horror, comedy and adventure are all valid themes for game designs. Therefore, the aim of the game should not just be to provide happiness but it should be to provide entrainment. The game designer must be able to create emotions such as happiness, relaxation, anger, fear, frustration (Niklas et al. 2004, 344), tension, distress and success (Callele, 2006, 302).

The game design process consists of two main parts. These are; the recycling and the innovative section. In the recycling section, design tools used in similar type of games are used as identical. In the innovative section unique selling point is designed for the game (Hagen, 2007, 24). By doing this the minimum expectations of the gamers are met and heuristic experience of past games are utilized to the maximum and at the same time game gains a unique selling point (USP) and provides a new gaming experience for the players.

With regards to serious games, players have become accustomed to certain game mechanics, features and dynamics. Particularly some game genres have certain game elements that are fixed and accepted by all players. Therefore, the players have developed specific criteria towards for games. Unless these criteria are met the game can be considered as incomplete or "not good". Thus, it is important to use previous games as a benchmark and recycle the key elements and the creative focus should be shifted towards developing the educational content and the USP.

2.1.2 Gameflow

Gameflow is key in shaping the pace of the game; therefore, the state of feeling of the player. Designing gameflow can be challenging. If the gameflow is designed to include complex decision-making processes or situations in which players must react quickly, it has been found out that the player has difficulty remembering the in-game knowledge at a later stage (Gerling, 2012, 239). This is an important design note for serious games; the game element should avoid putting too much cognitive stress on the user. Another useful tip for creating community around the game is to leave deliberate information gaps that hinders the gameflow. Therefore, compelling users share strategies, tactics, maps and secret information with each other. From the serious game perspective creating a community enables users to share their educational knowledge and motivation with each other (Koivisto, 2003, 10). There are few design methods that help to ground this process. These methods are as follows;

- Differential Effect. Skills and items possessed at the start of the game should possess average quality. However, these items and skills should be simple and unusable with respect to items and skills acquired towards the end of the game.

- Hedonic Treadmill. Design of the game flow should convince the user that he will be happy when he achieves the next goal, but when the player achieves the goal, his happiness must go back to the base level and focus on the next goal.

- The Illusion of Progress. Is observed that users are more likely to complete progress if some progress is already made. In a case, it was found out that users are more likely to complete the remaining 10 stamps when the first two of the 12 stamped award cards were stamped (Lewis et al., 2012, 173-176).

- Sunk Cost Fallacy. It is argued that as the time and effort that players have spent on a game increases, it becomes harder for the player to let go of that game. This logic dictates, in such games main aim should be to design the game in such a way that the time and expense that the user spends in-game should be maximized.

- Approaching Target. User should always be shown a clear target, and every action should make the user that he is getting closer to this goal. Conditioning, using rewards to condition the user towards specific actions. In-game build-up and character levelling system creates a sense sense of progress that is moving towards to the target (Chris Lewis et al., 2012, 173-176).

- Rewards and Achievements. It can be used to manipulate the gameflow. There are various types of rewards and achievements. In-game currency is one of the most basic examples. Collectables objects can be collected during the game. However, these objects have contribution to the progress of the game or to its ending. Purchasable currency, they are usually tokens or coins that can be bought by real money or that can be earned in a small number. These type of currency can be spend on specific gains and status. There are many other resources provided in addition to a type of currency, wood and stone that can be used in construction for example (Chris Lewis et al., 2012, 173-176). Other in-game items can be crafted or found as, rare or special items that provides social status. Such items create a reason for users to communicate with each other. It is also provid motivation for users to gain sociak status. Crafting specific items from the necessary resources compels user to spend in-game time collecting recourses (Koivisto, 2003, 10).

2.1.3 User Control Interface

The control interface provides the main link between the game mechanics and the player (Gerling, 2012, 237). This connection is made with control devices such as keyboard and mouse. The control interface can be selected according to user, training and inventory requirements. When games are examined, the control functions are

tried to be simplified. In this regard, one of the most important considerations when designing the control interface is that the user should be able to learns to controls without difficultly, and that they should not lose time learning the basic controls.

2.1.4 Story

One of the most important aspects of the game design process is the story. An entraining and engaging story makes it possible for the user to forget the reality and let he/she fall into the flow of the story. The story provides context for the results, events and problems reflected by the game. The narration provides meaning to the users' actions within the game and story helps connect the player more closely to other players or to the game world (Koivisto, 2003, 9). Stories can vary depending on the lessons and characteristics of the game. There is no one right way to write a good story. However, through the use of storyboards it is possible to create non-functional requirements such as story flow, aesthetic and continuity (Callele, 2006, 250).

2.1.5 Game Characters

The mechanics, characteristics and representation style of the avatar representing the player has great importance in terms of creating the user's connection to the game. In a way this character mirrors the player and becomes its virtual representation in the game world; thus, creating a virtual-self. The ability to personalize the character allows the user to reflect his/her social personality (identity) and strengthens immersion to the game. In the same way, when the player is allowed to choose the skills and abilities of the character, users have been observed to form a natural connection and possession towards the character (Koivisto, 2003, 4-8).

In multiplayer systems, the ability for characters to communicate with each other is important for establishing a social system. There are three main communication methods during in-game sessions; Written, spoken and gestures. Gestures can be pre-determined and can be active through the interface for quick reaction and communication. Spoken communication requires additional infrastructure but recently there has been many developments for all-in-one voice and text chat systems for gamers. It is cost effective to utilize such systems then to develop a new one. There are five different written communication types; (I) General/regional: all

players in a specific region can see and join the chat. (II) Screaming: All players in a particular perimeter (including the enemy) can hear the conversation. (III) Dialog: all players in the immediate vicinity can hear the talk (including enemies). (IV) Whispering: Occurs between very short distance, or secret chat between two players (Koivisto, 2003, 4-8). (V) Group talk: Only users in a certain group can communicate.

2.2 Game Development Process

When development processes of digital game development companies are examined it is observed that agile development without detailed game design documents process is followed. This iterative process heavily relies on prototypes for improvements. Prototypes are played by stakeholders and beta testers who are gamers and their feedbacks are used for further development. This agile prototype driven development is useful for assuring the quality and the playability of the game. But it is also easy to lost track of the development plan and could lead to version dragging (Walfisz, 2006, 493). The functional requirements never stop and it becomes nearly impossible to freeze development to produce a release version. In order to solve this problem version based ten-day cycle method is being adopted. The spirit cycle has been chosen as ten days. This number was justified as two working weeks. It was believed one week was too short to develop enough functions for a new version (Walfisz, 2006, 493). Then day cycle method is as follows:

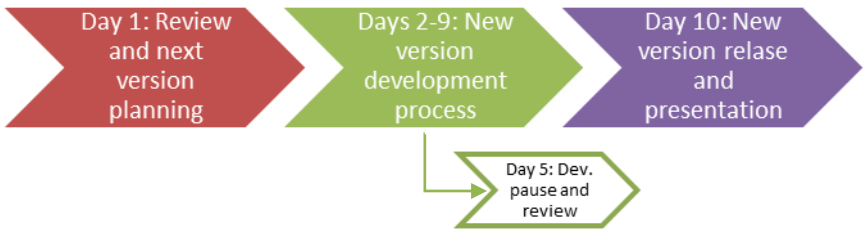

Figure 1 10-Day Cycle

At beginning of the ten-day cycle review and next version planning takes place. First day meeting consists of four individual meetings. General project meeting evaluation of the progress is conducted by every member of the development team. Designer

presents the latest version, from the customer and end-user perspective. Feedback is used to decide the next functions. Team leaders and project manager meet to assign the priority and development order of the new functions for the next version. Design, visual arts, sound and software development teams separate conduct the priority order of the functions of the next version is performed. Internal meetings start with evaluating the complication rates of the previous task. If any task is incomplete the reasons for it is investigated. Following, the new design is reviewed for creating a schedule based on priority for new functions and development is made. Team leaders and project manager meet for the final decisions for the next version. Each responsible party makes a presentation on what they will be able to do for the next version. Coordination for inter-team co-operation is discussed and deliver requirements is clarified in this meeting. After this final meeting project manager writes a report about the proceedings and decisions.

Between the second and the ninth days' development progress is conducted. In day 5, development is paused review is conducted by team leaders and project manager. The progress in the current cycle is discussed. Each team leader makes evaluation on their team's situation. Especially reality of pervious assumptions in the 10th day plan is evaluated. Finally, requirement for mid cycle change are discussed. On the tenth day a version is released. Team leaders make a presentation to the project manager on the completed tasks (Walfisz, 2006, 493).

2.3 Serious Game Design

Preparation of game design documents and software development process are two key elements of serious game development process. One of the major problems faced with using game design patterns for serious games design process is that game design documents are limited to the conventional methods. This adds to the difficulty of the designing process. In order to overcome this problem high level design aspects of the document can be adopted as a framework. High level design elements include: User experience (Gameplay and rules), tasks (Level designs), story, menu and interface flow chart

Once the high level design is completed rapid prototyping process should start to compensate for the lack of detail. It is possible to test the success and quality of the thoughts in the game design document only by the prototype creation method (Neil, 2012, 2-3). Following section will analyse design document templates for further guidance.

2.3.1 Serious Game Design Document

Design document starts with the summary of the Game & Properties of the Game. In the overview section most designers summarize the main elements of the game and important topics in this section, in some cases, targets and objectives are added to form boundaries during development. This section is followed by game experience, assumptions and limitations. Game experience points out the important aspects of the game and the expectations set forth by these points. Assumptions and constraints help point out the technical and/or business assumptions and limitations of the game (Salazar, 2012, 82-84). Next section focuses on targeted platforms. Under this section which systems and technical features of the game will be used are identified (Salazar, 2012, 82-84). Following sections usually include player characteristics and their preferences as a target audience as well as game elements and key gameplay design (Kapp, 2018). Documents are usually followed by game mechanics, control interfaces, interaction rules and goals. The literature defines goals as mission, quest, level design, challenges and rewards

Sections above can be categorized as game features. These sections state functions, supporting elements, and/or the characteristics of the game. For example, in chess, the movements of the stones and the game line are the game mechanics. The game feature is, that there are two sets, one is black, the other is white, and the pawns are more worthless than the other ones. The game dynamic is determined by the balance and representation of the game elements. In order to track user progress, successes and achievements data collection needs are determined in this section. Graphic interface is the method in which the game represents itself. Finally, sound and music aesthetics requirements determine what users should perceive with their audio and visual senses.

2.4 Serious Games Development Process

The game aspect is one of the most important parts of serious games. In addition to game development processes serious games also has; cooperation with subject matter experts, pedagogical and educational goals, cost reducing development action plans and the analysis of non-functional recruitments (Callele, et al., 2005, 249).

2.4.1 Story in Serious Games

In serious games, stories are used to provides opportunities for learning from others, retrospective evaluation, re-enactment, sampling and inquiring. The use of stories in the educational setting provides information about serious game's, physical, emotional and time context. Moreover, it also helps to set up the profile of the main and supporting characters in the game. In addition, the story plays an active role in convincing the user to the importance of the game conflict and recruits the user for the cause (Dickey, 2006, 248-260).

In games cut scenes and cinematics are usually utilized for the storytelling. Usually such cinematics heavily rely on animations. Visual elements and animations development requires a separate team and expertise; therefore, it can impose quite a bit of stress on the budget. For this reason, quality of the animation can be restricted or alternative story telling methods can be used. Although, if the delivery method and consistency of the story is poor, it is most likely the story will fail to deliver its message (Dickey, 2006, 248-260).

As mentioned in the previous chapters, there is no one way to create a good story. However, Christopher Volger (2010), in his book titled "The Writer's Journey: Mythic Structure for Writers" mentions hero's twelve-step journey which can be used as guide while developing a story. Steps are as follows:

- First step is ordinary world where the heroes exist before the adventure. This setting is important for us to learn critical details about the hero's personality and the world. This ordinary time is important to anchor the hero as a human. Thus, making it easier to identify with him and empathize with his ordeal.

- Second step is *Call to Adventure* when the hero receives a call to action. It can be a major treat or a simple phone call. However, the call to action is received it disrupts the comfort of the hero's ordinary world and presents an adventure.

- Third step is *Refusal of the Call* at first the hero might all together refuse the call or he might have fears that need overcoming. This refusal could lead to hero to suffer somehow. This refusal and wanting to stay in the comfort of home would also be our own response and help the user to form a bond with the reluctant hero.

- Fourth step is *Meeting the Mentor*, in this turning point hero receives a guidance form a mentor. It would be powerful object, critical information, and training or help hero through his inner journey. Mentor dispels hero's doubts and fears and prepares him for the adventure.

- Fifth step is *Crossing the Threshold;* the hero embarks on his physical, spiritual or emotional adventure. Finally, hero crosses the threshold between the ordinary world to the adventure world. This crossing could be leaving home or doing something he has been scared of to do before. Threshold presents hero's commitment to his journey.

- Sixth step is *Tests, Allies, Enemies*, adventure starts and hero is faced with challenges that test him. Obstacles present it in the forms of physical hurdles or people. Hero needs to overcome these challenges towards an ultimate goal. Hero meets allies and enemies and in constant struggle for who can be trusted and who can't. Each person the hero meets in his own way; help prepare him for the future challenges yet to come. During this stage hero uses his skills, powers and minds to solve problems, while helps us gain deeper insight into his character and help us identify with him even more.

- Seventh step is *Approach to the Inmost* Cave, can sometimes be an actual location with extreme danger or it could be a metaphor for the biggest

conflict hero will face. Before entering or facing the inmost cave hero has another strike of doubts and fears. At this stage hero might reflect upon his journey and the challenges he might face in the rest of the adventure. This brief hesitation can help the audience understand the magnitude the conflict and create tension in anticipation.

- Eighth step is *Ordeal*; it could be a dangerous physical test or a deep emotional crisis. It is a life or death situation or a metaphor for such a struggle. Hero needs to use all of his past experiences to overcome this problem. Falling means dead or end of life as he knows it.

- Ninth step is *Reward (Seizing the Sword)*, after defeating the enemy and surviving the ordeal or overcoming the personal challenge hero emerges as a stronger person often with a reward. This prize could be a power object, secret knowledge or insight. It could also be reconciliation with a loved one or ally. Receiving the rewards, her quickly set forwards returning and gets ready for last leg of his journey.

- Tenth step is *The Road Back*; hero starts his journey back home the feeling of danger is replaced with acclaim, vindication, absolution or exoneration. Returning requires one last push. Before the coming back her might experience a choice between personal feelings or the higher cause.

- Eleventh step is *Resurrection*; hero experiences the climax of his journey and has his final and most dangerous encounter with death. This encounter has great and far-reaching consequences to hero's world and the lives of the loved ones. Hero is faced with even more responsibilities. The stakes and the suffering of the hero grip the audience and empathize with the hero's hopes, fears and dread. Has hero succeeds his brush with dead he emerges cleansed and reborn.

- Twelfth step is *Return with the Elixir*; hero returns home a changed man. His return brings hope, solution and new perspective to his old world. After his

returns he obtains the final reward it could be celebration, self-realization or, end to strife, change, success and proof of his journey. Return home triggers resolution for the other characters of the story. Doubters will be proven wrong, enemies defeated and his allies rewarded. In the end hero returns to where he started but the feeling is things have changed for the better and for forever (Dickey, 2006, 255).

2.5 Digital Game Development Process

As mentioned before digital game is a separate branch of the game development process. Game development is intertwined with the software development process; an idea for the game directly translates to a coding requirement. Therefore, digital game development process relies on its own literature. Currently, there are two main development methods in the gaming industry; AAA and Indie. The term "AAA" was used in the late 1990s, by development companies at gaming conventions in the US. Term is very similar to blockbuster for the movie industry. It stands for high budget games developed by a mid-sized or major publisher, typically having high marketing budgets (DeMaria, Rusel et al., 2002). An independent video game or more commonly referred as indie game, is a video game developed by small teams with small budgets with almost no marketing budget. Indie developers rely on low cost digital distribution methods. They focus on innovation and creativity rather than quality graphics or technology (Irwin, 2008).

The difference between AAA and Indie is important for serious games. In many cases serious games have started to intrigue the defence sector. Serious games provide various opportunities and benefits for distributed learning while motivating the user. They represent a trade-off between e-learning, simulations and games. As the younger and digital generation is entering the military and defence sector, serious games' appeal has been on the rise. Defence acquisitions and projects are more similar to AAA game development processes. But there is a cost effective and innovation driven mind-set indie development can provide for serious games.

2.5.1 Use of Game Engines

Recent technological advancements have allowed for small team of indie developers to flourish. Especially commercial game engines have been great help. Game engines are software frameworks designed for the creation and development of video games. Engines usually includes rendering engine ("renderer") for 2D or 3D graphics, a physics engine or collision detection (and collision response), sound, scripting, animation, artificial intelligence, networking, streaming, memory management, threading, localization support, scene graph, and may include video support for cinematics (Game Career Guide, 2018). Gaming industry heavily relies on game engines. There are two options when using game engines; custom engine development or commercial game engines. Custom engines are usually used by AAA companies to enable for full flexibility and control. It is a costly and long term investment. But on the other hand use of a commercial game engine allows cost effective rapid development by trading off certain flexibility. What is lost in flexibility is gained especially in graphic quality and assets. Commercial engines have been focusing on providing high and optimized graphic quality rendering, one aspect indie games where they were heavily disadvantaged against AAA games. It should be admitted that serious games have not reached its full potential in the market. Therefore, there is a still trial and fail period for many projects. It is beneficial, to adopt rapid and cost effective commercial game engines for serious games. If the serious game start to prove itself and the feedback loop suggests future versions of the system, then considerations should be made for a custom development engine.

2.5.2 Development with Modification

The term modding refers to development by modifying the game to perform functions that are not originally conceived or intended by the designer, or to achieve a specific change (BI', 2018). Most of the contemporary games have modding option. In a way the game itself acts as a quasi-game engine. Though, engine features are very specific to the actual game. Given most of the time source codes cannot be reached modding is a very limited development option. Depending on the budget it is possible to involve the original game studio to increase the flexibility, all the while

still achieving a cost effective development method. One of the biggest benefits modding offers is, by using a full game as the foundation for the serious game, risk of not providing an entrainment could be mitigated. This allows the developers to shift more focus on training needs. Even if modding might not offer a full solution, it could provide an opportunity for rapid prototyping. There are few different modification approaches. (I) Complete overhaul: resulting game has entirely different gameplay, graphics, and elements. Usually game is used as an engine to create a complete new game, even though this new game is legally binding to the original game studio. (II) Upgrading: changing the playing style, graphics, dialogs and music of the original gaming environment and concept. (III) Attachment: keeping the majority of the game unchanged but, adding certain weapons, tools and characters such as new or re-mastered graphic models. While not altering the main concept of the game. (IV) Visual Modification: game is kept as is but some or all of the visual elements are changed or re-mastered.

CHAPTER 3

SERIOUS GAMES

3.1 History of Serious Games

The history of serious games goes back 2000 year to Milan. Initially, it is thought that war planning and strategy are the basis of serious games (Raybourn, Elaine et al., 1961, 7). Serious games based on table top games have maintained their dominance for a long time. With the development of computer systems, computer aided serious games started to emerge. HUTSPIEL was developed in 1955 and is being thought to be the first example of computer aided war-games (Raybourn, Elaine et al., 1961, 8). HUTSPIEL is a two-person computer-aided education system for possible war scenarios and nuclear warfare during the Cold War period (Djaouti, Damien, et al., 2011, 27). In 1958 second version of HUTSPIEL, NEWS (Naval Electronic Warfare Simulator) was developed (Djaouti, Damien, et al., 2011, 27). HUTSPIEL series were followed by T.E.M.P.E.R. in 1961, an education system aimed at officers training on Cold War international conflicts (Djaouti, Damien, et al., 2011, 31). Development of such serious games continued in to the 60's the process were overseen by the U.S. Joint War Games Agency (Djaouti, Damien, et al., 2011, 27). With the increase of graphical and technological capabilities of computers, digital serious games in the modern sense started to emerge. SGI Flight was developed in 1983 and is regarded as the first modern version of aircraft simulator (Raybourn, Elaine et al. 1961, 11). Harpoon in 1989 was a multi-player naval warfare simulator and, represents the introduction of graphical interfaces to the theatre-level simulators (Raybourn, Elaine et al. 1961, 11). With Spearhead in 1998, 3D models were started to be used for training tank tactics in an immersive simulation environment (Raybourn, Elaine et al., 1961, 12). Militaries do not only use serious games for educations, but also for promotional and propaganda purposes. The Americas Army 2002 was developed for the purpose of promoting a carrier in the army to young students (Smith, 2009, 69). With advancing technology and

emergence of virtual reality headsets tactical level training simulations begun to emerge. DARWARS AMBUSH, 2003 is one of such examples to virtual reality training. While, DARWARS Tactical Iraqi 2003 provides operational training to infantry units (Raybourn, Elaine et al., 1961, 11), serious games have now started to become specific to the nature of missions and territories. Tactical Iraqi, BiLAT 2006, is such example. BiLAT is a cognitive training simulator and aims to provide effective training for negotiation strategy, cultural awareness and, confidence building. The game is designed according to the Iraqi culture (Smith, 2009, 73).

Classification of serious games is done according to the method of game type, purpose, scope (Gameplay / Purpose / Scope- G / P / S) (Žavcer, Gregor et al., 2014, 283). In this context, purposes of serious games can be listed as; health, advertising, education, education, science and research and production (Raybourn, Elaine et al., 1961, 6). While public, defence, health, marketing, communication, education, companies and industry can be listed as the main sectors for serious games (Raybourn, Elaine et al., 1961, 6).

3.2 Definition of Serious Games

There is no one definition of serious game, but it is generally defined as games with educational purposes (Tawadrous, et al. 2012, 178). Many studies have shown that serious games improve academic achievement (Smith, 2009, 58). Serious game's use the knowledge and technology of the game industry (Žavcer, Gregor, et al., 2014, 282) to achieve engaging training atmosphere that promotes creating new knowledge for a specific purpose (Tawadrous, et al., 2012, 178). Game technologies can be listed as 3D game engines, graphical user interface, artificial intelligence, communication network technologies (Smith, 2009, 58). In addition to the technologies game elements such as, story, themes, music, quests and levelling are used to transform education from a didactic structure to an interactive structure. Serious games are especially useful for cost effective training for subjects that have time, location and safety constraints (Smith, 2009, 58). Unlike classroom training serious games also utilizes trainees' analytical, interrogative and strategic thinking, self-control, problem solving and recognition as well as, short and long memory, visual processing skills, and psychomotor abilities (Smith, 2009, 58).

3.3 Serious Game Components

3.3.1 Game Module

Four main components of serious games are; Game, training, instructor and after action review components. If game component in serious games aren't almost identical to games for entertainment, it defeats the purpose of having games in serious games. Therefore, a serious game needs to provide gameflow, difficulty of a challenge and graphical interface just like any other digital game.

When incorporating game component to serious games, achieving a balance between entertainment and training is key in creating a successful serious game (Breuer et. al, 2010, 6). There are three different methods of balance. First one is the *supporting method* where game is presented as a reward. Completing a certain stage gives access to entertainment. Second is the *motivation method* the game is used to capture the attention of the user and prepare for the training. Third one is the *blend method* training module and game components are mixed together. From the point of view of the user training is equal to entertainment (Breuer et al., 2010, 6).

In addition, entertainment and training aren't always positively correlated. In his book titled "Why so serious? On the relation of serious games and learning, Journal for Computer Game Culture" Johannes and Gary Bente Eludamos (2010, 6-7) identify three types of relations. *Linear Positive*: more fun equals to better training. *Linear Negative*: fun distracts the user, so more fun decreases the educational performance. *The Reverse U*: fun is important for learning but, there is a peak point. After this point is exceeded fun starts to decrease educational performance.

Therefore, the main aim when developing serious games should be obtaining a balance between fun and education rather then, maximizing entertainment. Game component is strategic for keeping the user motivated and wanting more throughout the training session.

3.3.1.1 Game Technologies

Game technologies are sets of tools that come together to form the core gameplay. Game technologies can be listed as; Game achievements and missions, game rules (score and interaction rules), obstacles, end game and/or main mission (Appelman, 2005, 242), game tempo, in game psychics rules and in game events. User technologies are compiled as; Avatars & customizable avatars, in game equipment, character controls and in game achievements. Games also utilises game themes, game displays (2D/3D) (Tanget al., 2011, 5-6), story and narrative, feedback, ranks, levels and titles, time pressures, simultaneous communication systems (Deterding *et al.* 2011, 28-30) and artificial intelligence.

In order for a game to be considered a complete game it needs a certain blend of technologies listed above. Unfortunately, there is no one formula how these technologies can be used to make an entertaining and successful game. But it is certain that in cases where these technologies are overlooked or missing the game tends to fail. This brings us to one of the biggest issues about serious games; The game component of serious games needs to be a fully developed entertaining game. Given the infinite combinations of game technologies, game design requires specific experience and expertise. However, the currently gaming industry do not focus on serious games all the while serious game developers are usually not from gaming industry background. This has been the main issue behind serious games taking off and becoming as successful as simulations or games.

3.3.1.2 Game Mechanics

Game mechanics are core functions that users systemically repeats throughout the game in order to complete the game. Game mechanics is one of the key components that define the characteristic of the game.

Super Mario Brothers' (Nintendo, 1985) jumping ability can be show as an example to this. Further, game mechanics can be used to create a specific emotion in the users (Sicart, 2008, 6-8). As another example, Call of Duty 2's (Infinity Ward, 2005) on screen blood effect when the player is being shot can be shown. When the user is

taking damage the screen is shaken and sides of the screen is covered with red blood effect, while this gives user a warning to take cover it also creates an atmosphere of tension and excitement.

Table 1 Serious Game Identification Framework

Platform	
Theme	
Training objectives	
Training methods	Repetition based learning
	Discovery
	Observational learning
	Trial and error
	Conditioning
Target Audience	
Interaction	Single player
	Multiplayer
	Massively online multiplayer
Fields of Application	
Control interface	Console controllers
	Keyboard and mouse
	Motion control
	Touch screen controlling
Game tags	Puzzle
	Simulation
	Test
	Role-play

Multiplayer also comes under game mechanics. Multiplayer allows for multiple users to team up or to compete against each other. This creates the opportunity for infinite gameplay where with every new set of players the game flow changes thus creating a new and unique experience for the user (Deterding et al., 2011, 28-30).

As stated before with both game technologies and mechanics there are infinite number of combinations is only limited by imagination. In order to better understand these combinations, avoid confusions and aid game design processes a serious game identification framework is used. Elements of this framework are shown in Table 1 (Breuer et al., 2010, 10-11).

3.3.1.3 Graphic Interface

The main theme of the game is determined by the game graphics. However, the term "good graphics" has a misconception among the serious game circles. The concept of digital training has been pioneered by simulations. High fidelity means everything in simulations including the graphics. This is not the case for games. Realistic graphics does not mean good graphics in gaming industry. In games, graphics that helps to create an immersive environment that asserts the theme of the game are considered good graphics (Libes et al., 2007, 3).

Immersion is the key word for games. Immersive environments allow players to be surrounded with the emotions and entertainment that game provides. Whilst, designing the game component of serious games it is imperative to focus on creating the immersion. Every single game elements or task should aim to create immersion. As it was stated above, although, there is no one formula to make a successful game. Success of the game can be tested by the level of immersion the game provides for its users. Immersion in serious games increases user's involvement and motivation in training thus having a positive effect on the learning outcome.

As for variety and types of graphic designs in games Call of Duty's (Infinity Ward, Activision, 2005) realistic graphics and Candy Crush Saga's (King, 2012) colourful and cartoonish designs can be shown. Both themes are praised by the players and considered as the key characteristics of the game.

3.3.2 Training Module

Key feature of serious games are on top of including all the game elements like story, aesthetics and art they also include a module that aims to increase knowledge and skills by education and training (Susi et al., 2014, 4). Training modules barrow from simulation technologies in order to achieve learning objectives. These technologies are listed in Table 2.

Table 2 Simulation Technologies

Goals and Missions	Different to digital games, goals and missions are designed with specific training purpose and with high fidelity.
Modelling	Models, behaviours and environments that are related to training material are simulated to represented reality as closely as possible.
Controls	Though the control interface varies, control reactions are modelled to represented reality.
Manipulation	Games can heavily rely on scenarios with specific endings. Simulations are shaped by user actions therefore cannot accommodate fixed endings.
Consequences	User actions create changes and effects within the simulation environment (Appelman, 2005, 3).

When games are compared with simulations, all manner of designs is accepted for the sake of creativity. On the other hand, in order to achieve training goals and avoid negative training achieving highest realism is the main aim of the simulation. Serious games have to find a balance between realism and creativity. Therefore, while design a serious game one of the first step is deciding the lowest accepted level of realism (Casanova, 2008, 172).

When serious games are used to compensate for real life training, the line between serious games and simulation starts to blur. This is why achieving the minimum reality with a solid training goal is key for designing a successful educational serious game. Furthermore, educational serious games utilize various pedagogic processes in order to achieve training goals. These pedagogic processes can be listed as shown in Table 3.

Table 3 Pedagogic Processes

Capture Attention	Capturing and holding the user's attention is a prerequisite for a successful learning outcome. Serious games utilize graphic design, story, themes and mechanics to realize this goal.
Notifying the user about learning outcomes	Users who participate in training to advance personnel carrier will be motivated by the learning outcomes.
Remind the previous training	If the game is used for a previous training. It is important for the training to have the elements that reminds the previous trainings.
Guide the user	The system should guide and support the user throughout the training.
Enable performance	System should increase and encourage performance of the user.
Feedback	The system should provide feedback to the user about the actions, replies and the course of the training.
Performance measurement	The training should measure performance in order to improve future versions and to monitor the performance of the user (Tang et al., 2011, 4).

It has been observed "acquiring information" rather than "dumping information" approach is more common in successful serious game examples (Breuer et al., 2010, 8). During this study similar dilemma was faced developing the Counter IED training game. The two options for providing mission briefing was; showing a mandatory in game video about IEDs or let the users fail as the game progress and offer video as further information. Videos or photos was found by the users an interrupting the flow of the game thus the other method was chosen.

When training modules are examined the following key concepts are identified. Any action carried out in the training module should further the flow of the game in a meaningful and holistic way (Fikar et al., 2013, 2). Modules must be compatible with the main structure and mechanics of the game and should not disturb the flow of the game (Fikar et al., 2013, 2). For example, during a first person shooter game stopping the game and asking multiple choice questions would break the flow of the game. In cases where the user fails at a training related subject game should punish the user without effect the motivation. On the other and good performance on the training subjects should be rewarded (Fikar et al., 2013, 2). Failures should not discourage the users, on the contrary they should motivate the users to play even more. All the while users are seeking an alternative solution re-playing the game repetition provides the opportunity to repeat the course material (Breuer et al., 2010, 6). Training module should be pleasantly frustrating; meaning the game mechanics should challenge the user rather than making it hard or almost impossible to pass. Even if the module is slightly hard it should not be boring (Breuer et al. 2010, 6).

Users look for a certain level of reality in the training modules. It has been observed that when users cannot see a clear link between real life and the serious game and think the system does not reprehensive reality they are usually alienated from the training (Ahmed Binsubaih et al., 2006, 343). All information should not be compressed into training. Information other than basic training should be presented as support material in digital or printed form. Digital games are usually linear and at a certain pace. But, allowing user to determine the time spent on and the order of the training can increase the motivation and help obtaining knowledge (Johnson, 2010, 176).

3.3.3 Instructor Module

The instructor module has five main roles. Determine training scenarios and goals. Prepare the training scenarios in the form of in-class training, support and homework material depending on the lesson plan. Run and manage after action reviews (Binsubaih et al., 2006, 343). In the case of in-class training, monitor and record the training (Chen, et al., 2005, 4). Furthermore, instructor modules with higher capability also have record, stop, pause, fast forward or rewind ability (Metello, et al., 2008, 173).

3.3.4 After Action Review

In classical education, the success of education is measured by testing. This measurement shows if participant is ready for the next level of education, its ranking and completion of a certain training module. However, digital systems offer after action review module as an alternative to testing. The after action review module follows the user throughout the training and provides quantitative data on the training and user's knowledge at the end of the training. AAR module's success closely depends on the variety and detail of the data kept by the system. In this context, the AAR module should keep the following data as a minimum requirement; the duration of the training and/or training modules, the number of errors made and the number of error corrections.

In addition to these data, it is also possible to develop an intelligent system that tests the user on specific questions. For example, if the system offers two options to the user, at the end of the training the user can be asked why they choose option X and why they did not choose the option Y. These automatically generated questions can provide a more in-depth assessment of the participant's learning level, as well as other metrics available through AAR (Chen, et al., 2005, 2-4).

3.4 Classification of Serious Games

3.4.1 Digital Serious Games

There are two main classifications for serious games; digital serious games and gamification. Digital serious games use video games for their game components. Gamification is the application of typical elements of gameplay (e.g. point scoring, competition with others, rules of play for educational) purposes.

3.4.1.1 Player Interaction for Digital Serious Games

Player interaction defines how player interact with each other and the game. *Single-player;* Video game where input from only one player is expected throughout the game and that can only be played by one person (Oosterhu, Feireiss & Lukas, 2006, 180). *Multiplayer;* More than one player can play in the same game at the game session. Player can partner, compete or fight against each other (Moshal, 2011). *Massively Multiplayer Online;* game is played by hundreds to thousands of players online (Techopedia, 2014). Local (Non-Networked) Multiplayer*;* This mode allows two or more players to play on the same device (Fernández-Vara, 2014, 9).

3.4.1.2 Platforms for Digital Serious Games

Platform is the device where the digital game's software is run. It is always important to identify the platform from the beginning of the development process, every platform has its unique processing and graphic power hence the ability to run a specific digital game greatly varies. These platforms are listed as; Personal Computers, smart phones, tablets, Play Station consoles, virtual reality headsets, web browsers, augmented reality headsets, smart TVs and hand held gaming consoles.

3.4.1.3 Gamification Methods

Competition Games instill a sense of competition between the players. Winning means defeating other players. Progression-based games provide a series of escalating goals. Levels, new settings, challenges and goals keep the gameplay fresh.

Badge-based games focus on the collection virtual goods or elements of gameplay. User actions are rewarded. Sense of achievement is provided by including milestones. Recall and Memorization rewards the use of the player's memory. Judgment Games are based on evaluation of evidence to make an educated and correct decision. Consequence Games provides large number of choices and paths leading to different consequence exploration of choices our creating one's own destiny with unique story outcomes becomes the main drive. In Strategy Games users often has to use autonomous decision-making skills and needs decision tree style thinking, and typically requires very high situational awareness. Exploration Games stokes players' curiosity by creating a sense that there's much to be discovered. Simulation Game gives the player the chance to play the role of various responsibilities in realistic scenarios and/or environment (Simplicable, 2018). These games can be played by one person or the player can partner, compete or fight against each other (Moshal, 2011).

3.4.1.4 Platforms for Gamifications

As mentioned before, gamification requires no more than the person's imagination. But over the years different methods of gamifiying our imagination has emerged. For example, board games are games that use tabletop boards and played by moving pieces while card games have a deck of cards that is distributed among the players. According to values of cards and time it is used players gather points towards winning. These methods are named as platforms in this thesis. Because they provide a psychical platform for the games to represents them.

Yet at the same time role-play games are games Game in which participants act out according to the roles of a specific characters. They do not always have psychical platform, tools or information sources. Nevertheless, they have rules and they are fidelity based, may be it they exist in an elvish land or a child acting out a tea party. These games are a part of a tradition and verbal history. In a way they provide a cultural platform to the game.

Despite the fact that we solemnly thing as a gamification method most obvious form of gamification is sports. These activities are athletic activities or they use a physical

skill that involves competition. Therefore, sports can be used as a platform to develop a game around.

3.5 Purpose of Serious Games

3.5.1 Games for Health

Exergaming; Video games playing means exercising and promotes an active lifestyle. Sometimes systems can track body movement or reaction (Sinclair, et al., 2007). Rehabitainment Disease Management games are used to rehabilitate injured individuals. It covers pain control; restore co-ordination, training doctors, concussion detection (McCallum, 2012, 85-96). Self-Ranking games are a method that playing the game leads to evaluation of patients own health status (Sawyer, 2008, 28). First Aid Medical Information serious games are oriented specifically to first aid education (de Urturi, Zelai Sáenzet al., 2011). Patient Healthcare games are usually interactive game that contains instructions for quantitatively analysing the medical condition of the patients, and/or counselling instructions or self-care instructions (Brown, 1999). Patient Communication games trains the doctors to increase the effectiveness of doctor-patient communication (Ha, 2010, 38-43). Pain Distraction game a designed to significantly distract, and lower pain intensity during treatment (Bryan, et al., 2009, 439-448). Cyber Psychology a new health research area that focuses on analyzing the individual's online identity, online relationships, personality types in cyberspace, cyber addiction, regressive behaviours, online gender-switching behaviours are measured (Jared et al., 2009, 25). Virtual Humans are a developing field where high fidelity human models are used for training or data gathering (Health Standards, 2018). Public Health Messaging games are designed to convey a message and make a call for action to protect user's health (Northwest Center, 2018). First Responder training games are designed according to the specific needs of the first responders in various real life scenarios (William, et al., 2008, 1152-1159). Epidemiology games trains or gathers data on probability of occurrence, distribution, and possible control of diseases (Last, et al., 2001).

3.5.2 Advergames

Standalone Advergames are games created by a company with the sole purpose of promoting the company, product or service (Marolf, 2007). In Game Placement method is integrating an advertisement of a product, company, branding or service in the core gameplay which differs from advergaming, which refers to a game specifically made to advertise a product. Political advergames promote a political message, ideology or person. Public security announcements convey messages and makes call for action about public safety while playing the game. Recruitment games are used during job interviews to analyse candidate's aptitude, creative thinking and problem solving capabilities. In addition, recruitment games can be used to promote a company or organization (Yi, 2005).

3.5.3 Games for Training & Education

Games for training mostly focus on development of the player's skills. In the literature skills development is divided in two main approaches; Single task and comprehensive training. While single task development games focus on training skills very specific single task. Comprehensive approach focuses on training a certain skill and exploring all aspects of it in-depth (Chatham, 2007, 36-43).

In Elementary Skills games players are trained to use simple and rudimentary skills. Occupational Safety game teaches health and safety conducts for a specific task or job. Job orientation training games focuses on teaching a specific task, job or general conducts of a company. Awareness games increases awareness of the player on a specific topic or subject. Communications games focus on increasing commutation skills of the player users are compelled to utilize communication skills to win the game.

While games for education is all about teaching, expanding, reinforcing and crating understanding on a certain learning subject. Comprehensive learning approach is adapted for development of these games. Main differentiation between comprehensive learning and compressive training is that training is about development of skills while learning focuses on knowledge.

3.5.4 Games for Science and Research

Data Collection games are designed to gather certain data while user plays the game. This data is either about the user or user's actions lead to collection of a certain data. Data Visualization games' purpose is to visualize data results in a way it is easy for the user to understand. Data Processing games gamify the process of data sorting, classification and data analysis. Research games gather data on a specific research, though it is similar to data collection the main difference is clear and present research question (Breuer, et al., 2010, 7-24).

3.5.5 Games as Work

Direct Earnings means playing the game leads to financial rewards. Opinion type is when players stream their gameplay to earn money or hired by development companies for design or testing. Work to Play refers to player finishing certain tasks in order to for user to play the game. On the other hand, Play to Work – Competitive is when users participate in e-sports and tournaments as a professional player (Telegraph, 2018). Production type game as work refers to production or generation of games, audio, graphics or videos through playing.

3.6 Differentiation Between Serious Games, Simulations and Digital Games

3.6.1 Unifying Factors for Digital and Educational Serious Games

Although digital games and serious games are ecstatically two different entities, a full digital game is the very foundation of a serious game. In order to develop a successful serious game, first one needs to develop a successful game.

Unfortunately, this is the very problem may serious games face. In many occasions either serious game developers are not familiar with digital game development or the target audiences of the digital games are not gamers. Defining serious games are important for cases like these. If agreed with the notion that serious games are, digital games with educational purpose. Then faced with similar problems the user of serious games should be considered again to a possible alternative of gamification.

There is no one way of developing a successful game but a full game is defined by combining elements of story, graphic design, interactivity, immediate feedback, control interfaces and accessibility to create a *"gameflow"* that is an immersive entertaining digital environment that makes user to lose the sense of place and time (Atkinson-Bonasio, 2008).

Elements described above can be broken down to specific sub game elements. Therefore, in order to incorporate a fully developed digital game into serious games, it needs to include combinations of these specific game elements in various quantities and designs. Serious games aim to achieve a balance between teaching elements and game flow. This balance can be obtained through use of serious games framework.

Table 4 Use of Serious Games Framework

Sub game elements	**Elements of the framework**
Processing of in-game knowledge and using it to win	Assigned tasks / targets must not depart from being realistic, even if they demand a certain level of skill
Using limited resources to win	Ensuring the level of user attention throughout the game
Elements that create time pressure	Targets set in the game must be clearly defined
Elements within the scenario that trigger events that in return trigger reactions from the player	As soon as the goals are achieved within the game, providing an instant feedback
Unexpected actions that take place (Hartog, 2009, 16).	Emotional satisfaction that provided by the game achievements must worth the effort put into the game
Collectible achievements	Be immersive enough that users forget their daily problems
Having fantasy elements	Actions taken creates feeling of control over the game
Feedback or support from artificial intelligence	Strength the sense of self
Having a specific winning scenario	Effects the perception of time passage (Michaud, et al., 2008).
Having points, winners and leader boards	
Having Story-based narration (Kapp, 2013)	

Assigned tasks or targets must not depart from being realistic, even if they demand a certain level of skill; ensuring the level of user attention throughout the game. Targets set in the game must be clearly defined. As soon as the goals are achieved within the game, it provides an instant feedback. Emotional satisfaction that provided by the game achievements must worth the effort put into the game. Tasks must be

immersive enough that users forget their daily problems. Actions taken create feeling of control over the game. Strengthen the sense of self. Finally, effect the perception of time passage (Michaud, et al., 2008).

Every digital game has a type of gameflow. The quality of this flow differentiates a game from a good one and a bad one. Introducing selected game elements to any training or education should be perceived as gamification. While this is the case serious game development includes the combination of serious game framework elements and gameflow.

3.6.2 Identifying the Difference Between Digital Games and Educational Serious Games

There are many different ways to define serious games. Though this is the case digital serious games can be generalized as, digital games that educate the user by leveraging the technology and atmosphere of digital gaming elements (Stone, 2005). Variations of this generalized explanation of serious games defined in the literature are as follows:

> *Serious games are communication tools in the field of education, health, and strategy, which are digital games that are designed around certain rules, with a strong purpose of entertainment (Zyda, 2005, 38).*

> *Serious games are identified as digital games. As well as they are educational, they provide design and entertainment elements (Sørensen, et al., 2007, 559-566).*

> *Games that use gaming technologies for education and training are serious games (Felicia, 2009).*

> *Serious games are defined as games with a purpose. In other words, serious games are integrative medias that support learning that are within the boundary of entertainment (Stone, 2008).*

> *Serious games are sometimes referred to as "games for change" and "social games". This technology and this method of education attracted the attention of various NGOs, politicians, activists, teachers, artists, soldiers and designers (McGonigal, 2011, 14)*

Defining serious games provide as many explanations as definition of digital games. This is due to many shapes and forms of providing entertainment to users. Similar to movies different methods of entertainment causes many variations of sub genres. Therefore, from various definitions of serious games we can understand that, serious games are digital games, they are entraining and they are used to train or educate the users (Michaud, et al., 2008).

Looking from a scenario based definition. Serious games are combination of **"Education Scenario + Digital Game Scenario"**. This combination creates the biggest difference between digital games and serious games (Michaud, et al., 2008); Digital games are created to entertain the users. While serious games are created to train or educate the user while entertaining them

3.6.3 Identifying the Difference Between Simulations and Educational Serious Games

The term simulation has been strongly associated with digital training tools. This creates a confusion separating simulation from non-simulation training software. When digital games and simulations are combined we get simulation games genre. Usually simulation games do not have a specific wining scenario (Alvarez, et al., 2010). For example, in the simulation game “Flight Simulator” the user flies to different locations with different types of planes and tries to successfully land. But, the game does not have a levelling system or a specific wining scenario.

The key differentiating factor between serious games and simulations is as Roger Smith (Atkinson-Bonasio, 2009) states "In simulations users motivates themselves". Therefore, simulations seek to maximize the reality of the training and do not focus on increasing the motivation of the user. On the other hand, serious games’ fidelity of the simulation is just another game mechanic. Thus, the game can bend the reality

to increase the entertainment fact or to fit with the rest of the game flow. Serious games heavily rely on game elements to form the mechanics and the flow of the game. The section below will discuss the difference between simulations and serious games with respect to game elements.

Table 5 Differences Between Simulations and Serious Games

	Serious Games	**Simulations**
Story	User does not need a background information to start the game	Serious amount of background information is needed to understand the current situation.
In Game User Camera	Provides a selection off isometric, 2D, platform, 3rd person view, orbital 3rd person, first and second person view cameras.	Main practices focuses on first person and orbital cameras
Environment Design	Various types and reality, only limitation is the imagination of the designer	Developed around real life scenarios. Usually limited with photorealistic environment designs and characters.
User Interface	Usually console or keyboard and mouse. Touch screen controlling and motion capture has been immerging interface methods in the recent years.	Realistic modelling of dummy control devices
Rules	Rules govern the game. Mastery over rules leads to increase on the success.	Knowledge governs the simulation. Increase in knowledge leads to correct decisions in the simulation.
Linearity	Learning does not have to be linear.	Decision making process moves linearly.
Changing Rules and Situations	In different levels or stages rules can change or new ones can be added. Gameplay style or difficulty can change.	Situations, variables and environment can change with new scenario.
Feedback	Immediate feedback is made enable by points and levels. Failure comes in the form of not being able to continue playing.	In decision trees feedbacks can be delayed. Success or failure is determined by measuring the results.
Wining	Wining can be score gathered in the end of the game, reaching the final level, limited amount of replay or ranking the gamers' profile. Even though he wining scenario can be the same different types of wining conditions can mean infinite game play for repeating players.	Wining is defined as completing the main mission with limited decisions. Using the simulation, a second time becomes easier, but because the experience is similar, this helps strength the training (Petroski, 2012).

Even though the differences between simulations and serious games. Serious games can have simulation elements while simulations can have game elements. When some parts of game elements are combined with simulations gamified simulations are formed. Only when a complete digital game and training simulation is combined serious games are formed.

3.7 Common Development Problems in Serious Games

Many serious games do not properly translate knowledge, facts, and lessons into the games. This results in games that are often neither engaging nor educational. One of the most important problems with serious game is finding the best training method, then designing an entraining game and finally finding a balance and harmony between training and game. While developing the educational component of the serious game lessons learned has highlighted the importance of identifying the learning out comes and having access to educational material (Rooney, et al., 2009). Successful games have always been characterized by high-quality or artistic graphics. Such feature makes the game more appealing to wider audiences. Achieving such graphics due to high need of expert graphic designer is not always easy for serious games.

Table 6 Common Development Problems in Serious Games

	Reasons
Storylines were hard to follow	Story advanced by only cut scenes without subtext
	Story is complex and difficult to follow
They were unable to complete tasks or puzzles	Vital clues were given in story which users already had hard time understanding
	All clues are given in long texts that users do not read
	Requires specific actions with the control interface that users find challenging to complete
It was hard to figure out how the game was played	Lack of a system tutorial
	Poor documentation or documentation written for experts explaining the game
Game was too hard and character get killed repeatedly (Bierre, Kevin, et al., 2005)	Inability to recognize audio clues
	Lack of indication of dangerous situation
	Requires specific actions with the control interface that users find challenging to complete
	Game is too fast for users to react
Hardware given to control the game was hard to use (Susi, Tarjaet al., 2007)	User was not accustom to the hardware required to play the game

User control interfaces are the fundamental aspect of game control. When designing a serious game for non-gamers it proves challenging to find easy to understand, memorize and master user control interface configuration.

When other serious games are analysed, the most common problems that the users stated are shown in Table 6.

It is evident that the game should be designed according to a clearly defined target audience. While trying to make the game entertaining it should be made sure not to overcomplicate it. Moreover, these problems emphasize the importance of version driven design and stakeholder testing in between versions. Although, some of the serious game projects has stated that even though they knew the importance of a clearly identified target audience they had trouble in the identification process. It was reported that by narrowing the target audience by use of age, gender, race, location, cognitive, emotional, or physical attributes and experiences helped the project to further narrow their target audience (McCallum, 2012).

While identifying stakeholders it is important to make a comprehensive list. Starting from research to marketing and to disposal all possible stakeholders needs to be identified. If the list is not comprehensive it leads to gaps in needs and requirement analysis and could lead to system being developed without key functions. It is also critical to involve stake holders during the development phase and version testing.

Educators, experts who select the educational contents, content providers, art directors, game designers, scriptwriters, software developers, graphic and sound designers all needs to work together during serious game development. This causes two main problems; Large team equals to budget constraints and mutual understanding is a must. If the team members and stakeholders do not have pervious expertise on the serious game development, conflict of interests can occur. Experts with different subject backgrounds, with different expertise and expectations discussing design ideas and reconciling contrasting ideas proves challenging (Rooney, et al., 2009). One project has stated that while the developers were focused on the functionality of the game, and realistic visual effect, the lecturers, was more focused on the educational and content of the game (Rooney, et al., 2009). Creating a harmony and coordination has the same importance of identifying the stakeholders. Strong leadership and achieving common understanding between different disciplines is key to success in serious game projects that requires large stakeholder involvement (Mortara, et al., 2014).

Furthermore, a serious game project for educating food safety and environmental health reported that the rapid prototyping design approach proved to be crucial within the interdisciplinary team. It allowed the team to come together in weekly meetings to discuss and create common interdisciplinary understanding to create prototypes of the game designs at weekly stages (Rooney, et al., 2009). This lesson learned speaks for the proposed system engineering inspired development model. By combining agile development with system engineering not only helps with version based development but also helps managing an interdisciplinary project team.

It is important to consider various development options. Due to budget constraints it could be logical to use commercial off the shelf, ad-hoc implementation or modification (Bellotti, et al., 2010). The game market is 18.4-billion-dollar industry (Statista, 2018) and in 2017 it is projected 5.000 new game titles will be released (pcgamer 2018). In such a large market finding the right off the self-solution or modification opportunity can prove challenging. It is useful to utilize game reviewers and professional gamers to find the right title. Another important problem related to serious games is reusability. In a fast changing game industry game theologies and mechanics also change rapidly. Thus, meaning a game can be come out of date very fast. Furthermore, serious games usually are developed with a single training or education task when tried to be used other than its indented propose it usually fails to provide favourable outcome thus limiting its reusability (Stanescu, et al., 2012).

All the problems above strongly speak for limiting the initial investment on serious games and focus on cost effective solutions. In addition, some serious game developers have stated that users compared the games with commercial ones and developing a relevant back story accompanying the game environments proved a challenging task (Barrett, et al., 2010). Inserting learning opportunities into story in a way that users find the story immersive and entertaining requires further research so far combination of educational dialog lightly supported with game-like interfaces has proven ineffective (Zyda, 2005).

As stated above game industry has a very large market compared to serious game market which is estimated to reach 5 million dollars in 2020 (markets and markets, 2018). The contrast in the market size brings forth a dilemma, while users expect the

quality of games the funding available for serious games do not match the game industry. Creating all the game content is a major effort and requires a large development budget for a modern computer games (Yannakakis, et al., 2010). Budget constraints are a persistent problem in serious game development. Therefore, it is important to not use AAA game titles for benchmarking but draw inspirations and perhaps development teams from the indie game development community.

As a cost effective solution many of the serious games chooses to use a source game engine for development framework. Although, such engines provide great opportunities for game development nevertheless they come with technical constraints. This constraint has been a frequent problem in serious game development. During the engine selection phase research needs to be conducted to determine if the system needs can be fulfilled by available game engines. If there is no clear indication such functions have been developed before, design and budget allocations should be revised (Rooney, et al., 2009).

Using graphics, sound and story elements to provoke sensory stimulation in users' mind for increasing the sense of presence contribute to building a feeling of immersion (Zyda, 2005). Serious games often seek to model real world the importance of visual interactivity, immersion and fidelity are rising. High Fidelity Serious Games comes requires engines that are capable of such performance. At this point the line between simulation and serious games starts to blur. In order to navigate through this dilemma, it is helpful to do a research among the simulation games available in the market. If the required fidelity suppresses the available options it is important to revert back to the first step of the development process and re-evaluate if the training needs to be a serious game rather than a simulation, there could be third option to use gamified simulation training (Petridis, et al., 2010).

A common problem in adult education is finding time and space for training. Usually workload and reluctance of the organization on labour loss are key factors in this problem. In addition, adults can reject mentor training if the training limits the freedom of choice. In essence emergence of entertaining and educational games aims to solve these time, location and unwillingness. Though many serious games have come across these problems, one of the best options is to avoid mandatory trainings

all together and rely on the word of mouth. If the game is truly entraining and educational users who engage it willingly will refer it to them colleagues thus invoking to spare time to try the system (Mortara, et al., 2014). Contemporary games are long, challenging and complex. As stated before time is a major constraint in serious games. Mimic the game time and complexity of games proves challenging or trying to make shorter version of such games do not always succeed. Focusing on developing a compact, short but challenging enough serious games helps to overcome these problems. It is important not to try teaching everything with a single serious game (Stapleton, 2004).

3.7.1 Common Development Problems Survey

Among 42 serious game experts a common development survey was conducted. The survey was conducted using online survey tools and serious game development conferences and associations were used as medium to reach these experts. Survey was conducted on the behalf of the NATO Science and Technology Organization Research Task Group SAS-129 Gamification of Cyber Defence/Resilience. Average expertise ranged from 1 year to 10 years.

While experts stated that they held different roles such as project manager to content developer as well as game designer over the course of their careers. Three top audiences the experts have worked with were adults (general), military Personnel and university students. The results of the survey are shown in Table 7. Results of the survey show that majority of experts has struggled on securing the necessary funding. Given serious game market is an emerging market and return on investment is relatively smaller then games or the traditional training market it should be still noted that without the big investment many of the development problems can persist despite the growing frameworks and guides. Another major problem is that target audiences of the serious games in most cases are not gamers. Therefore, it leads to the problems of users' inability to determine how the game is played and to follow a storyline. Therefore, the problems experts having such as designing the games, storylines as well as balancing the entertainment and education can be credited to having trouble coming up with designs that is different to the vast experience of the gaming industry

Table 7 Serious Game Survey Results

Questions	**Answers**		
Do you experience problems identifying stakeholders?	64% - No	36% - Yes	0% - Other
Do you experience problems considering all the needs of stakeholders from research to marketing?	60% - Yes	40% - No	0% - Other
Is finding necessary development funds a problem?	71% - Yes	29% - No	0% - Other
How would you score the challenge of finding a balance education and entertainment?	47% - Challenging		
Are you able to find literature on extensive user tests that collect quantitative feedback from already implemented systems?	54% - Yes	20% - No	26% - Other
How difficult is to identify SG's learning outcomes	48% - Difficult		
Finding the graphic designer with necessary skills and expertise is challenging.	38% - Agree		
Finding necessary funds for a graphic designer is challenging.	49% - Agree		
Creating graphics for scenarios, levels, narratives etc. is a major effort and consumes a large part of the budget.	59% - Agree		
How difficult is to design user experience to be “pleasantly frustrating” - Gameplay that is entertaining and challenging	71% - Challenging		
How difficult is to create an iterative collaboration environment consisting of various experts during the development phase?	54% - Difficult		
How challenging is to overcome time and space limitations for SG based education?	59% - Challenging		
How challenging is to develop a relevant back story accompanying the SG?	30% - Challenging		
Developing long, challenging and complex serious games that are similar to games for entertainment.	53% - Challenging		
Finding modification options for existing game engines and collaborating with others.	26% - Challenging		
Capturing player expectations.	58% - Challenging		
Limitations of visual interactivity, immersion and fidelity.	29% - Challenging		
Target demographics for serious games are often non-game players.	56% - True		
Making sure that the subject/content of the game is relevant to the training objective.	%51 - Challenging		
Designing for the whole context of use, including learning methods and domain specific constraints.	58% - Challenging		
Are you able to implement rapid prototyping?	79% - Yes	21% - No	0% - Other
Do you find measuring success of SG problematic?	64% - Yes	36% - No	0% - Other
Do you agree with the statement "Successful video games have always been characterized by high-quality 2D or, now ever more, 3D graphics?” (For Digital Serious Games)	43% - Yes	57% - No	0% - Other
How difficult do you find designing human-computer Interaction in Serious Game development? (For Digital Serious Games)	51% - Difficult		

This leads to yet another problem. Majority of experts has stated that they are having trouble finding literature on lessons learned of other serious games as well as modification options to build their games upon. On the previous sections it was discussed that game design was for the large part was based on extensive benchmarking a previous game and adding unique selling point. Without this

possibility is benchmarking serious games development has the potential of being stuck in a loop of development problems. When the core problem of lack of sharing is analysed the survey suggests measuring the success of the serious games proves problematic. Moreover, designing and documenting the whole context of design including the extensive needs of all the stakeholders is stated to be another problem. These two problems combined leads to "you cannot share what you don't know".

Table 8 Serious Game Challenges Survey Results

During Digital Serious Game developing which of the followings aspects of development proves challenging?	
(For Digital Serious Games) Creating photo realistic assets and environment	15% - Challenging
Obtaining the necessary level of fidelity	44% - Challenging
Developing necessary animations	19% - Challenging
Developing or buying sounds, sound effects and music	2% - Challenging
Developing supporting AI techniques	46% - Challenging
Developing game physics	12% - Challenging
Building a Developer Toolkit	12% - Challenging
Obtaining accessibility learning curve	34% - Challenging
Creating documentation and support	%15 - Challenging
Developing multiplayer infrastructure	36% - Challenging
Enabling heterogeneity multiplatform support	17% - Challenging
Creating artful 2D or 3D gaming environments or assets	12% - Challenging
Source engine limitations	17% - Challenging
Finding Serious Games options for commercial off-the-shelf-components	15% - Challenging
Developing ad-hoc implementation	12% - Challenging
Finding customization options for Serious Game development	27% - Challenging

Unfortunately, there is no one silver bullet to these problems and solutions simply require time and change in the broadest terms. The major lessons learned emerges from the analysis is shifting the majority of funds and efforts on identifying the needs and requirements of all the stakeholders and the development context in order to establish strong design constraints and then focus on designing the best game/education that fits into that gap rather than focusing on designing the best game/education.

CHAPTER 4

SERIOUS GAME DEVELOPMENT METHODOLOGY

Unified software development process brings together best practices of software development together to produce a single process (Jacobson, Booch & Rumbaugh, 1999). Given this studies are trying to achieve a similar goal of producing a single methodology for development of serious games USDP was taken as an inspiration. The figure below depicts to proposed Unified Serious Game Development Methodology (USGDM).

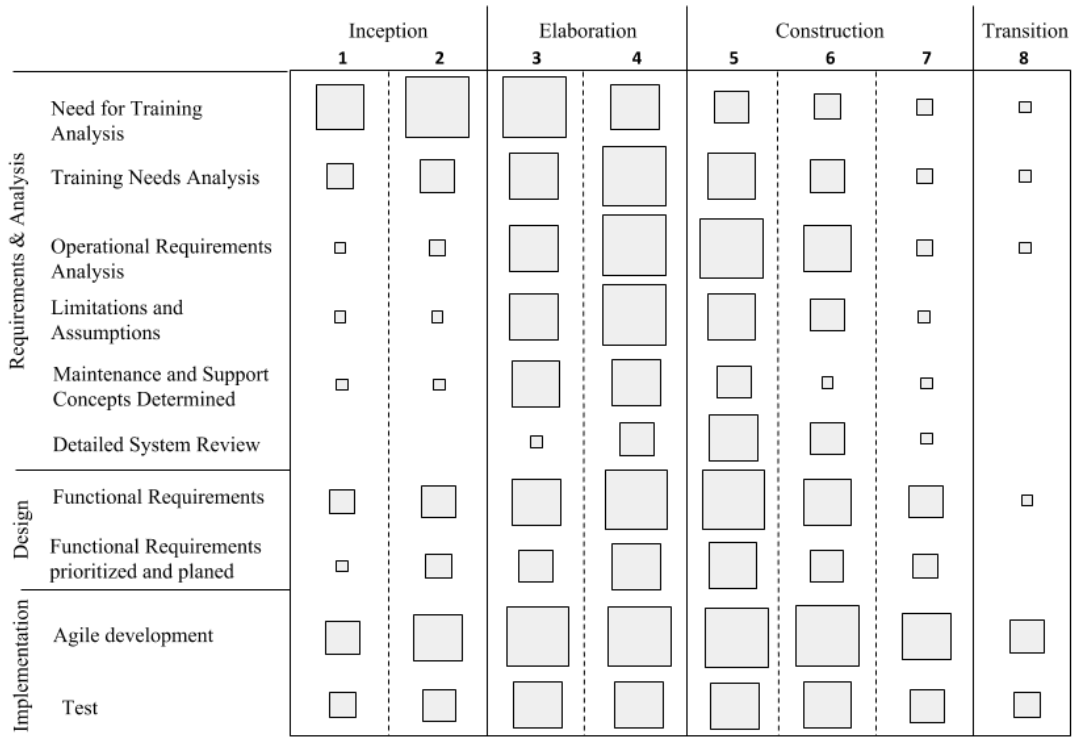

Figure 2 Unified Serious Game Development Methodology

Development cycle of the USGDM consist of four phases (Bennett, McRobb & Farmer, 2006). *Inception* phase focuses on analyzing scope and purpose of the project. This phase has two main iterations. It is suggested that these iterations are divided with the development of two versions of the playable prototypes and tests.

Such division would enable for the generation the necessary information production to set the foundations of the elaboration phase. The phase focuses on analysing scope and purpose of the project. This phase has two main iterations. It is suggested that these iterations are divided with the development of two versions of the playable prototypes and tests. Such division would enable for the generation the necessary information production to set the foundation of the elaboration phase. As it can be seen this phase very heavy emphases development and need for training analysis. This was done so due to the lessons learned from the survey, literature review and case studies. It is important to get the playable version as soon as possible given it is the best way to capture key needs and requirements as well as deciding the limitation assumptions and system requirements. To increase the accuracy of the elaboration phase it is important to get the playable version as soon as possible given it is the best way to capture key needs and requirements as well as deciding the limitation assumptions and system requirements. Furthermore, if it can be decided that such training does not need a serious game or a different type of gameplay within this phase it will solve a very critical fail reason from the very start of the project.

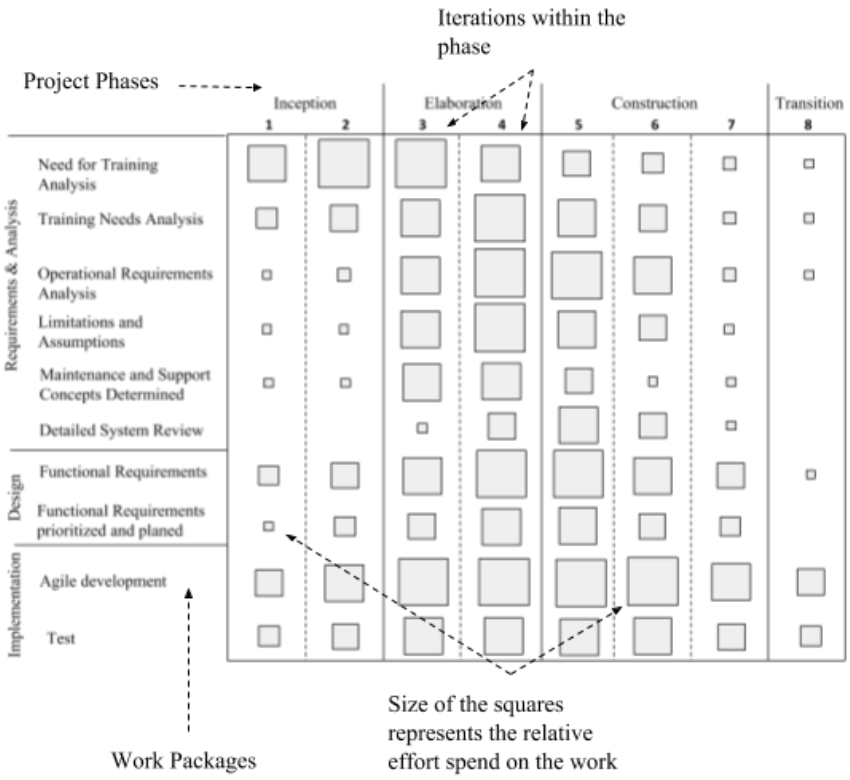

Figure 3 USGDM Explanations

4.1 USGDM Phases

Elaboration phase captures and determines the structure of the system. This phase also consists of two main iterations. This phase has the heaviest workload. First iteration starts with the design and testing key assumptions through prototype developments and testing. Second iteration sees a decrease on need for training analysis. Towards this stage it should be more or less clear if the system is warranted and going forward in the right direction. This phase should end with the critical assumptions and vague points of design document and functions tested through another prototype.

Construction is the phase where the game is actually developed. This phase includes three iterations. Given digital games aim for entrainment while serious games have much more complex needs & recruitments especially first two iterations of this phase gives heavy emphasis on analysing and testing the system for verification and validation. It is believed that by distributing the validation and verification process in an iterative way to the development process it is possible to ensure avoiding critical pitfalls of common development problems of serious games.

Transition is the integration, installation and start of the in-operation support phase. The remaining active work packages focuses on game balance, patching and adding new factions to keep the system alive and functioning. This phase ends with either by systems disposal as a legacy system or start of the entire USGDM to develop the release of an expansion pack or version two.

4.2 USGDM Work Packages

Work packages are divided in the three main tasks. Each phase contains sub-tasks that are designed to the unique needs of serious game development. Recruitments and analysis phases consists of six sub-tasks. These tasks specifically focus on finding out the needs and requirements the stakeholders, operational environment and most importantly self-justification of the serious game. This phase concludes with the review sub-task to ensure the correct implementations of the work package.

Next work package is the design task. This task consists of two sub-tasks; they focus on the functions of the serious game. Given the nature of the methodology this sub-tasks are not independent from the other work-packages. In accordance with the system engineering approach detailed system review process also includes evaluation of system functions to determine the fulfilment rates of system needs and requirements. This work package concludes with concludes with function prioritization and development plan

Final package is the implementation task that consists of two sub-tasks. This work package should be solely version driven. Heaviest emphasis is given to the development of the systems. It is further suggested that and agile development approach should be taken. As detailed on the pervious sections game design and development process is an agile one. Usually game developers avoid detailed – "mammoth" design documents, and prefer developing by doing. Development starts with the most basic functions and graphics and within cycles of developed it is played and added with new factions and mechanics. General concept to game design is benchmarking a previous game in the same genre and adding unique selling points in a function driven iterative agile development. Serious game development can be done in a similar. The spirit cycle should start with ten days and could incrementally build up towards 3-4 weeks depending on the size of the project.

Table 9 Training Analysis

Important questions should be asked during this sub-task	Why am I teaching this subject?
	Who am I teaching this subject to?
	What am I teaching?
	How am I teaching?
	When and for how long will I be teaching this subject?
	What are the obstacles and facilitators to using SGs (Ellotti, Francesco et al., 2010, 22-35)?

4.2.1 Special Consideration for Sub-Tasks

Before starting serious game development, it is essential to conduct need for training analysis and identify the target audience and learning outcomes. As the development

project precedes this analysis if often looked back and utilized. Also collecting relevant educational literature on the subject helps non-subject matter experts to confidante during the development phase.

Second aim of the sub-task is to conduct feasibility analysis. This sub-task keeps asking the questions "Can this training be gamified?" and "Should this training be gamified". Some educational content does not fit too well in a gaming scenario as well as it might not be cost effective. Although, it can be argued that anything can be gamified, making everything into an entraining game is not always a cost-efficient task. As the implication work package starts to produce playable content it is highly useful to involve the stake holders by showing them concepts of the system it is more likely to get useful feedback then providing oral or written explanations of the system.

Under operational requirements analysis, technologies that will be used to develop the serious game are analysed and decided. It is suggested that design document should be presented to development teams. Depending on the requirements teams cab decide and preferably test the relevant technology. In addition, during this sub-task targeted platforms and operational needs of the platform are identified.

Depending on the size of the project and number of stakeholder it is suggested that during the detailed system review all the outputs of the previous phases are collected in a single system design document and reviewed by all the stakeholders.

Moving from the initial analysis and before the design phase during the requirement finalization, stake holder involvement is critical, but most importantly subject matter experts and game designers should be involved and work together during this phase. Their involvement covers the validation process. Another important input to this phase is the lessons learned and feedback from the previous payable versions of the serious game.

Usually the design phase includes the development of a game design document. There is no one standard for developing a design document. Almost each project or company has their own version of the design document. The size and detail of the

document depends on the size of the project. Some agile independent game development teams completely avoid design document and use story and character boards to design a game. It is suggested for a serious game development projects to produce a game design document for making it easier to track learning goals and game design elements. Following table show suggested section titles for such design document.

Table 10 Suggested Section Titles for Design Document

Serious Game Design Document Suggested Under USGDM	Summary of the Game & Properties of the Game
	Player characteristics: The preferences of the target audience
	User experience (Gameplay and rules)
	Game Mechanics
	Control interfaces with relevant to game mechanics
	Mission, quest, level design - rewards are included under section
	Game elements and flow
	Interaction rules between game elements
	Story - If relevant the requirements for cut scenes and cinematic
	If applicable achievements and collectables
	Menu and interface flow chart
	Key performance indicators - Game and educational data collection requirements
	Graphic interface requirements
	Sound and music requirements
	Trainer module requirements

Depending on the project and the preference of the team, a software development documentation can also be developed in this phase. Such document is definitely suggested for larger digital serious game projects with various software development teams.

While system functional requirements are finalized, prioritized and planed according to the design document requirements list of system functions should be developed. It is useful to develop a project timeline in this phase and cross referred to the deadlines. In a case of inconsistency, decisions could be made with functional priorities. It is also useful to involve stakeholders in this stage. Any incorrect decision could lead to unentertaining game or serious game failing to fulfil educational goals. Once the functions are finalized, they should be analysed by the project team to make sure they are detailed enough, doable and not duplicated.

During the agile development and test sub-tasks involvement of the subject matter experts and members of the target audience is highly suggested. Using the prototypes developed, functions should be compared with training needs, learning out comes, game and system requirements to make sure the all requirement are met. Following the test and equipped with feedbacks the development team should conduct version review and plan for the next version.

4.3 USGDM Specific Testing Methods

As mentioned previously, digital games are intertwined with software development. There are many studies and methodologies that solely focus on software testing. This section specifically focuses on methods for testing the quality of the serious game as well as the game component of the system. There could be and usually is a case where the serious game is developed according to the development methodology yet the game is not fun or it fails to achieve its educational goal. At that point the developer team needs a method to tell them exactly what is not going right. The section below argues by utilising a checklist derived from literature review and common development problems survey as well as *Octalysis* framework.

Interface Design and Structure	N	PN	PY	Y	NA
Is the graphics and control interfaces easy to understand and use? (Yildirim, Sule, 2010:6-8)					
Does the game include a help and hints function? (Liu, Eric Zhi Feng et al. 2009)					
Educational Module	N	PN	PY	Y	NA
Is the information in the game accurate?					
Is the modelling of the real life realistic or in accordance with the demanded system fidelity?					
Doe the learning material utilises real life incident or scenarios and user is aware they are real life or likely incidents? (Yildirim, Sule 2010, 6-8)					
Are the challenges in the game related to the learning materials?					
Is the order of the contents reasonable?					
Is the important information presented clearly? (Liu, Eric Zhi Feng et al. 2009)					
Is the feedback provided in a timely manner?					
Does the system provide a proper assessment of the user's skills?					
Can the system report a user's current status?					
Can the learning process be analysed (Liu, Eric Zhi Feng et al. 2009)? *****					
Does the after action review process demonstrated change in behaviour, imparting of knowledge or skills, or the improvement of motor and cognitive capacities among your user? (Goethe 2018)					
Is there before and after the training comparative knowledge measurement?					
Does the system make it clear that failure in the game is a reflection of a serious mistake in reality? (Bellotti, Francesco et al. 2010)					

Figure 4 Extracted from the System Quality Control Checklist for Serious Games

4.3.1 System Quality Control Checklist for Serious Games

Designing an entertaining game on paper is a challenging task. This is why in the previous section version driven design method has been promoted. Nevertheless, it is also a need to test the quality of versions in-between development cycles. Below is a quality check list derived from similar military serious games.

The checklist consists of 67 questions and 7 sections; Design, digital game development engine selection, game content, motivation, multimedia, interface design, educational module. The full checklist is given in Appendix A.

The questions are derived from literature review and common developments survey. They are designed to be used at the any stage of the development. Though the quality of the answer will greatly change if a playable version is developed. There are five possible answers to the questions; No, partically no, partically yes, yes and not applicable. It is completely up to the person how they would like to answer the questions. The questions simply exist to remind key issues and envoke the thinking process. Following example is given from NATO STO RTG SAS-129 Multi Domain Wargame checklist analysis;

> *Is the win and lose cases balanced?*
> *Partially Yes. While Blue has a larger force Red can use the city to its advantage to win. On the other hand, it is easier for Red to win. The game is designed in this way on purpose within its learning outcomes.*
>
> *Is the gameflow and variety of actions enough to reduce fatigue and boredom?*
> *No. Two opposing teams with three sub groups with different combat mechanics cause interruption of the gameflow. Player requires a more dynamic flow especially for the war game.*

The analysis was done after the first prototype was tested with subject matter experts. Checklist question helps to ground and formulate tangible answers to the subject matter experts' inputs and observations made during the game. Even though the method is self evaluation going into the design of the second version was made easier by the checklist by providing information on exactly what was missing or what required further improvements.

4.3.2 Measuring the Quality of the "Game"

USGDM focuses on functional design of the serious game. Though the methodology offers guidance on game design, there is no one way of designing an entraining game. In addition, more functions or specific combination of functions does not always equal to an entertaining game. Therefore, rather than functional focused design, human focused design approach that takes in the consideration of people's feelings, insecurities, and drives needs to be taken. Octalysis is a gamification framework developed that has gathered core drives game of games that motivate the players.

Each drive has a corresponding game mechanics, elements or features derived from literature analysis and practice. This list helps us understand how core drivers specifically translate into the game.

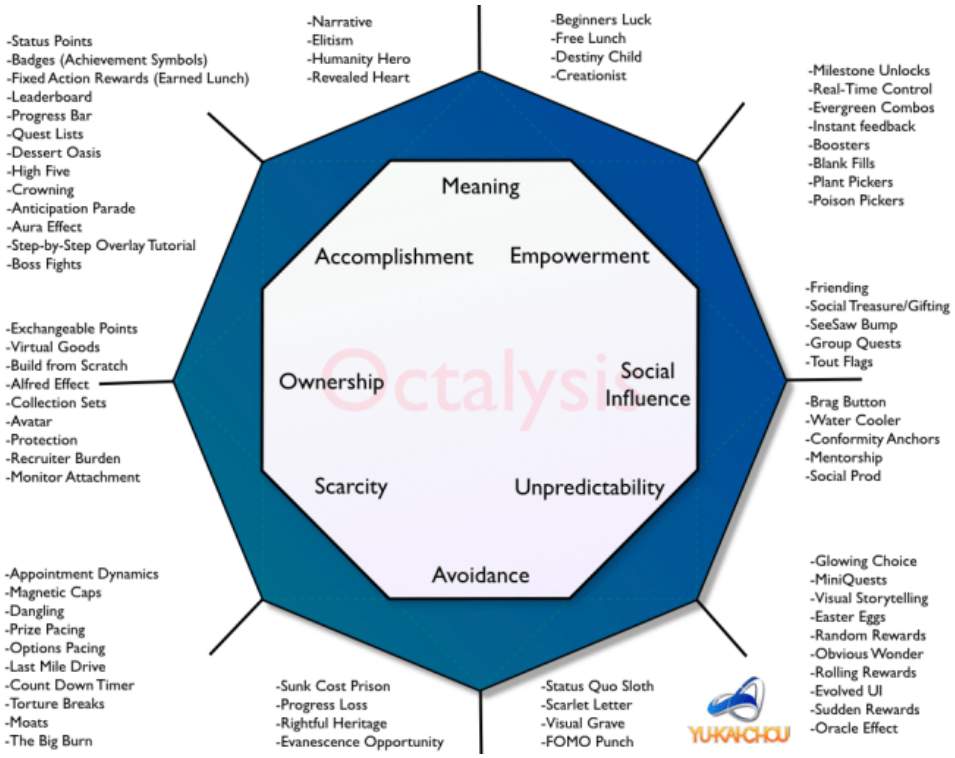

Figure 5 Octalysis[1]

[1]https://yukaichou.com/gamification-examples/octalysis-complete-gamification-framework/

4.3.2.1 Meaning

When player believes he is part of something greater then himself or he feels as the "chosen". This self-importance becomes a major drive for the individual. Meaning can be achieved through following game mechanics and functions;

Narrative in a regular sense is the story that establishes the logic parameters around the game. But different to classic narratives as in novels, movies or television game narratives do not have to be linear. Game narratives can be interactive and can be shaped by the player. The player lives through the narrative of the game. Thus, game narrative becomes a significant part of immersion (Qin, et al., 2009). Elitism has two main applications; larger group and rivalry elitism. Larger group elitism requires the player to be a part of a group that makes them feel like they are part of a larger cause. In rivalry elitism the group or player attempts to defeat the competition. Achieving victories lead to pride therefore feeling of elitism. Humanity Hero happens when participating in or purchasing the game has real life charitable return. Revealed Heart is also called "beginners luck". When the player receives an epic item giving the feeling the player is chosen from the beginning.

4.3.2.2 Empowerment

Player engages in creative problem solving and receives positive feedback. This reward mechanism for one's creativity helps the individual feel better about himself thus the player comes back for more reassuring positive feedback. Empowerment can be achieved through following game mechanics and functions;

Milestone Unlocks is when player is playing the game they set up an internal clock based on milestones like defeating a certain level or reaching a place. Games use this mechanic by introducing milestones that unlock other milestones as they are reached. Real-time Control gives control of the hero/power to the player. By being able to control every aspect of the hero it becomes an empowering feeling for the player. Evergreen Combos design element happens when player uses their creativity and skill to keep playing the same game to find new methods of wining. Instant Feedback means the player receiving instant positive feedback to your accomplishments helps

the player feel successful thus inducing the feeling of empowerment. Boosters items or powers give additional capabilities to the player. Making the player feel stronger, invulnerable and empowered. Blank Fills iswhen player uses their skills and creativity to fill the blanks, a gap or a problem to solve a problem or proceed further in the game using this kind of personal ingenuity helps to add to the empowerment feeling. In Plant Picker design approach player is presented with equivalent choices with no obvious option they use their own selves and reflection to make a choice. This self-reflection and ability to choose becomes and empowering feeling for the player. On the other hand, in the Poison Picker design approach not all choices are always positive but being able to choose the lesser of two evil with your own free will and withstand it to overcome the challenge becomes an empowering event for the player.

4.3.2.3 Social Influence

Person as a social being comes with many drives such as mentorship, acceptance, social responses, companionship, as well as competition and envy. Games that have multiplayer elements can utilize this drive to motivate users. Social influence can be achieved through following game mechanics and functions;

Friending oriented design focuses on finding new friends and establishing social relations is a major part of social person. Many games create the opportunity to meet new friends and establish social connections. Therefore, playing the game becomes same as meeting the friends. Social Treasure/Gifting means certain items; powers or even discounts can be only received if it is gifted by an in-game friend. This leads to players to either establish friendships in the game or bring their real world friends into the game. In SeeSaw Bump participating drive for the game comes from mutual convincing from your social environment. Thus it becomes a cycle of individuals of the social group convincing the group to participate more. Group Quests are banding to gather to achieve an ordeal speaks to a fundamental part of being a human being. Tout Flags is similar to friendly rivalry as you see others with better items or powers player tries harder to achieve the same status. In return others try the same creating the seesaw effect. Different to tout flags Brag Buttons are desired actions to broadcast supremacy to other players. Water Cooler effect means additional dialog,

exchange of ideas and sharing of information is possible in or around the game community this adds to the social influence of the game. Conformity Anchors forces the player to face with the competition to create the feeling of rivalry. Mentorship dynamics work when long time players find profound enjoyment to share their knowledge and improve other player's gameplay expertise. Social Prod mechanics create social interaction with least amount of effort. Best example can be given as Facebook's like button.

4.3.2.4 Unpredictability

Appeal of unexpected, anticipation, surprise and mystery is a major motivator for people. Gambling is mostly based these drives to instil addictive behaviour. Unpredictability can be achieved through following game mechanics and functions. Glowing Choice: By adding glowing effects to certain items or options makes them a curious therefore appealing option for the players. Mini Quests withholds information from the player and reveals pieces of information as the player advances in the quest series. Visual Storytelling is story telling in which the story is conveyed to the player can be used to instil sense of unpredictability and curiosity out the game. Easter Eggs are hidden objects or messages that usually have no additional value to the gameplay expect being hidden by the developers. Looking for possible Easter Eggs adds to the feeling of hidden and mystery. Obvious Wonder is the ability to explore the ordinary game environment without knowing what you will find. Rolling Reward effect similar to lottery where buying more tickets to increase the chance of winning is equal to playing more. Some games start with simple user interface as the game progress and skill level of the player increases the simple UI might be not enough and the player can customize and make it more complex by utilising Evolved UI approach. Sudden Rewards provide player unexpected rewards or expectation of receiving unexpected rewards. Oracle Effect: Players can guess a certain event to happen. But this creates a curiosity to see if the prophecy will come to be.

4.3.2.5 Avoidance

This drive put forth by the framework is identical to loss avoidance in behavioural economics. People generally weigh loss heavier then gain, even when they are motivated by gain. Even then gain is a different frame of loss. It is no surprise that many games use fail and loss as a motivator. Avoidance can be achieved through following game mechanics and functions. Sunk Cost Prison is a cycle where more commitment is given to the game more it becomes harder for the player to quit the game. Progress Loss mechanic doesn't save player progress. Game requires player to continue playing to save their progress. Rightful Heritage: This dynamic makes the player believe something is rightfully theirs but then makes them feel like it will be taken away if the desired action is not taken. Evanescence Opportunity is when player is presented with an opportunity with a time tag unless the desired action is taken. Status Quo Sloth is players who after making a choice become unwilling to change their current choice. Scarlet Letter Not progressing in the game and staying behind means losing social status. Visual Grave means presenting negative feedback to the user when a level is lost. Fear of losing out or FOMO happens when not participating in the game could lead to being left out.

4.3.2.6 Scarcity & Impatience

This drive deliberately prohibits user from playing the game or obtaining a goal. This drive is based on wanting something you cannot get. Some games utilize an appointment system and compels user to come back after a certain cool down. By doing this the user automatically starts a countdown and consequently ends up thinking the game for the whole count down. Scarcity and impatience can be achieved through following game mechanics and functions. Appointment Dynamic introduces limitations on the gameplay time. Only with certain cool downs or recourses the player can continue playing the game. Magnetic Caps is whatever the resource or assets the game presents the design makes it so there is not an abundance of them, just enough to make the player collect more. Dangling is when either the game itself or elements in the game keep showing itself to the player as a reminder to draw attention. Prize Pacing is a method that stops player from receiving rewards in large quantities but give out a small amount and expect user to continue to receive

more later on. While Options Pacing is when options available to the player increases overtime as the player progresses in the game. Last Mile Drive gives motivation or boost given when nearing the end of the game. Countdown Timer is literally a time counting backwards to motivate the player. Torture Breaks are a specific game design that stops the players' desired action in a forced stop manner. This unwanted break leads the player to comeback for the game later on. Moats build barriers and stops around a desired action to induce impatient feelings in the player. The Big Burn is items or powers that requires very large amount of recourse to obtain or unlock. Best studied for end game content for veteran player.

4.3.2.7 Ownership & Possession

This core drive focuses on the accumulation of wealth and possession instincts. In game currencies, items, collectibles and achievements drives most basic human instinct of wanting more and better. In addition, more time spent on a game customizing the avatar or the game environment more the player assumes the ownership of it. This possessive behaviour becomes a motivational drive for more. Ownership & Possession can be achieved through following game mechanics and functions. Exchangeable Points are similar to any currency logic user has the passion of interchangeable currency to spend according to his will. Virtual Goods are like any commodity in game that can be owned by the user trigger ownership and possession feeling. Build from Scratch is when game presents the fundamental building block but leaves the end protect to your creativity and skills this could lead to imitate possessive feeling to end product that has been built by the user. Alfred Effect when the game or an element is tailor made to fit the player it becomes extremely hard to leave the designed product. Collection Sets are in game items, achievements or related merchandise presented as collection sets this speaks to the collector nature of humanity. Avatar: Player creates a unique bond with the character that represent player in the game environment. The ownership feeling amplifies when there is further customization option available for the avatar. As the player moulds the character according to their preferences the possessive feeling also increases. Protection: Game is designed in a way the player is made to protect a certain item, place or a character. This instinctual feeling of protection leads the player to assume possession of the thing they are protecting. Recruiter Burden is

when the player acts as a recruiter to promote the game to fellow gamers their feeling of ownership and possession in naturally inclined to increase. Monitor Attachment gives the task of monitoring the wellbeing of something to the player this inherently creates a protective ownership feeling.

4.3.2.8 Development & Accomplishment

Facing challenges and developing skills and tools to overcome a problem is a key trait of humanity. Therefore, it is no surprise this trait is also a core drive. Awards, points and badges are meaningless without the challenge. Achieving the development and progress making feeling is a key in game design for achieving this drive. Development & Accomplishment can be achieved through following game mechanics and functions. Status Points are points that help to keep the score. Especially, for achieving status over other players these points become tangible evidence of being better. Furthermore, they can act as currency for in-game purchases. Badges are achievement symbols. They can be anything from an item to a digital badge. Most important aspect of designing badges that they have to actually symbolise real achievement. Given in large qualities for undeserved effort undervalues these badges greatly. Fixed Action Rewards are earned through specific actions that are clearly known by the player. Leader board lists all the achievements and points therefore promoting and rivalry. Being seen and being able to see the completion creates the necessary environment. Progress Bar uses the general human trait of not leaving things unfinished. Furthermore, starting and continuing a game means the payer wants to complete the game. Progress bars gives the feeling on incomplete to motivate the players to engage more. Quest Lists is a list of things to do as a part of the immersive game environment keeps the player engaged with short term goals ensuring long term engagement over the items of the quest list. Dessert Oasis is the end goal of the game can be seen visually the environment is designed in such a way that visual representation of the end is the centre piece. High Fives are small appreciations given to the player every so often to make the player feel good about themselves. Crowning happens when user earns wins or receives a great gift or status in the game. Anticipation Parade promotes the almost there feeling that increases as the player gets closer to the end, creating anticipation towards the end reward. Aura Effect is when certain people have that personality trait that draws

people to them. When a player start establishing a gathering around him or his character, Step-by-Step Overlay Tutorial provides a way for gaining mastery and understanding how to be better at the game helps during the on boarding or the commitment phase of the game. Playing throughout the challenges of the game and facing and defeating the biggest challenge yet faced in the game fills the player with sense of accomplishment this feeling is achieved through Boss Fights.

4.4 Application of Octalysis

In order to better understand how Octalysis can be applied Super Mario was taken as an example. Super Mario was chosen because it is well known and can be used as a benchmark in understanding Octalysis elements when Super Mario receives 322 total score over 800.

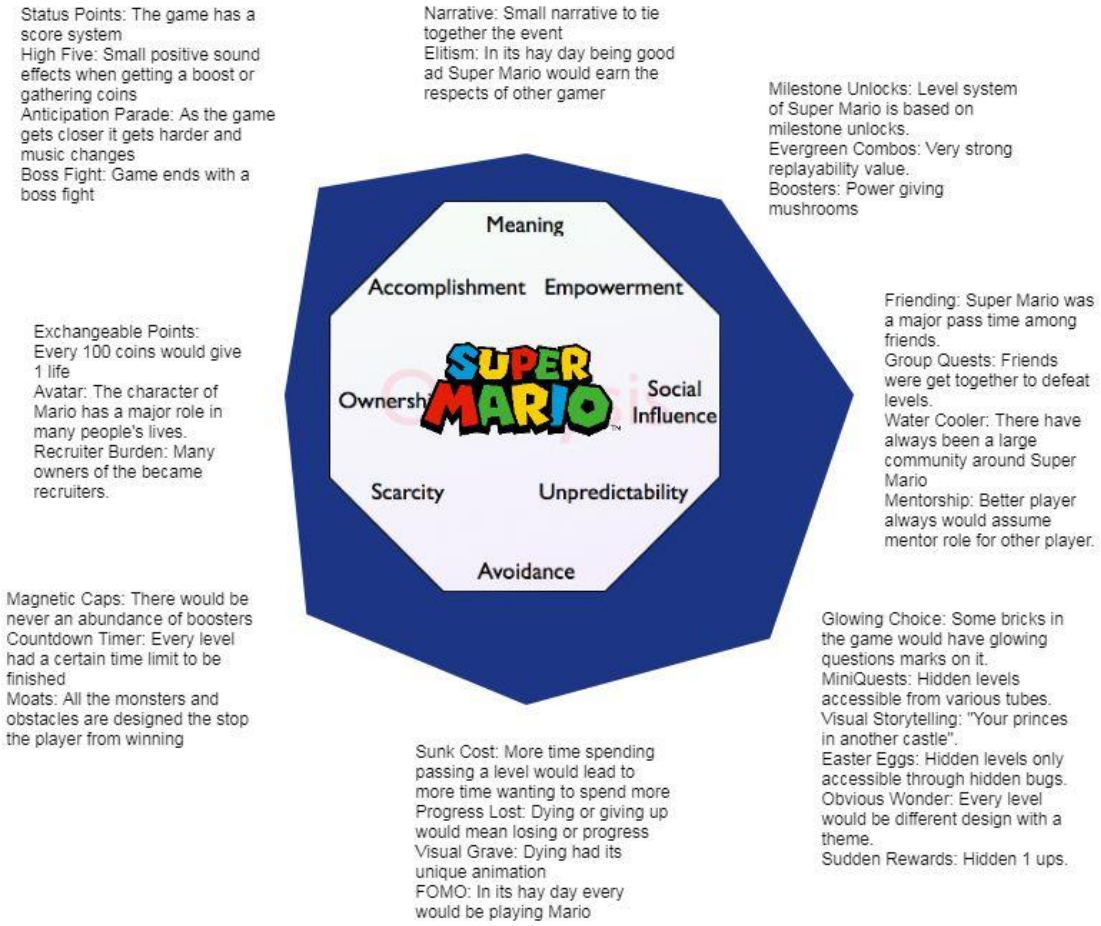

Figure 6 Octalysis of Super Mario

It can be seen that Super Mario gamification is based on social aspect, unpredictability and loss avoidance. While, receives the least points form epic meaning and ownership. But it is important to note that in the Atari game console days having the Super Mario itself was important status and feeling of ownership. But analysis was conducted for in game elements and mechanics. In addition, analysis is highly subjective there and breaking down every element of the game can be up to interpretation on which element of Octalysis might cover it. Though Super Mario scored 322 over 800 less than 50% it was a very successful game which preserves it value to this day. But, Super Mario might not catch the same fame and follower base if it was released today. Though there have been many new releases of Super Mario they have failed to catch the same success as the original. Therefore, it is critically important to consider the context of where, who and when the game is being released and used. In the end while using Octalysis approach similar to Delphi method could be employed to overcome objectives problem. Though the analysis might not be enough to tell if the game will ultimately be successful it is definitely an important tool to measure which core drives the game speaks to.

4.5 USGDM Project Team Position Suggestions

NHL Stenden University has created a unique model for serious game development team. This model distributes project team's roles and responsibilities on the system engineering's v-model. There are six roles designed.

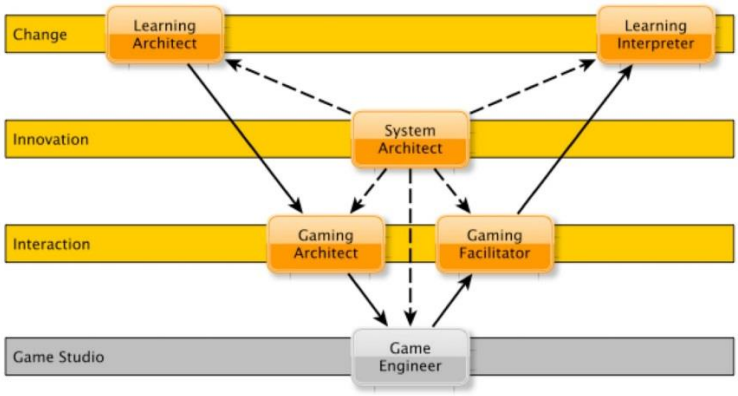

Figure 7 Project Team's Roles and Responsibilities[2]

[2] https://www.stephankloer.nl/index.php/masteropleiding-serious-gaming/over-de-master

Learning Architect, works on the developing the learning goals and training/education design. *Game Architect* translates learning goals and educational design into game design. *Game Engineer* develops the game into a product or service. *Gaming Facilitator* works as the presenter/trainer for the game one the game is in operation. *Learning Interpreter* analyse the impact of the serious game and its effects on the individuals or the organization. Finally, *System Architect's* role is to oversee all the process and ensure the cooperation of the interdisciplinary roles and responsibilities. It is very critical to indicate that one person can fulfil all the roles illustrated above. Nevertheless, depending on the size and scope of the project is possible to assign these roles to different members of a team.

The v-model was extended to fit the USGDM. The nature of the methodology is to bring together various stakeholders in an iterative way for developing serious game. The six roles designed fits perfectly to the knowledge and skill requirements of the USGDM. Combination of learning and game architect brings forth the key requirement of serious games; blending of education gamification. Furthermore, by including defining the developer as game engineer the model enables game development expertise to be involved in the serious game projects. Finally, by creating two roles of gaming facilitator and learning interpreter model brings two key stakeholders and their expertise from the in-operation phase to the project from the beginning. Thus, enabling a future oriented design approach. Finally, USGDM takes its core principles from system engineering approach because of the multidisciplinary nature and complex stakeholder needs of serious games. As model suggested including a system architect would greatly increase the implementation success of the USGDM and coordination of the different roles need for the development process.

4.6. Principles and Values of USGDM

USGDM takes its core principles form system engineering and its values form behavioural economics. The principles shape the process and the nature of the methodology and its direct impact can be seen very clearly in its design. The values are not represented in the work-packages or the phases. The values are there to remind the user of the USGDM that this methodology is a human oriented one.

While using the USGDM the developers need to beware of the key assumptions of behavioural economics are good source of guidance to achieve behavioural change and learning. In the end the single most important value of USGDM is that serious games are an effective tool for individual behavioural change.

4.6.1 System Engineering Principles

Structures that are formed by combining components that have different functions to fulfil a purpose or achieve a goal are called "systems" (Simmons, 2014). System engineering is an interdisciplinary approach that gathers tools and methods for the developing a successful system (Blanchard, et al., 1990, 17). The main focus of system engineering ensures that systems are accepted by the community, remains functional throughout its lifecycle (Bode, 1967). In other words, system engineering is an approach for transforming operational needs and requirements into a system that can operate in sync with its operational environment (DSMC, 1990). Systems are interacting and integrating with other systems in an increasing rate (Enclosure 12, 2008). This case is most valid for software systems. In order to ensure this connectivity Systems and Software Engineering Life Cycle Standards has been developed (5 ISO/IEC., 2008). Though this standard offers some solution to system development, still many systems fail to fulfil all the requirements and performance criteria. Research into this problem has suggested system's harmony to the staff behaviour of the organization where the system is running is an important to systems success (Henshaw, 2015). This shows the importance of human centred design for systems. System engineering utilizes both top-to-bottom and bottom-to-top approach to ensure requirements of users and systems integration are met (Dahmann, 2015).

The system engineering process covers the lifecycle of a system, from conceptual design to disposal (Enclosure 12, 2008). This process is listed as follows:

- Conceptual Design: Identification of the need, identification of the problem, analysis of the needs, determination of operational needs, introduction of maintenance and repair concept, evaluation and selection of technology, identification of the system on functional basis takes place in this phase.

- Primary Design: functional analysis, allocation of needs and requirements to the functions, trade off decisions during the allocation phase, determination of initial design alternatives, start of the procurement planning. For chosen alternative takes place in this phase.

- Detailed Design: Subsystem and component level designs completed, trade analysis is made, alternatives are evaluated, prototypes are developed, and production planning is done during this phase.

- System Analysis: Evaluation of system functions to determine the fulfilment rates of system needs and requirements.

- Development Phase: Production of subsystems, components and systems finished, activities carried out with the suppliers, acceptance tests carried out, deployment of the system, operational tests and system evaluations are carried out.

- Operational Support: Running all logistical activities including maintenance and repair, operational tests and modification analysis are carried out.

Steps listed above makes system engineering approach an ideal candidate for serious game development methodology. In its essence serious games are combination of different disciplines. They are heavily human centred. They have various goals, ranging from providing entertainment to acquirement of a specific skill. Sometimes serious games are a single component in a larger training program. Finally, validation and verification processes of system engineering would be crucial in ensuring large list of requirements of educational games are met.

4.7 Behavioural Economics Values

The core goal of the serious games is to achieve behavioural change. Understanding human behaviour is the first step for achieving change. Though this is the case, human decision behaviour is rich, subtle, suggestible and context dependent

(Bertrand, et al., 2006, 25). Behavioural economics provides a unique opportunity for both understanding and using human behaviour itself to achieve behavioural change. Behavioural Economics is an emerging field that works on integrating research from psychology, neuroscience, and sociology to better individual decision making (Lavecchia, 2016, 4). Section below will analyses using behavioural economics for understanding the serious game user and providing a guideline for user oriented serious game design.

The assumptions of classical economic models on "rational" behaviour have been observed to be wrong. People are much more concerned about losses then gains, severely discount future compared to present, prefer to stick with status quo, dislike uncertainty and value fairness. Unless it is a very simple decision people generally do not try to find the optimal solution. Rather than searching for the best, they apply simple decision-making strategies either they stick with what they know, follow others, they are readily confused and prone to misleading advice, settle for something good enough, stick with the default option or avoid the decision all together if deemed too complex (Reeson, et al 2009, 1)

4.7.1 Decision Making Process

Before discussing the methods of effecting the decision making process first we need to gain further understanding on how are decision making process is effected according to Behavioural Economics.

4.7.1.1 Role of Emotions in the Decision Making Process

People have two main systems. System 1 works fast it is similar to an autopilot. It uses habits, emotions and intuitive to decide what to do. System 2 calculates probability, carefully and slowly assesses the alternatives before deciding what to do (Sunstein, 2012, 56). Although people have a system 2 to list the possible benefits and find out the most optimal and rational choice, most of the time people decide with emotions. In one study effects of emotion on decision making was test on a patient who lost the ability to experience emotions due to a brain damage. When asked to pick a date for the next appointment few days apart, patient proceeded to

enumerate reasons for and against each of the two dates: previous engagements, proximity to other engagements, possible meteorological conditions. For a half hour the patient continued his cost-benefit analysis, outlining, comparing options and possible consequences. When the team told the patient which day he should come he simply said “that’s fine”. This test is a clear indicator that system 1 and emotions has a major part in our decisions. In the end after faced with all the different choices emotion becomes the main motivation for choosing among them (Sunstein, 2012, 57). Therefore, serious games’ ability of creating emotions through game play could be an immense opportunity for training. Thus, while designing serious games it is critical to attach emotions to the learning outcomes. It can be argued that in the future when the user is utilizing his/her training system 2 will recall the training material and system 1 will be able to remember the emotion associated with that decision, thanks to the ability of serious games on creating emotions through game elements.

4.7.1.2 Heuristic Decision Making Process

The fundamental problem of system 2 is that emotions can be manipulated and affected. Some effects are biological. For example, a study has shown that parole judge rules in favour of the prisoner decreases over the course of the day until the judge has a food break: Following lunch, the judge’s likelihood of approving parole exhibits a discrete increase (Kamenica, 2011, 12-13). This case is a stark revelation on human decision making. It is also important to note during serious game design human biology should also be considered. For example, the same study has put forward an idea of choice fatigue. People have limited cognitive resources and many decisions to make. Although, emotions are a major effect people still have a desire to make the most optimal choice. Therefore, in economic terms use heuristics to reduce the cost involved in thinking (Reeson, et al., 2009, 11). Heuristics are ‘rules of thumb’ faced with a decision people search their memory to select the most familiar option. By using heuristic approach to reasonable approximation they achieve a pattern-matching based on logic and experience (Reeson, et al., 2009, 13). Thus, it is important to design the serious game with pattern-matching stand-point. The experience user will have during the training session should be similar enough to the real life that in the future it can be recalled by heuristic pattern-matching. The reason

why system engineering inspired development approach in many steps has underlined the importance of involving subject matter experts before the test phase. They will be able to comment on the similarity of game experience to the real life scenarios.

4.7.1.3 Role of Feedbacks in Decision Making Process

As mentioned above even though human decision making is based mainly on heuristics and untimely the final decision lays with the emotions, there is a desire for choosing the most optimal choice with cost efficient cognitive effort. Therefore, there is an inner mechanism that optimizes heuristics. In the absence of any feedback people are unlikely to change their decision-making strategy (Reeson, et al., 2009, 11). To help people make good decisions, it is more beneficial to provide clear and simple feedback on the outcomes of decisions. Rather than providing large amounts of information in advance. If people do not receive any feedback they are likely to convince themselves that the decision they made was actually correct and therefore they have no reason to change their behaviour (Reeson, et al., 2009, 17). This is a crucial piece of information for serious game design. Rather than providing the information about the correct course of action the training should focus on enabling the user to choose an option and live out a scenario and provide positive or negative feedback (Sunstein, 2012, 44).

4.7.1.4 Role of Choice in Decision Making Process

People value freedom of choice and often dislike having their choices overridden, punished, or even significantly influenced in essence they like choosing and want to choose for themselves (Sunstein, 2012, 44-46). This is a strong argument against mandatory trainings. By taking away the choice of the user, according to this suggestion it should be expected for user to have negative opinion towards the training without considering the necessity, subject or method of training. Therefore, it could be an idea to offer choice of dates or deadlines to mandatory training to protect the freedom of choice of the user to some degree. It is also important to note that digital serious games provide distributed training opportunity to further enable flexibility of training locations and times. It is important not to forget as a

fundamental treat Individuals value the ability to control their lives, paths, and choices (Amir, et al., 2008, 19).

Related to game design, the findings argue that more choice, tool options or mechanics within its game elements could provide more entrainment to the user. Although this is the case it was found out that ability to make choices is depleted over time particularly if the decision maker has had to make taxing decisions in the recent past (Kamenica, 2011, 13). Thus, it should be noted that there should be a balance of choice and game pace. The pace of the game should be designed to enable relaxation periods. For serious games it is also critical to avoid cognitive energy depletion from playing the game. Such case could have detrimental effects on the learning goals of the training. Moreover, abundance of choice coupled with stress could lead to stress choking (Kamenica, 2011, 13.8). Unless serious game specifically focuses on stress such choking points should be avoided in order to protect the pace of the training.

4.7.1.5 Role of Short Term Gratification in Decision Making Process

It has been strongly suggested that people downplays the importance of future and overemphasize the present (Lavecchia, et al., 2016, 8). Therefore, when faced with a spending time in a training course as oppose to possible future benefits behavioural economics suggests that the trainee will choose the immediate benefit. A study has shown that even if the investment appears to pay off in the relatively short-term consumers are unwilling to participate. The study argues that this is because the benefits are not clear enough (Sunstein, 2012, 1826). It is important for serious games developers to note that while trying to convey the short-term benefits of the training, it is critical to be realistic and believable. It has been put forward that short-run gratification is valued more than long-run preferences (Sent, 2004). This is also a good argument for using serious games. It is possible to promote the entrainment element of serious games to appeal to short-run gratification. It is also important to note here that training that directly relates to the users' career development is can also be considered as a short term gain, while safety or awareness trainings' short term benefits are harder to justify. As for the educational content of the serious games short sightedness provides an important obstacle. When training a user for a

possible scenario if the probabilities are difficult to predict studies has shown that user tends to be overconfident about user's knowledge and/or abilities than what would be warranted by facts (Acquisti, 2007). It is critical to identify these areas where the users are analysed to be overconfident and incorporate these areas into the serious game in order to provide reality like experience to balance the overconfidence of the user. Faced with short sightedness and focus on short-run gratification, motivation becomes highly important for achieve behavioural change.[3]

4.7.2 Nudging in the Decision Making Process

4.7.2.1 Nudging

Arguments given in the section above suggests human decision making is not perfect, biased and can have inaccurate calculations of expected benefits and costs. Despite, knowing self-biases system 1 induces people to continue making emotional decisions. Although, this is the case system 1 has its certain preferences and it is argued with human interference and design that these preferences can be used against system 1 as a corrective measure (Amir, 2008, 11). While people are not optimizing machines, their behaviour is predictable and even more predictable when it departs from economic rationality. These insights can be applied to form a choice architecture to nudge people in beneficial directions without restricting freedom of choice (Reeson, et al., 2009, 15). For example, it can be as simple as providing distilled information to help people think more carefully about a decision (Amir, 2008, 11). By designing the decision environment, it is possible to have significant impact on decisions thus human behaviour (Reeson, Andrew et al., 2009, 15).

One of the most efficient ways nudging the behaviour is framing. Numerous studies show that the way the information is framed can affect individual's behaviour. For example, by framing an option as a default greatly increases that option being chosen (Kamenica, 2011, 13.2). Furthermore, in an awareness campaign about "The Benefits of Mammography" participants were randomly assigned two conditions, half viewed a gain-framed video showing the benefits of Mammography while other half was shown loss-framed video showing risks of neglecting Mammography. Liking of the video was not affected by the framing. However, while 66.2% of the women who

watched the loss framed video obtained a mammography, 51,5% of women who watched the gain framed video obtained a mammography (Bertrand, et al., 2006, 18). Therefore, it is empirical to understand how the information is presented is as much as important as the content of the information.

As mentioned before human decision making process heavily relies on heuristics and pattern-matching. It can be argued that by achieving the desired behaviour through choice architecture during the serious game it is possible to create heuristic data to be used by the user in the future. The section below will argue methods of implementing nudges into serious game design to achieve behavioural change;

4.7.2.2 Nudging the Behaviour with Motivation, Rewards & Incentives

There are various definitions of reward. Sometimes, it can be used as a synonym for reinforcement, or in reference to "appetite" or "primary motivation", while it can also refer to "pleasure". Main motivations of humanity can be surmised as happiness of family, control over lives, social status or enforce sense of purpose in life (Sunstein, 2012, 40). This section will focus on using rewards as a primary motivation and pleasure (Salam one, et al., 2009, 1). Rewards can be offered to increase commitment and performance of the user. At the same time by rewarding favourable behaviour it is also possible to enhance future behaviour (Lavecchia, 2016, 24-31).

A study on blood donation has shown that when blood donators received one-day paid leave donations for existing donors to make one extra donation per year, an increase of approximately 40% and presence of incentives increases the number of donors by approximately 15%–20% (Kamenica, 2011, 5-6). It is a clear indication that incentive motivated already committed individuals to increase their participation also helped accruing new participants. But there is balance to reward to performance ratio. A study gave the users of psychical fitness app users GOODcoins as a reward for motivation. The results found, when rewards were between 201-300 GOODcoins, %65 of the participants completed the challenges. As rewards were raised to 401-500, completion dropped to %55 and for over 600 coins, completion was under %47.

The study explained this decrease as more reward did not mean more completion due to effort oriented decision making process (van Mierlo, et al., 2016, 6).

Although, rewards can be motivated people have a complex relationship with rewards. People who are rewarded for a behaviour that they would otherwise have found interesting and enjoyable consequently, can view the behaviour as less attractive. During a classroom experiment children were observed to play with magic markers during their free period. A "good player award" was offered to play with magic markers while the control group was not offered any incentives. Results found that while children who did not receive an award showed no decrease in interest other children showed little interest in the markers (Bertrand, et al., 2006, 9). As a possible explanation an experiment suggested that when a reward as a motivation is offered individual could assume that the activity is not enjoyable and thus forgo it, even though if they have tried it they might have enjoyed the activity.

While more rewards can lead to less willingness to participate and decrease of productivity, it is argued that charging or a possibility of loss can be more motivational (Kamenica, 2011, 13.2-3). It has been found that incentives framed as losses appear to outperform those framed as gain (Levitt, et al., 2012, 24). This phenomenon explained as the exposure to monetary or equivalent incentives crowds out intrinsic motivation and therefore reduces interest in the activity (Kamenica, 2011, 13.4-5). Positive effects on participation and enjoyment from group based challenges (van Mierlo, et al., 2016, 6) has identified the impact of how beliefs about peers' attitudes strongly increase the willingness to participate in an activity. From the serious game design perspective points, leader boards, achievements/badges and progress gains meaning and becomes much more motivational with peer observation, participation and social status gain.

It is beneficial to include group based activates within the training, the peer relation in itself become the main motivation and without any other rewards gain of social statue becomes its own reward. Furthermore, a study into motivational affordance has found that the ability to exert effort, sustain work, overcome obstacles, and attain access to motivationally relevant stimuli is a part of human nature (Salamone, et al., 2009, 4). Therefore, levels, story/theme, clear goals, feedback, progress and

challenge designed in a way that give the feeling of effort and overcoming an obstacle it should be motivational for the user (Hamari, et al., 2014, 3027). From the reward as a pleasure view point, previous studies on games have shown an increase in continuous playing and perceived enjoyment (Hamari, 2015, 300).

Another study suggests when people receive incentives even before starting the actual task they become willing to participate and complete the task given all the participants receive the same amount of initial incentive (Acquisti, Alessandro et al., 2007, 371). In conclusion entraining serious game and training is its on motivation and reward therefore first and foremost aim of serious game should be achieving entraining training.

4.7.2.3 Using Loss to Nudge the Behaviour (Loss Averse)

In the way choices are presented or in the way information is conveyed can lead to large changes in behaviour (Lavecchia, et al., 2016, 4). People are highly risk and loss averse. A fully rational economic agent is indifferent between $50 and a 50% chance of $100 or $0. However empirical studies show that most people are risk and would prefer the certain $50. The degree of risk aversion varies between individuals; some can be risk seeking for a higher payoff. Loss aversion is quite an interesting and important part of human behaviour. People tend to give potential losses greater value then than potential gains. Even if two options are in economic terms equivalent people are far more tolerant of a foregone gain than a loss.

Loss has a far greater motivating effect. This effect is so great that by simply changing the wording from “keep” to “lose” can cause a significant proportion of people to change their behaviour (Reeson, 2009, 4-6). As mentioned before some people are risk takers, this situation can be explained also be explained by loss aversion, people become risk seeking when the result is perceived as a loss relative to their starting point (Kremer, et al., 2013, 447). Due to this effect raising perceptions of the likelihood of bad outcomes does not guaranteed to reduce risk-taking behaviour (O'Donoghue, et al., 2001, 64). While designing the educational module of the serious games it is important to frame the training from the loss perspective. But this loss perspective should not be boiled down to listing negative outcomes of the

future. Serious games provide a unique opportunity to let the users lose a certain scenario and learn from their mistakes.

Furthermore, loss aversion is also a useful tool for motivating users to participate in the serious game training. The training can be justified in a loss framing similar to food stamps campaign. A research suggested that while trying to convince people to participate in food stamps rather than using "Getting food stamps helps you buy good food for your kids" it would be more effective to use; "By not enrolling in food stamps, your children are being deprived of essential nutrients"; or "Every month you go without signing up for food stamps costs your child." (Bertrand, et al., 2006, 18).

Finally, a study on time pressure and loss awareness has shown that: "When recruited students of a theological seminary to deliver a practice sermon. Half of the seminarians were led to believe that they were running ahead of schedule, while the other half believed that they were running late. On their way to give the talk, all participants passed an ostensibly injured man slumped in a doorway, coughing and groaning. The majority of those with time to spare stopped to help, whereas among those who were running late, a mere 10% stopped, and the remaining 90% simply stepped over the victim and rushed along. Despite years of ethical training, biblical reading, and contemplation of life's lofty goals, the contextual nuance of a minor time constraint proved decisive to the decision to stop and help a suffering man" (Bertrand, et al., 2006, 10). This case gives us two essential clues for serious game design; first, the motivational power of lose is so great that it can over write system 2 completely, second, time pressure is a useful tool to create motivation serious games.

4.7.2.4 Using Status Quo Bias to Nudge the Behaviour

People prefer status quo, individuals choose not to look for solutions or alternatives. They prefer, on average, for things to stay relatively the same (Acquisti, et al., 2007). People tend to value things they already have more than things with equivalent value. The amount a person is willing to pay to acquire something tends to be less than the amount they would be willing to accept to part with it. Parting with something

triggers loss aversion in the human mind. Therefore, due to fear of incurring a loss people tend to stick with the status quo.

Furthermore, increasing the uncertainty compels people to neglect potential gains even more. It should be noted that status quo bias can be overridden. Status quo bias was not observed in professional traders while selling their stocks (Reeson, 2009, 4). Yet, such behaviour is another form of loss aversion. Simply, experienced trader has more heuristic data that lets the individual know sticking to a losing stock increases losses. Therefore, from the serious game design point it can clearly be seen that there is a natural inclination of people to stick with their current behaviour. Best way to overcome such inclinations is providing experience where the original behaviour leads to loss.

A savings program has shown that simply telling and encouraging them to save more proved ineffective. Thus, serious games where the game tries to show the right way should not prevail to achieve effective behavioural change. In the end the savings program got participants to pre-commit a portion of their next pay rise to a savings fund in a non-binding agreement. Then, status quo bias meant people stick with the commitment (Reeson, 2009, 15-16). This solution is shows the importance of framing effect. The presentation and context of choices influence decision making (Kremer, et al., 2013, 447). Therefore, it is curial for the educational aspect of the serious game focuses on presenting their learning out comes to appeal to the loss centric views of the individual.

4.7.2.5 Using Hyperbolic Discounting to Nudge the Behaviour

Hyperbolic discounting is where future benefits are discounted against the present (Reeson, 2009, 4-6). Usually, serious games focus on future quite heavily. It is in the nature of the serious games to achieve future behavioural change as in any training or education. In this case hyperbolic discounting works against serious games. Furthermore, devaluation of future also causes probability neglect. In which individuals under calculates the probability of a bad thing happening. This devaluation increases even more when such events are difficult to picture mentally (Acquisti, et al., 2007, 371).

This is an important point to note for serious game design. Serious games have a unique opportunity to provide the environment where the individual can live through the worst case scenarios and create mental images. This does not only prepare the individual for the worst case but also help overcome hyperbolic discounting thus, increases the readiness of the user. Although, importance and probability of future is discounted in some cases the contrary case can be seen. Affect-rich outcomes, involving in-tense emotions, are likely to produce probability neglect. But contrary to a discount this neglect means an increase on the perceived likelihood of the event happening. Such cases usually happen when strong emotions are involved, it was suggested that when people are asked how much they will pay for flight against "terrorism," it was found out that they were willing to pay more than flight insurance for monetary losses from all causes. It was argued that word "terrorism" evokes vivid images of disaster, thus effecting probability judgments. Such effect also should be utilized by serious games. Therefore, serious game should create negative events as vivid and as realistic as possible to allow the mind the feel the real situation. Such experience as suggested by the example above could be useful to overcome human instinct to down play a negative event and help settle the positive behaviour (Sunstein, 2002, 1298).

4.7.2.6 Using Equity Fairness and Reciprocity to Nudge the Behaviour

Despite being highly loss averse laboratory experiments has found that participants were often willing to settle for a smaller payment provided everyone gets the same (Reeson, 2009, 8). This behaviour is tied to inequity aversion. Because of this aversion individuals express discontent when other individuals are treated unfairly or others receive rewards they do not deserve (Acquisti, et al., 2007, 371). While designing serious games that involves multiplayer game elements especially games where players play against each other it is not just enough to balance the gameplay it is also critical to balance the individuals level of competence and knowledge. An imbalance in the competing players will end up alienating the rest of the participants. Importance of fairness leads to individuals often sacrificing their own interests for the sake of the greater good.

While working for the greater good individuals become willing to cooperate. Neuro-economic studies suggest cooperating with others can be inherently rewarding – it stimulates areas of the brain associated with reward processing, more so than more profitable non-cooperative actions (Reeson, 2009, 8). From serious game design point of view this studies shows us that games that have cooperative gameplays can lead the players to engage and enjoy themselves more during the training. But it is important to note that individuals do not cooperate unconditionally, people contribute when others do the same but if some do not participate in the cooperation they stop (Reeson, 2009, 8). It is important to note for comparative serious games even if the serious game's design has no flaws and inherently entraining if the cooperating partners has a different participation levels they might end up effecting the rest of the party to decrease their level of engagement.

4.7.2.7 Using Uncertainty Aversion to Nudge the Behaviour

Individuals are uncomfortable with uncertainty (Reeson, 2009, 13). This behaviour also extends to serious game mechanics and gameplays that users do not understand. If the user feels a degree of uncertainty about how to play the game they according to uncertainty aversion they will feel uncomfortable towards using the game. This sort of ambiguity about the game is not resolved by providing more information to users about the game and how to play i.e. rulebooks, how to play guides etc. It is best managed by face-to-face communication or personal contacts as a source of expertise (Reeson, 2009, 18). Therefore, best option is to have personal one-to-one walkthrough of the game. In many cases such action is not feasible it is critical to have users in groups who are experienced in games to quickly understand the game and teach others and tutorial levels that teach the gameplay in easy and linear steps.

Another side to uncertainty aversion is that, when individuals gain information to resolve uncertainty they tend to give it more weight than the same information if they received it from the start (Reeson, 2009, 18). Therefore, in serious games rather than giving all the training material from the beginning the game should be designed in a way to create information gaps that lead to uncertainty where the user has to complete a specific action to gain that missing information. According to this study then user will give more value to that information thus, increasing the longevity of

the knowledge. Furthermore, in the face of uncertain odds people are unrealistically optimistic and if they receive information that is better than expected, they are likely to change their beliefs but if what they learn are worse than expected their beliefs stay the same (Sunstein, 2012, 18-19). It is important not to expose individuals with negative facts to achieve behavioural change, according to this study for example for a cyber-security related training exposing the individuals to factual numbers about yearly attacks will not achieve the intended effect but, will be ignored by the user.

Although, individuals are uncertainty averse there is a limit. If the cost of learning something regarding a decision is perceived to be higher than the resulting benefit that decision individuals apply rational ignorance and do not spend their time (Acquisti, et al., 2007, 372). Rational ignorance effect is a major problem for serious games. Users especially for mandatory trainings can consider the benefit gained from the training as lower then time and effort spend during the training. Serious games have the advantage to provide entertainment and emotional gratification in the short term, for cases of rational ignorance it is critical to empathize the notion of not spending time in this training is time missed form entertainment and emotional gratification. But, in order to promote this notion, the serious game itself has to be truly entraining.

4.7.2.8 Using Default Choice to Nudge the Behaviour

Individuals have a limited ability to make decisions, throughout the day this ability decreases. While more information can help individuals to make better decisions increasing the number of choice does not have the same effect (Lavecchia, et al. 2016, 15). The limited cognitive capacity and attention further burned by other concerns such as money time or other circumstances. In order to optimize the finite resources picking the default choice becomes a cost efficient solution (Lavecchia, et al., 2016, 19). Therefore, by changing the default action it is possible to modify the choice environment and influence the decision (Kamenica, 2011, 13). Serious games usually require the players to make many choices. In a case where a certain choice architecture is needed without interrupting the flow of the game it is a good option to design the choice in a default formant increasing the likelihood of that choice is taken. Furthermore, previous sections have discussed the importance of freedom of

choice for individuals, while mandatory trainings are needed it conflicts with freedom of choice. This could be overcome by providing a default date for training but also allowing for a reschedule options. Thus, it is possible to have mandatory trainings that do not override individual's choice.

4.7.2.9 Using Anchoring & Priming to Nudge the Behaviour

In an experiment when customers were exposed to French or German music in a grocery store, they were likely to buy French wine when French music was playing, but they were likely to buy German wine when the music was German (Kamenica, 2011, 16). Using this effect on purpose to effect decisions is called priming. In another study priming was observed during a polling to raise taxes in order to increase the spending on education. Voters who were assigned to vote in schools were more likely to support the increase (Kamenica, 2011, 13.14). Anchoring is similar to priming. It happens when people focus on an initial piece of information, even if it is uninformative. As a sales tactic anchoring can be used by "price reduced" signs to make a good appear cheap (Reeson, 2009, 6). Priming provides an interesting opportunity for serious games. While designing the training environment or the digital 3D environment in digital serious games it is possible to design in such elements that can be used to prime the user and help embed the training further. Furthermore, by providing information that will be utilized later on by the user anchoring effect can be achieved therefore providing an alternative way of providing memorable information during the serious game sessions.

4.7.2.10 Using Channelling to Nudge the Behaviour

Channelling occurs when barriers are removed and achieving a certain goal is made easier in order to guide behaviour. During a communication campaign about vaccination, it was observed turnouts were greatly increased when a map with directions to the health centre and its opening hours included with the information package. This study showed removing any barriers real or perceived is important when seeking behavioural change (Reeson, 2009, 19). Channelling effect indicates that individuals are less willing to engage in certain actions if they perceive them as hard or the action is surrounded with ambiguity. For non-gamers serious games can

be a challenging and complex task. In a workshop for increasing bank usage among the low income families it was observed having a bank representative on-site increased registrations (Bertrand, 2006, 13). Having an expert assistance present could help reduce anxiety of making mistakes as well as simplifies the process without needing detailed instructions and review. Furthermore, having an expert present cold enable personal encouragement to empower individuals to engage further (Lavecchia, et al,. 2016, 45). Though digital serious games offer an opportunity for distance learning it is important to note the engagement can be based on inclination of the target users towards gaming. As stated before, individuals who are not accustomed to gaming could need a helping hand to warm them to the concept of gaming. In addition, a study on school choice for parents showed that simplified information led parents to choose higher quality schools (Lavecchia, et al., 2016, 71). Therefore, it is also important to note that while designing information regarding the how to play it is important to make it as simple as possible.

CHAPTER 5

DEVELOPMENT METHODOLOGY CASE STUDY

In the game industry term, mammoth design refers to spending more time and effort on the design process before the development phase, while agile development is referred to as little to no design document being needed to start the development project. Only idea and concept of the game is enough to start the development process. In this model game is developed in build cycles playing and adding new functions becomes the iterative method of development. In the age of early access game market this method is being highly used especially by indie (Independent) game developers. This flexibility of game design and development is important to keep in serious game development. Not every serious game has to have a mammoth design document. Particularly designing "fun" in game design documents is a notoriously difficult and often futile effort. As the common development survey in the previous section stated, achieving fun and entertainment is a common problem for serious game developers. Therefore, USGDM has been developed to be adaptable to both mammoth and agile design principles. The section below will analyse two case studies applying the USGDM for two different types of serious games with different design approaches. Counter Improvised Explosive Devices training serious game will analyse how mammoth design approach applied to USGDM while Integrated Logistics Card Game case study will discuss how the USGDM can be utilized for an agile approach.

It took nineteen serious games of the course of seven years to finalize the proposed methodology in this study. Though the case study section will focus on two examples so far the methodology has been tried on additional three serious games; NATO STO SAS-129 Research Task Group's Multi-Domain Future Urban Warfare game, Logistics Boardgame developed for Ankara Logistic Centre and Critical Infrastructure Cyber Security Boardgame developed for Presidency of Defence Industries and Turkish Cyber Security Cluster.

5.1 Squad Level C-IED Training and Awareness Serious Game Case Study

As the face of modern warfare changes, one of the biggest threats faced in asymmetric warfare are improvised explosive devices (IED). With the increasing technological capabilities and introduction of new IED tactics it is becoming increasingly difficult to protect the personnel under IED threat. Counter IED effort can be gathered under three pillars; Defeat the device, attack the network and train the force. Current solutions of training the force can be improved by the utilization of serious games. Serious games can be the next step on military training due to the ever increasing and ever so popular game technologies. With this in mind multiplayer counter IED (C-IED) serious game project were started in Turkish Military Academy, Science and Technology Institute. A concept prototype and a BETA version were developed. Three dismounted infantry squads with previous IED training that have served in active duty and encountered IED attacks were invited to test the serious game. Teams' reactions were tested for the purpose of fidelity. In addition, a questionnaire was provided to the participants to measure the effectiveness of the training course. The following section will provide example of USGDM application from the C-IED serious game case study.

5.1.1 Inception Phase

Improvised explosive devices are one of the biggest threats in modern warfare. IEDs are typically the main weapon choices in asymmetrical war theatres. IED related deaths were increased in constant rate between 2001 and 2011 (Kotwal, et al., 2011). After the introduction of three pillars of counter IED effort; "Attack the Network", "Defeat the Device" and "Train the Force" (Eisler, 2012, 9-15). There has been consistent decrease in the number of causalities in Afghanistan as it is shown in Figure-5.

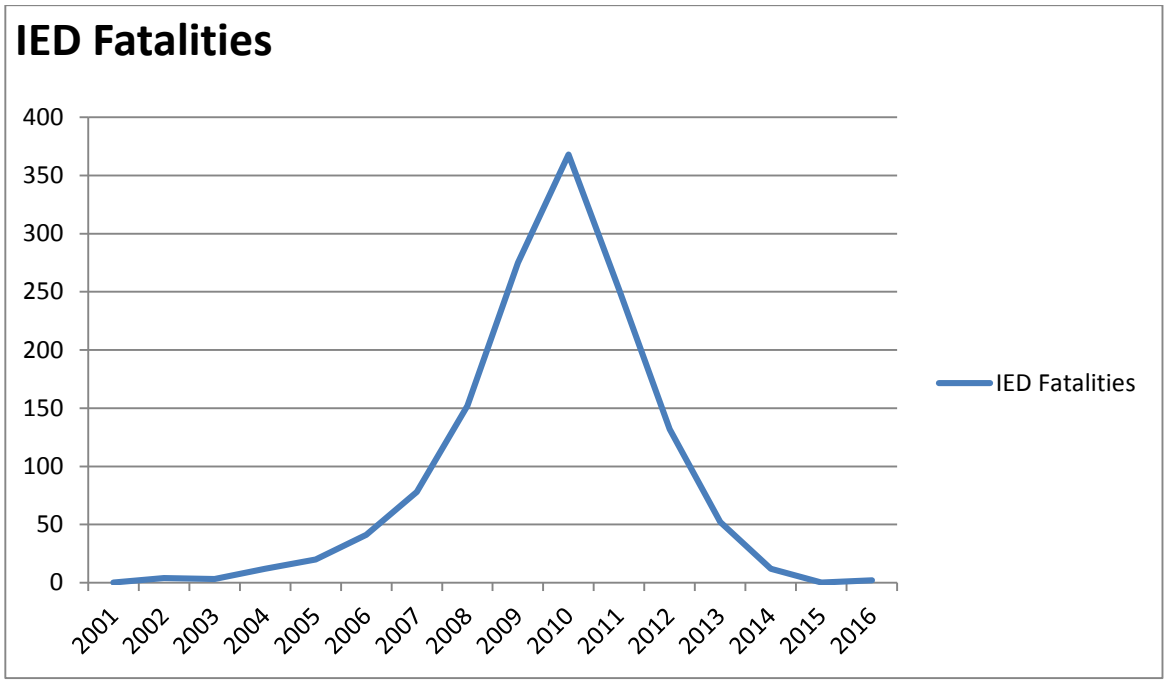

Figure 8 U.S. IED Deaths in Afghanistan by Year.[3]

A similar study was conducted as a terror pattern study for Turkey in Turkish Military Academy, Defence Sciences Institute. IED attack numbers and casualties have been constantly rising from 2010 to 2013. IED threat in Turkey has reached its highest devastation in 2015. Asymmetrical warfare in home front compels armed forces into disadvantage of protecting everything (Blank, 2003). All the roads, country side, mountains and urban areas are considered as to be protected. When a threat is identified within the logic of domestic counter terrorism operation, immediate intervention is required. This causes arms race, armed forces are constantly coming up with new methods, tactics and technologies to counter IEDs, while new IED deployment and trigger methods are being developed by the terrorists.

This struggle is creating a huge data flow on new tactics and counter measures. This data could be used to gain an insight on future IED threats and possible preventive counter measures. This data is vital for training the force and turning these lessons learned to permanent information that can be updated and carried to the battlefield in

[3]U.S. Fatalities in and around Afghanistan, Support iCasualties, Retrieved on 29.08.2018 http://icasualties.org/oef/

the minds of new officers. With this idea in mind, two master thesis studies were started under the Turkish Military Academy, Defence Sciences Institute with the task of completing the need analysis and detailed design of training system for countering IEDs in the form of a serious game. Though Serious Games are not widely used, they possess a certain potential. In its essence, serious games could be a key visualization opportunity for years of IED experience (Kirkley, et al., 2005).

The research done under the Defence Sciences Institute stated that key problems with developing a serious game there is gap of communication and mutual understanding of terms among armed forces, defence industry and game developers. During the development process, there are three parties involved armed forces as customer, trainees as end users and IED experts as subject matter experts. Years of experience meant a long list of needs, and the development and usage restriction of the armed forces posed strong strains on the end product. Further, using game technologies for motivation and better learning opportunity has no strong framework to follow. Serious gaming has not been tried before in Turkish Armed Forces for training and education purposes. Given said problems to consolidate all the parties involved, System Engineering (SE) was decided to be implemented during the development process. The game development processes were incorporated to serious game development and System Engineering. In this paper, the nature of this new method and lessons learned from the development and test of the prototype and a beta version will be discussed, as well as the serious game design document that has been developed during this study.

When faced with the questions “Can this training be gamified” and “Should this training be gamified” regarding counter IED training, we set out the discover concepts of IED trainings within the Turkish Military. We found that current methods where based on educational videos – real and animated, real life training field and printed literatures supported by visual contents. The common theme for all the training were visual contents, this showed us the importance of such content. This was our first link to serious games. Furthermore, the real tactical environment of modern warfare is heavily replicated in digital games throughout the years. Finally, we found out that similar attempts for C-IED training using digital serious games have been made by different militaries. Literature review of these games pointed out

due to the inadequacy of artificial intelligence, multi-player systems were preferred to enable a realistic combat environment (Schneider, et al., 2005, 6). Though, single player modes where utilised for teaching the fundamental principles of the training and core gameplay elements (Nieborg, 2004, 4). Most of the games where designed as first person shooter games and all the game elements such as uniforms, weapon models and environment were realistically modelled, including weather conditions. Teams were made up of 1-14 users, and separated into different roles like medics etc. (Schneider, et al., 2005, 6-15). Classic digital game combat dynamic of death player being cut out of the game became a problem for serious games; being cut out of the game meant being cut of the training. In order to solve this other games allowed the user to respawn after a time penalty (Nieborg, 2004, 4). Combat bullet mechanics were also presented a problem, while bullets were not affected by gravity upon impact the damage they caused with respect to their impact point was based on numbers rather than psychical damage. As a mid-way solution after receiving a certain level of damage the character was modelled to become injured and required medical help before returning to game or dying from injuries if the help did not reach in time (Nieborg, 2004, 7). After reviewing the serious games while answering "Should this training be gamified" the games were showed to a focus group consisting of possible trainees. Their outright rejection of unrealistic of the combat environment and strong belief on psychomotor skills cannot be training using keyboard and mouse compelled us to leave the combat dynamics out. Training goals for C-IED games where identified as; Experiencing realistic IED tactics, scenarios and adversity tactics. Systems were designed specifically to be easy to use, include various operational environments, use real geographical data to create the 3D environments and allow necessary tools for editing game scenarios. During this game the user plays the attackers role. The user can choose eight different roles; Leader, IED manufacturer, placer, observer, trigger-man, cameraman, financier. Through these roles user learns the phases of planning, situational awareness and defence, entrance to IED placement site, exit from the IES site, IED attack and cancelation of attack (Unrau, et al., 2011, 19). In the end we were able to answer the question "Can this game be gamified" as yes. But we decided that further research was needed if the game should be gamified.

Following the decision to leave out the combat mechanics, it was decided to focus the serious game efforts create realistic environments, IED placement scenarios, and IED placement indicators. A concept prototype was decided to be developed. Unity game engine was decided as the development environment, this decision was made due development teams existing expertise to enable rapid prototyping. Unity asset store was utilised and a 3D environment graphic pack was acquired. Because realism was key the pack was not used as is, but rather Turkish Army elements such as forward operating bases (Üs Bölgeleri) were modelled into the environment. During this adjustment subject matter experts from the military where involved in the design. IED department of Turkish Land Forces were consulted for realistic IED placement scenarios with indicators that could give away the placement of the IEDs. A single player character was included in the game with human like moving capabilities. At certain checkpoints voice recordings played containing orders for the user to follow giving information how to proceed with the game. An unseen IED was placed in the map; if character came in contact with the IED an explosion animation was designed. It was also designed that screen would blacken after the explosion. Though, there was no win scenario when nothing was added after an explosion prototype was criticized, so development team felt the need to add a lose scenario.

Prototype was tested in Turkish Military Academy, Defence Sciences Institute by subject matter experts. Environment was accepted as quite realistic and SME praised the high quality of the 3D environment. Adding in the Turkish elements was also warmly welcomed. It was also argued that scenarios should be extended to include dismounted small squat operation and motorized operation training manuals. It was also argued in addition to C-IED training the game should also include small squad training essentials, it was argued that without the right operational behaviour of small squads C-IED training could not be achieved. SME experts also stated that given the operation environment game should support multiplayer gameplay, with different representing small squad composure. Furthermore, it was added the different types of IEDs should be included in the scenarios. SME experts pointed out that most of the IEDs in the field were discovered through observation and a keen awareness for IED placements was a key for successful observations. Hence, it was noted number and variety of indicators needed to be increased. Trainer module and after action review systems were also stated as future requirements.

It is very important to note that capturing the needs for functionality became much easier after SME were able to observe the prototype. Only after seeing the prototype's capabilities it was made clear to the SME the nature of the serious game and from that point the game became a platform in their eyes hence it was much easier for them to describe the future capability needs.

5.1.2 Elaboration Phase

Requirements were grouped into four main titles: C-IED training, performance and system operating conditions, trainer and after action review module requirements.

In addition to lessons learned from the prototypes and SME interviews, C-IED training learning outcomes were derived from related Turkish Military Domestic Operations Manuals in additions Lessons Learned publications from Education & Doctrine School Command were utilized. From these documents training needs analysis were conducted and were listed. Sixteen main training subjects with 365 requirement objectives were identified (Appendix-A). Recruitment analysis was conducted to make sure the recruitments were detailed enough, doable and not duplicated.

Target audience for the training was benchmarked from the current C-IED training. Usually games have a very specific target audience. Usually this audience is identified but their preferences of game type, age, platform they use and likings. As it can be seen from the previous sections if the target audience of the serious game denies or cannot use the serious game the system becomes useless. This presented a problem given the current Turkish Military C-IED training target a large training audience from officers to serving privates with diverse background of knowledge experience and age. Furthermore, people who already played games were even lower. Finally, common perception was that games were for fun and younger generations. The properties of target audience presented the biggest challenge for using serious games for C-IED training. Prototype was the best place to observe the user-system dynamic and make the final decision on if this training should be gamified question.

Less than 1 percent of the participants had played computer games before. Despite this fact after a brief introduction to control users had no problem controlling their charter as well as understanding the game mechanics. The debrief section and the discussions with the participants led to the following requirements regards target audience; Controls always need to be simple. Number of control functions should be limited. First person shooter dynamics are considered more simulation like. Movements, uniforms, in game equipment and train should be realistic. Serious game should not be framed as an alternative to real live training. In accordance with a military carrier the game missions should be challenging and have a level of frustration, good performance should be rewarded and game should represent the hieratical structure of the military.

During identifying performance and system operating conditions it was evidently clear that military equipment and work environment attributes were presenting the main limitations. These limitations were gathered under 5 topics; Cost-efficiency, easy to set up and transport, system that is already in the inventory, to be able to work outside the secure network infrastructure.

Trainer module requirements were mostly benchmarked from already existing similar systems. During the prototype testing it was possible to identify the unique needs of the system. Non-player observer camera was added to the system to mimic the trainer module during the prototype phase. This observer camera also dubbed as the live presentation camera. C-IED trainer was given the control of this system and after asked what additional functions would be required.

After action review module requirements were divided into three sub categories, Main AAR database, Local AAR database and list of in training data that will be logged. It was important to differentiate between local and main ARR modules. Military requirements were clear on using training within career development planning. At the same time this also contradicted with the requirement that the system needed work in local area network, be a modular system for transportation that was not be connected to the military or public network. An alternative system for creating training records for HR career planning system was needed. Therefore, the main AAR module requirements were developed. The local system requirements

were developed according to needs derived from the prototype and C-IED trainers that participated in the trials based on the needs for debriefing. Data that needed to be logged by the system was divided as qualitative& quantitative. The list was developed based on the learning outcomes. Collection of qualitative data that could not be tracked automatically by the system was integrated into the trainer module as ARR sub-module. Were the recorded training was evaluated by the trainer according to a checklist.

Prototype phase had given a clear idea the type and genre of game best suited for the training. Benchmark research was conducted to determine the industry standard technologies used for development. It was analysed that industry was either using commercial game engines such as Unity 3D, or Unreal or, developing their own game engines. Self-developed game engines provide greater flexibility and security usually trading of graphic quality and cost. Given the system requirement clearly stated that the system will be running parallel to secure network only in LAN. Therefore, security did not have high priority. In addition, development costs were preferred to be kept low. This leads to the decision of using off the shelf game engines. Other factor effecting development technologies were using virtual and augment reality as well as movement capture technology. Expert interviews, trails and testing have shown that off the self-theologies was not robust enough for military heavy duty use. Furthermore, though there was hype around using these theologies within the military. During the prototype phase it was discovered that SMEs and small squad operations members had a belief that psychical skills that they require in the field cannot be thought over computer systems and, stated that serious games were better suited for cognitive skill building. Further they mentioned technologies like motion capture, VR headset and augmented reality with their current status did not provide enough fidelity. Despite actually testing their claims design team decided not to utilize these technologies it was argued that in adult training accepting the benefit of the training by the user is as much valuable as the system being useful. Therefore, adding technologies that carried prejudices to an already alien serious game concept it was decided that the trade-off was not worth it. In addition, interviews with VR SME experts subjected that using the VR headset more than 15 minutes was not recommended. Given the average scenario length decided in the

prototype phase was 45 minutes VR headsets were ruled out as a later option to be added to the system.

Operational environment constraints, requirements and development technologies that will be used gave the necessary information to decide the targeted personal computer that the game system needs to run on. SME were consulted and benchmarking off the shelf game lowest setting hardware requirements led helped the design team identify the minimum requirement for hardware requirements.

Most important decisions and limitations were documented to be referred throughout the development and testing phase. Most important decisions were; System will not try to replicate the real combat dynamics. System will focus on developing cognitive skills and will not focus on developing any physical skills. System will not include VR and augmented reality but development will be made so to allow future integration for testing purposes. System will be limited to local use only. Average trainee of the system will be able to present at least the same level of knowledge as a trainee of the current C-IED training within the Turkish Military. Designing a game from functional point of view is a difficult task. Therefore, during these phase game design principals where adopted. Design document included following topics;

Table 11 Topics Included in the Design Document

C-IED Game Design Document (Subtopics are given in Appendix-B).	System Summary
	Game features
	Game elements
	Graphic needs including 3D animation needs
	Gameplay
	Game mechanics
	Interaction effects between all the game elements and mechanics
	Game control interface
	Game scenarios/levels
	In game data that will be recorded for AAR system

Also after the completion of the design quality control questions were applied to the design document. Preferably in smaller projects for some of the questions it is a good idea to produce concept prototypes and attest for answers. Another solution is to employ ten-day development cycle to test key assumptions within the cycles.

As mentioned in the previous sections, designing the game in functional terms is not an efficient way. Therefore, while conducting the functional analysis internal analysis were conducted. For example, when analysing game mechanics, designed mechanics were accepted as individual functions and analysis were conducted accordingly same method were applied for every topic.

Tracking the recruitments within the design document was crucial. Recruitment items were referenced as footnotes to design items. For example;

> *Headlights of the vehicles will have adjustable beams – ref. requirement code: 4.4.1.16.33*

This method allowed for easily tracking recruitments over serious game functions. When the design document was completed functional analysis were conducted and documented as an annex to the design document. Explanations to high level system recruitments were given under this section. In addition, recruitments that were left out was mentioned in this section with explanations for why. During this phase the system was accepted as another off the shelf digital game and maintenance and support concepts were benchmarked from the industry. All the documentation output was combined in a single detailed design document and shared with all the stakeholders of the project. Partial or all stakeholder meetings were conducted for joint decision making. Revisions were collected necessary changes were made and the final version was realised.

5.1.3 C-IED Case Study Conclusion

Currently C-IED project is in the beginning of the C*onstruction Phase*. The total duration of design so far has been over a year and produced of two master thesis. C-IED project is a good example for mammoth design for such projects it is vitally important to start with prototypes even before establishing the final design document. Findings from the prototypes become invaluable during the design process. In addition, C-IED project had two prototypes before the design phase. A concept prototype was developed within 3 days using off the shelf game assets to test key assumptions during the preliminary feasibility analysis. Later, another prototype with

more game mechanics and elements were developed. This prototype also included multiplayer infrastructure. Finally, adopting the ten-day build cycle was planned going into the development phase. Quality control questions including game quality measurements can be applied during these cycles by actually testing system. It is critically important to note that every single phase always included all the stakeholders. For example, from the beginning of the project including the first prototype military SMEs were part of the design and development process. Finally, C-IED project was the first time USGDM was employed. Therefore, it was also a trial and error process for the methodology. Above section has focused on projecting the experience as is.

5.2. Integrated Logistic Support Card Game Case Study

As new threats are emerging requirement for defence armaments are also increasing. At the same time, many NATO countries are applying more and stricter defence budget controls. Integrated Logistic Support (ILS) is an effective method for determining the real cost of acquisition. Usually and depending on government structures, ILS requires series of organizations working together to function. In some instances, the ILS concept can be completely foreign to a nation or partially implemented. In all cases, to increase cooperation, awareness, and dissemination of ILS workforce training is required. In order to achieve this Turkish MoD, Defence and Technology Training Centre (DTTC) started a two-day course on ILS targeted to the defence industry, government employees and military personnel. This gave rise to the opportunity to implement a gamified training for ILS. This section will discuss the design process and implementation of USGDM.

5.2.1 Inception

The most important criterion in defence systems research projects is undoubtedly the fulfilment of the system design needs. It is important use cost efficiency analysis whilst alternative systems with same capability are selected.

In addition to the purchase cost, system accumulates lifecycle cost as long as they stay in the inventory. Furthermore, additional cost occurs during the system disposal

phase. Integrated Logistics Support (ILS) lists all the criteria for the life cost supportability in a single framework. ILS has been adopted by the Turkish Military but there have been various problems executing ILS system. Due to this fact Turkish MoD, Defence and Technology Training Centre (DTTC) has been training various key stakeholders. This is where the main need for the training originated from.

Two main questions posed in this phase are "Can this training be gamified?" and "Should this training be gamified?". There has been an acquisition and defence system alternative choosing serious games in the past therefore it was clear this subject can be gamified. After talking with the instructors of the DTTC, it was analysed current ILS training relied on computer assisted presentation and though the training was a two-day training most of the basic theoretical training could be given in a day. Rest of the training focused on demonstrates the practical application the system. Trainers were looking hand on solution for frothy trainees. Therefore, gamification was accepted as a viable solution to test out.

Benchmark analysis showed card games where preferred for similar trainings. Training material was used to develop a basic prototype and hand crafted cards were made. Various game mechanics like player vs. player, deck control and turn based decision making were tested out. Finally, turn based decision making mechanics was decided due to long list of learning outcomes that were expected from the game. Game relied on mathematic and attention to detail skills forth core gameplay. Using the behavioural economics approach rather than designing the win scenario prototype was tested with loss ordinated design. Players were divided in two teams and compete with other groups in terms of scores. The highest score a team could achieve was 100 while wrong decisions were penalised in every turn resulting in the possibility of ending the game in minus 400 points. Finally, the first prototype was tested with the trainers from the DTTC and it was decided to carry on the next phase.

5.2.2 Elaboration

Learning out comes were derived from the class notes and joint analysis with the DTTC trainers. Graphics for card designs were also tested during the prototype phase therefore their requirements were also finalised in this stage. Target training audience

was benchmarked form the C-IED project. Though considerations were made for operational needs, trainer module and after action review only learning outcomes were documented rest of the recruitments were noted down as considerations.

Graphic design and printing were analysed as the two main development technologies needed for development. According to target audience requirements the card design quality had to be in a high standard. Therefore, a free software developed for card designs were utilised for card designs. A printing company was contacted for deciding printing method and prices.

Time and place considerations were listed. Game setting and team arrangements were decided. Psychical facilities of DTTC, learning objectives and target group properties were the key constraints during this phase.

Most important assumption was that loss oriented score competition dynamic would be motivating enough for the players. Furthermore, game was limited to the repeating the tasks set forth by the learning objectives rather than focusing on comprehensive ILS training. In addition, ILS Card Game's was limited to DTTC ILS workshop; there was no focus for developing a standalone game.

5.2.3 Construction

Methodology's flexibility was utilised in this phase by combining the three system requirements phase into a single phase. During the game design phase rather than developing a design document black board brain storming method was used.

Table 11 Construction Elements

Design Topics	Game elements
	Graphic needs
	Gameplay
	Game mechanics
	Interaction effects between all the game elements and mechanics
	Game scenarios/levels
	ARR & Scoring Concepts

Development process became intertwined with the design process each turn was had an effect on the following turn therefore spreadsheet of calculation was developed to help the team track effect of the changes on turns for the overall of the game. Play-to-develop approach was taken to develop/design the game. Once the correct path of the game was designed testing was conducted to make sure incorrect way of playing would not result in a win case. Numbers and calculations were checked several times over. Finally, trainer supervision checklist, score card and answer key were developed. Learning goals and mechanics that were duplicated were either changed or left out. Because game was developed for single DTTC workshop, no consideration to maintenance and support were given. Following, DTTC trainer and design team played the game from start to finish and necessary corrections were made. Finally, cards were sent to be printed.

5.2.4 Transition

The game was played by nine groups of five participants. For every three teams an assistant was assigned. They were tasked with teaching the game and answering questions as well as score keeping. At the end of the training a survey was conducted. From the16 questions 3 questions were about learning outcome, 6 of them was about quality of the game and 7 questions were about the scenarios. Finally, last question was an open ended question about evaluation of the training.

When the survey results were evaluated majority of the participants found the training very educational. Other results indicated game was found fun, short, and easy to learn and play. Furthermore, participants liked the card designs. Finally, on average the tasks were found easy. Open ended questions suggested that for further versions participants wanted longer and challenging scenarios and information packages about the game handed out beforehand. Currently, a new version of the card game that includes ILS considerations in contested and degraded environments is being developed using the lessons learned from the DTTC workshop.

5.2.5. ILS Game Case Study Conclusion

ILS Card Game was design and developed within a week. No major documentation was developed and most importantly design and development phase was intertwined in an iterative cycle. This case study is a critical example how the USGDM can be implemented in agile development project as well as mammoth design projects. The methodology helps ground the design and development process and help to not overlook key considerations. Design and development aspects are for the greater part are same for big and small game projects while time and resource costs for each phase changes according to the size of the project. Therefore, supported by the case studies USGDM has the flexibility to work for different types of serious game and gamification projects.

CHAPTER 6

CONCLUSIONS

Literature review has shown, though there are game development methods and extensive information on design guidance there was no clear compressive methodology for serious game development. Such a methodology needed cover both functional development aspect as well as helping the developer to design the system that would succeed at achieving behaviour change. In addition, literature review and research on serious games has shown that serious games very similar to games are extremely flexible in design and development. Trying to implement a framework can easily lead to excess work or hamper creativity.

System engineering provides a framework for complex interdisciplinary projects. This level of flexibility provides the opportunity for system engineering approach to be used for serious games. Though this is the case on the other and system engineering mainly focuses on functional design. Bringing all the elements of game design to a functional level is almost impossible. For example, level design or emotional immersion are extremely hard and beside the point to examined from a functional perspective. Therefore, the development inspiration from the steps of system engineering was taken for the serious game development methodology. These steps then were combined with game design methods to from a hybrid development methodology. After the development steps were finalised the methodology puts forth behavioural economics considerations.

There is no one way of designing an engaging game, thus it is extremely challenging to provide a framework. But on the other hand behavioural economics reflects a light to human psyche. By examining the drives behind our behaviours it is possible to design an experience through a game that can nudge the players into certain behaviours. Methodology also tries to incorporate lessons learned for common development problems from serious games and through series of questions and considerations tries to direct the developer to navigate the common problems.

Finally, the methodology employs Octanalysis for testing the entertainment value the game element of the serious game. Early detection is a key for success in many cases. Therefore, methodology focuses on testing the gaming value in the very early stages of the design process.

Game design as well as development process requirements is extremely flexible. While one-person pen paper development is a valid game development process, one-thousand developer team with million-dollar development budget is as valid development process as any. Thus, the serious game development methodology needed to provide same flexibility to scale up and down. In the final section, application of the methodology is examined through two case studies. While one case study focuses on a mid-size military digital serious game application, the second serious game focuses on small size card game designed and developed in less than two weeks. This examination has shown that methodology shows adaptability and can have useful application for several of serious game applications.

It has to be noted that two case studies are not nearly enough to provide evidence that methodology creates more benefits then workload. Furthermore, there are many other functional and human oriented design approaches the methodology has been limited to system engineering and behavioural economics. Moreover, common development problems will change and evolve over time therefore unless methodology becomes a living document there is a real possibility it will become outdated very fast. There is also future study opportunity for developing methodology measurement system to test the development methodology's use for different developers and serious games projects. Furthermore, there is a need to conduct a comparative study between the development methodologies based on their use on serious game development process to fine tune methodology.

As a final related consideration future of games and education is limitless and quite unknown with the recent technological advancements as it has been in the past serious game industry will achieve an equilibrium as it matures and if games have existed more than four millennial and still there is no one method to development therefore it is highly possible that there won't be one solution to serious game development.

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APPENDICES

A. QUALITY ASSURANCE CHECK LIST

Design	N	PN	PY	Y	NA
Are the suitable user descriptions made? (Liu, et al. 2009)					
Have the player expectations captured in quantitative and measurable format?					
Have the player expectations processed as game adjustments? (Lopes, et al. 2011)					
Digital Game Development Engine Selection	N	PN	PY	Y	NA
Does the Licence Agreement of the engine fulfil system and legal requirements?					
Is the Cost of the engine within your budget?					
Is there sufficient Documentation and Support available?					
Is the Accessibility Learning Curve of the engine easy to master?					
Does the engine support the Platforms your system will operate on?					
Does the Audio-visual capability of the engine fulfil system requirements?					
Does the Fidelity capability of the engine fulfil system requirements?					
Does the Rendering capability of the engine fulfil system requirements?					
Does the Special Effects capability of the engine fulfil system requirements?					
Does the Shadows capability of the engine fulfil system requirements?					
Does the Lighting capability of the engine fulfil system requirements?					
Does the Texturing capability of the engine fulfil system requirements?					
Does the Animation Forward Kinematics capability of the engine fulfil system requirements?					
Does the Key frame Animation capability of the engine fulfil system requirements?					
Does the Skeletal Animation capability of the engine fulfil system requirements?					
Does the Morphing capability of the engine fulfil system requirements?					
Does the Animation Blending capability of the engine fulfil system requirements?					
Does the Scripting capability of the engine fulfil system requirements?					
Does the AI capability of the engine fulfil system requirements?					
Does the Composability Import/ Export Content capability of the engine fulfils system requirements?					
Do the Networking Client Server/ Peer–to- peer capability of the engine fulfil system requirements? (Petridis, et al. 2010)					
Content	N	PN	PY	Y	NA
Is the win and lose cases balanced?					
Are the win conditions easy to understand?					
Are there in game currencies or consumables embedded into core game mechanics? (Rollings, et al. 2003, 2-18)					
Is the game pleasantly frustrating?					
Is the gameflow and variety of actions enough to reduce fatigue and boredom?					
Is the game long and challenging enough to keep the interest of the users alive?					

Is the game conflict balanced with strategic thinking?					
Are the in game mechanics easy to learn but hard to master?					
Are the in game goals clear and easy to understand? Are there both short term goals and long term ones?					
Does user feel emotional connection to the game world and/or to the main characters (Desurvire, et al. 2009, 560-565)?					
Does the serious game have a tutorial level?					
Do your users find the tutorial educational and not boring?					
Is the storyline of the game in accordance with the learning content?					
Motivating the User	N	PN	PY	Y	NA
Is interaction between users creating social groups?					
Do the game goals motivate the users?					
Is the system gives enjoyment and pleasure? Does the system invoke intense and passionate involvement?					
Do the game rules enforce structure of the system?					
Is the game flow adaptive?					
Does the wining provide ego gratification?					
Does problem solving require creativity and use of gained new knowledge?					
Does the game's representation and story invoke emotion? (BinSubaih, et al. 2009)?					
Multimedia	N	PN	PY	Y	NA
Are the pictures, animations, sounds, and language used in the game suitable for the user?					
Is the game interface attractive according to your target audience?					
Do the graphics, animations, audio and visual effects increase users' interest? (Liu, et al. 2009)					
Does the Avatar's and character's representation interesting or realistic according to your target audience? (Yildirim, 2010, 6-8)					
Does your virtual environment promote immersion? (Desurvire, et al 2009, 560-565)					
Does the system provide playful feedback with visual and sounds effects (Desurvire, et al. 2009, 560-565)?					
Interface Design and Structure	N	PN	PY	Y	NA
Are the graphics and control interfaces easy to understand and use? (Yildirim, Sule, 2010:6-8)					
Does the game include a help and hints function? (Liu, Eric Zhi Feng et al. 2009)					
Educational Module	N	PN	PY	Y	NA
Is the information in the game accurate?					
Is the modelling of the real life realistic or in accordance with the demanded system fidelity?					
Doe the learning material utilises real life incident or scenarios and user is aware they are real life or likely incidents? (Yildirim, 2010, 6-8)					
Are the challenges in the game related to the learning materials?					
Is the order of the contents reasonable?					
Is the important information presented clearly? (Liu, et al. 2009)					
Is the feedback provided in a timely manner?					
Does the system provide a proper assessment of the user's skills?					
Can the system report a user's current status?					
Can the learning process be analysed (Liu, et al. 2009)?					
Does the after action review process demonstrated change in behaviour, imparting of knowledge or skills, or the improvement of motor and cognitive capacities among your user? (Goethe, 2018)					
Is there before and after the training comparative knowledge measurement?					
Does the system make it clear that failure in the game is a reflection of a serious mistake in reality?(Bellotti, et al. 2010)					

B. C-IED SERIOUS GAME DESIGN REQUIREMENTS TOPICS

1. Requirements for Possible IED Placements
2. Identifying the Possible Triangulation Points for IEDs
3. Identifying the Possible Indicators for Mines and IEDs
4. Small Squat Mission Preparation Procedure Before Leaving the Forward Operating Base
5. Small Squad Operation Mission Execution Principles
6. Small Squad Dismounted Operation Requirements
7. Small Squad Dismounted Operation Danger Zone Crossing Principles
8. Small Squad Winter Operation Principles
9. Small Squad Dismounted Operation IED danger zone crossings and procedure after IED identification
10. Small Squad Dismounted Operation procedure after IED attack
11. Principles and procedures on temporary Forward Operation Base occupation and IED treat assessment
12. Motorized Small Squad Operation preparation principles and procedures
13. Motorized Small Squad Operation C-IED principles
14. Motorized Small Squad Operation IED danger zone crossings and procedure after IED identification
15. Motorized Small Squad Operation procedure after IED attacks
16. Motorized Small Squad Operation road blocks and danger zone crossings procedures

C. C-IED SERIOUS GAME DESIGN DOCUMENT TOPICS

1. System Summery
2. Serious Game Features
3. Target Platforms
4. Target Audience Characteristics
5. Game Elements
6. Modelling Requirements
7. Gameplay
7.1. Red Force Mechanics
7.2. Health Mechanics
7.3. Weapons and Battle Mechanics
7.4. Hunger, tiredness and Dehydration Mechanics
7.5. Battery Depletion Mechanics
7.6. Weather Dynamics
7.7. Night/Day Cycles
7.8. In Game Mini-Maps
7.9. Mission Equipment Malfunctions
7.10. Mine and Bomb Detection Dog Mechanics
7.11. Save and Load Mechanics
7.12. Load screens
8. Game Element's Interaction Rules
9. Control Interfaces
10. Scenarios
10.1. Mission Preparation
10.2. Dismounted Operation
10.2.1. Illegal substance farm identification and destruction
10.2.2. River Crossing
10.2.3. Forward Operation Base Occupation
10.2.4. Return to Forward Operation Base
10.2.5. Rocky Terrain Crossing
10.2.6. Snow Weather Operation
10.3. Motorized Operations
10.3.1. Securing Roads
10.3.2. Danger Zone Crossing
10.3.3. Road Blocks
10.3.4. Convoy Ambush
11. After Action Review
11.1. Central After Action Review Database Requirements
11.2. Local After Action Review Module Requirements
11.3. Data Topics
11.3.1. Squad Commander

11.3.2. Movement
11.3.3. IED Identification
11.3.4. After IED Attack
11.3.5. Forward Operation Base Approach
11.3.6. Motorized Operations
11.3.7. Motorized Operation IED Attacks
11.3.8. Small Squad Members after IED Attack
11.3.9. Detector Personnel
11.3.10. Jammer Personnel
11.3.11. Medic
11.3.12. Quantitative Data

D. TURKISH SUMMARY/TÜRKÇE ÖZET

Bugüne kadar bulunan en eski oyuncağın 4,500 yaşında olması bize insanlık tarihinin başladığı noktada oyunların başladığını göstermektedir. Antropolojik açıdan bakıldığında oyun insan gelişiminin en önemli aşamalarından biridir. Çocuk oyun oynarken içinde bulunduğu toplumu, kültürü, yaşam tarzını ve Dünya'nın kurallarını öğrenir ve benimser. Manevi gelişmenin ve öğrenmenin yanı sıra psikomotor yetenekler ve fiziksel beyin gelişimi de oyunlar aracılığı ile gelişebilmektedir.

İnsan doğasının kendiliğinden yarattığı bu eğlenceli öğrenim yöntemini yetişkin eğitiminde kullanılması ciddi oyun olarak adlandırılmıştır. Ciddi oyunların yetişkinler için etkili olacağını destekleyen en güçlü argüman, insanın içindeki değişmeyen "oyuncunun" varlığıdır. Yaştan, meslekten ve statüden bağımsız olarak her insanın içinde; çizgilere basmadan yürümeye çalışan, hava kabarcıklı sargıyı patlatan, komik çoraplar seçen ve çizgi film izleten bir oyuncu vardır. Ciddi oyunlar ve oyunlar arasında fazla bir fark yoktur. Oyunlar eğlenceyi amaçlı yan etkisi öğrenme olan olgular iken ciddi oyunlar eğlenceyi öğrenim için kullanmaktadır.

Oyun geliştirmesi hayal gücü ile sınırlı iken ciddi oyunu zaman, maliyet, hedef kitle ve eğitim konuları gibi birçok tema ile sınırlandırılmaktadır. Bu nedenle geliştirme sürecine destek olacak geliştirme metoduna ihtiyaç doğmaktadır. Ciddi oyunlar üzerine geliştirilmiş kaynaklar incelendiğinde oyun geliştirme açısından birçok yol gösterici kaynak bulmak mümkündür. Ancak ciddi oyun geliştirme sürecine yönelik kaynakların yaygın olmayışı dikkat çekmektedir. Bu çalışmada, ciddi oyun geliştirme metodolojisinin temellendirebilmek için kaynak taraması sistematik olarak oyun geliştirme, ciddi oyun modülleri ve ciddi oyun tasarım ve geliştirme süreçleri çevresinde taranmıştır.

Oyun tasarım süreçleri incelendiğinde tasarım sürecinin esnek ve sınırlandırılmamış olduğu dikkat çekmektedir. Tasarım hedefleri ise kesin ve kurallar ile belirlenmiş hedefler yerine oyuncuda duygusal tepki yaratmak olarak belirtildiği görülmektedir. Tasarım sürecinde amaç oyuncu için duygusal bir deneyim yaratılmasının planlanmasıdır. Bu deneyimde oyuncunun ilerlemesini sağlayan ise oyun akışı olarak

betimlenmektedir. Oyun akışı oyunun müzik parçalarında olduğu gibi oyuna tempo katar. Bu tempoyu belirmekte yardımcı olan metotların önce çıktığı görülmektedir. Bu metotların ortak noktası ilerleme hissidir. Örneğin, fark efekti oyuncuya gelişen ve artan imkânlar ile sürekli gelişme hissi yaşatırken, yaklaşan hedef oyuncuya sürekli bir sonraki hedefi, hatta bazen, fiziksel olarak göstererek oyunun akışını doğrusal olarak sağlamaktadır. Ödüller ve başarılar yine bu aşamada ele alınmaktadır. Doğrusal ilerlemenin desteklenmesi bir sonraki ödülü elde etme motivasyonu ile desteklenmektedir. Ancak, bu aşamada öne çıkan en önemli ve dikkat edilmesi gereken nokta başarılar ve kazanımlar, gerçek anlamda başarı ve kazanım olmalıdır. Yani, dijital dünyada gerçek hiçbir değeri olmayan bu ödülleri değerli kılan oyunun harcadığı gerçek emektir. Tasarım çerçevesi açısından çaba/ödül değer dengesi en iyi kurulan ödüller gerçek anlamda oyuna katkı sağlamaktadır.

Oyun tasarımı kullanıcı kontrol ara yüzü ve oyun hikâyesi ile davam etmektedir. Kontrol ara yüzü oyuncuyu deneyime fiziksel olarak bağlayan etkileşim olarak tanımlanmaktadır. Bu etkileşim ne kadar akıcı şekilde tasarlanırsa kullanıcının oyun dünyasında olan hâkimiyeti haliyle oyun dünyasının sunduğu duygusal deneyime olan dâhiliği artmaktadır. Oyun hikâyeleri ise duygusal deneyimi çerçeveleyen ve kendi içinde tutarlı hale getiren mantık örgüsüdür. Duygusal deneyimin hikayeleşmesi ile oyuncunun bilişsel olarak algılayacağı hale gelmesi oyunun duygusal deneyime olan bağlılığını artırmaktadır. Tıpkı, film izleyicilerinin olay örgüsünde belirli duygular yaşaması gibi.

Tasarım kaynakları oyunların ortak öğesi olarak oyun karakterlerini betimlemektedir. Oyun karakteri oyuncunun oyunda sunulan duygusal deneyimin içindeki yansımadır. Bir başka değişle oyun dünyasında ki “ben”’dir. Oyun içi karakterleri tasarım açısından net kurallara bağlanmamıştır. Hatta gerçekçilik bile öne çıkan bir öğe değildir. Kullanıcının kurduğu bağ kavramsal seviyede bir bağdır ve gerçekçilik ile sınırlı değildir. Ancak, bu aşmada kaynaklar özellikle çoklu oyunculu sistemlerde iletişim yeteneğini özellikle vurgulamaktadırlar. İletişim kurama oyuncaların sosyal bağlar kurma motivasyonu tetiklemesi açısından özellikle önemli bir mekanik olduğu vurgulanmaktadır.

Oyun geliştirme süreci aşısından kaynaklar incelendiği zaman birçok farklı yöntem ortaya çıkmaktadır. Ancak aralarından ortaya çıkan yöntem on günlük tasarım döngüsü olduğu görülmektedir. Döngü, farklı paydaşları on günlük toplantı döngüleri üzerinden biraya getirilmesi üzerine temellendirilmiştir. Toplantılar içeriğinde farklı paydaşların sınırsız bir şekilde fikirler geliştirdiği ve ortak kararlar üzerinden bir sonraki döngü için geliştirme kararları verildiği görülmektedir. Bu sayede döngü yöntemi hem oyun geliştirme sürecinin ihtiyaç duyduğu esnekliği sunarken aynı zamanda proje yönetiminin esaslarını etkin bir şekilde bir araya getirmektedir.

Oyun tasarım ve geliştirme süreçleri incelendikten sonra kaynak taramasına ciddi oyun modüleri ile devam edilmiştir. Ana modüller oyun, eğitim, eğitmen ve faaliyet sonrası inceleme olarak belirtilmektedir. Oyun ve eğitim modülünün entegrasyonun tanımlayan üç ana yöntem olduğu görülmektedir. Destekleyici yöntem eğitim aşamalarının sonunda ödül olarak oyunun sunulduğu metot olarak tanımlanmıştır. Motivasyon yöntemi ise oyunun önden ilgi çekmek ve eğitime hazırlamak için sunulduğu yöntem olarak betimlenmektedir. Üçüncü yöntem ise karışım yöntemidir. Bu yöntem oyun modülü ve eğitim modülün homojen olarak dengelenmesi ve birbirinden ayrıt edilemez hala gelmesi olarak tanımlanmaktadır. Bu yöntemde oyunu oynamak öğrenmeye eşi olarak tanımlanmaktadır.

Oyun modülünde yol gösterici olarak oyun teknolojileri, mekanikleri ve grafik tasarım öğeleri öne çıkmaktadır. Kaynaklarda oyunların kullandığı yöntemlerin anlaşılması adına sınıflandırılması ve açıklanmasıoyun teknoloji başlıkları altında ele alınmaktadır. Anlık geri bildirimler, fizik motorları veya engel aşma dinamiği bu kısımda açıklanmaktadır. Oyun mekaniği ciddi oyun kaynaklarına göre tanımı incelendiğinde oyun boyunca tekrar eden ve oyunu kazanmak için kritik olan fonksiyonları olarak tanımlandığı görülmektedir. Bu açıklamanın bilerek esnek tutulduğu görülmektedir. Çünkü oyun mekaniğinin neler olabileceği gerçek anlamda hayal gücü ile sınırlıdır. Grafik ara yüzü ciddi oyunların özellikle üstünde durduğu bir konu olarak öne çıkmaktadır. Özellikle gerçekliğin önemli olduğu eğitimlerde bu konuya sık sık değinilmektedir. Yine bu kısımda kaynaklar grafik ara yüzün ne olması veya nasıl tasarlanması gerektiğinden daha çok grafik ihtiyacının belirlenmesinin önemi üstünde durduğu görülmektedir.

Eğitim modülünü ele alan kaynakların çoğunluklar simülasyon alanından destek aldığı görülmektedir. Simülasyonun eğitim metotlarının ciddi oyunlara doğrudan taşınabileceği özellikle vurgulanmaktadır. Kaynakların bu modül hakkında detaylı kuralar ve çerçeveler sunduğu dikkat çekmektedir. Özetle bu maddeler ele alınacaksa eğitim tekrarlanması, hatırlatılması, doğru ve yanlış davranışların vurgulanması ve eğitim temposunun kullanıcıya göre belirlenmesi öğelerinin öne çıktığı görülmektedir. Eğitmen modülü hakkındaki kaynaklar tekrar esnekliğinin korunması adına eğitim hedeflerinin belirlenmesi, hedeflere göre ölçüm metriklerinin ve yöntemlerinin belirlenmesi önemi üzerinde durmaktadır. Faaliyet sonrası inceleme modülü ise kaynaklar tarafından doğru yanlışın sayısal olarak ölçülmesi yerine nedensellik olarak derinlemesine ölçecek şekilde tasarlanması üzerinde durmaktadır.

Ciddi oyun tasarım süreci olarak kaynakların öne sürdüğü başlıklar sırasıyla; Sistem özeti, oyun deneyimi, hedeflenen platformlar, hedef kitle özellikleri ve oyun tasarım öğeleri olarak listelendiği görülmektedir. Ancak tasarım doküman geliştirme methodoloji açısından yol gösterici niteliği taşımaktadır. Hatta tasarım dokümanı oyun geliştirme açısından bakıldığında her zaman ihtiyaç duyulmaktadır ve sınırlayıcı özelliği de olabileceği gözlenmektedir. Geliştirme süreci açısında kaynaklar yol göstericilik adına hikaye oluşturmada kahramanın hikayesi yöntemini ve yazılım geliştirme süreçlerini öne sürmektedir. Ancak bu süreçler doğrudan ciddi oyun geliştirme metodu olarak algılamak mümkün değildir.

Ciddi oyunlar için geliştirilecek metodolojinin ihtiyaçlarının belirlenmesi adına ciddi oyunun anlaşılması önem taşımaktadır. Bu nedenle ciddi oyunların benzer sistemler olan oyunlar ve simülasyonlar ile ortak noktaları ve farkları üzerinde durulmuştur. Oyunlar ve ciddi oyunlar karşılaştırıldığında, oyunların ana amacının eğlence olduğu, ciddi oyunların ise eğlendirirken öğretmeyi amaçladığı görülmektedir. Ciddi oyunlar ve oyunlar arasındaki ilişkide öne çıkan en önemli husus ise, ciddi oyunların eğitici senaryo + oyun senaryosu olarak tanımlanmasıdır. Yani, ciddi oyunların tam anlamıyla bir oyunun tüm özelliklerini ve bileşenlerini kapsaması gerekmektedir. Simülasyonlar ve ciddi oyunlar arasındaki ilişki incelendiği aman benzerlik olarak gerçeklik hissinin yakalanma gerekliliği ve negatif eğitimden kaçılması öne çıkarken, duygusal dâhiliğin sağlanması ve eğlenceli bir deneyim yaratılması farklığı ortaya çıkmaktadır.

İlerleyen kısımlarda metodolojinin özellikle hitap etmesi gereken sorunların anlaşılması üzerine ciddi oyunlarda yaygın geliştirme aşamasında yaşanan sorunların analizi yapılmıştır. Kaynak taraması ile gerçekleştirilen bu analiz aynı zamanda ciddi oyun sektöründe çalışanlar arasında gerçekleştirilen anket çalışması ile desteklenmiştir. Özetlenecek olursa öne çıkan sorunlar, tüm paydaşların ihtiyaçlarının analiz edilmesi, geliştirme aşamasında yeterli kaynakların bulunamaması, eğitim yeri ve zamanın ayrılmasında sorun yaşanması aynı zamanda eğitim performansının ölçülmesinde yaşanan sorunlar olarak ortaya çıkmaktadır.

Araştırmalar ve analizler sonunda elde edilen verilerin ışında metodolojinin temellendirilmesi için sistem mühendisliği ve davranışsal ekonomiden yararlanmasına karar verilmiştir. Ciddi oyunların kompleks sistemler olmasından dolayı fonksiyonel tasarım konusunda yol gösterilmesi gerektiği kantine varılırken aynı zaman eğitim boyutundan dolayı insan odaklı geliştirmesinin de göz ardı edilmeyeceği öne çıkmaktadır. Sistem mühendisliği fonksiyonel tasarım aşamalarında yol göstericiliğinden yararlanılacaktır. Davranışsal ekonomi ise insan odaklı bakış açısının sisteme taşınmasında önemli bir rol oynayacaktır.

Sistem mühendisliği altı adımdan oluşmaktadır. Konsept tasarımı, ön tasarım, detaylı tasarım, sistem analizi, geliştirme safhası ve yaşam devrinin desteklenmesi. Tasarım aşamaları özellikle paydaşların belirlenmesi ve ihtiyaç analizinin nasıl yapılması gerektiği konusunda yol gösterici olmaktadır. Detaylı tasarıma doğru ilerlendiğinde ihtiyaçlardan sistem gereksinimleri oluşturulmakta ve sistemin fonksiyonel tasarımı elde edilmektedir. Analiz safhası ise sistem fonksiyonları, gereksinimleri ve ihtiyaçların tek bir celsede gözden geçirilmesi ve matris üzerinde analiz edilmesi sayesinde geliştirilecek sistemin gerçek anlamda paydaşlar tarafından duyulan ihtiyaca hizmet edeceğinin garantisini değerlendirmektedir. Geliştirme safhası ise tasarıma bağlı kalınması için gerekli adımlar konusunda yön göstermektedir. Son aşma ise sistemin yaşam devrinde çalışır halde kalması için gerekli aşamalar ile ilgili değerlendirmeler konusunda yol göstermektedir. Sistem mühendisliği ciddi oyunların çok paydaşlı ve çok gereksinimli süreçlerin düzene sokulması konusunda önemli bir çerçeve oluşturma yeteneğine sahiptir. Ancak, her ne kadar oyunlar sistemler olsa da sistem mühendisliği süreçleri oyun tasarımı konusunda sınırlayıcı ve gereksiz iş yükü yaratabilecek potansiyele sahiptir. Oyunların en büyük özelliği bir kişi ve kâğıt ve

kalem ile geliştirebileceği sistemler olabilirken bin kişilik milyon dolarlık projelerde olabileceğidir. Sistem mühendisliği her geliştirmeye kompleks sistemler bakış açısı ile yaklaştığı için ciddi oyunların ihtiyaç duyduğu esnekliği engelleyebileceği ileri sürülmektedir.

İnsan odaklı tasarım çerçevesinden bakıldığında ise, insanların davranışsal motivasyonlarını öne çıkarmak ve o motivasyonlara hitap eden sistemlerin geliştirilmesi öne çıkmaktadır. İnsanların davranışları motivasyonları, davranışsal ekonomi modeline göre; Duygusal, geçmiş davranış benzer patenlerine bağlı, sosyal geri bildirim tarafında şekillendirilen, seçim özgürlüğüne düşkün iken çok seçim karşısında paralize olan, kısa vade getirilerine odaklı, dışarıdan manipülasyona açık, kısa vade ödüllerine ve inisiyatiflerine karşı pozitif eğilimli, mutlak olarak kaybetmekten kaçınmaya odaklı olarak tanımlanmaktadır. Bu davranış motivasyonlarının dış etkenler ile manipüle etmek istediğinde ortaya çıkan metotlar ise; statükoyu koruma için harekete geçme, yakın vade hedeflerini uzak vade hedeflerine göre göreceli olarak değerlendirme, sosyal gurup arasında adaleti sağlamak için harekete geçmek, varsayılan seçim ile seçim yapmaya yöneltme, önceden şartlama veya algı hazırlama yöntemi ile davranış yönlendirme ve kolaylaştırma ile hareket sağlama olarak tanımlanmaktadır. Davranışsal ekonomi insan zihnini içerisine dair önemli perspektifler kazandırmaktadır ancak tek taraflı motivasyon açısından ciddi oyun sistemine yaklaşmak diğer önemli tasarım öğelerinin göz ardı edilmesine neden olacaktır. Bu nedenle sistem mühendisliği yaklaşımını ve insan odaklı tasarımı aynı anda oyun geliştirme yöntemleri yorumlayan hibrit bir metodolojiye ihtiyaç duyulmaktadır.

Öne sürülen bu Birleşik Ciddi Oyun Geliştirme Metodolojisi dört aşamadan adımdan oluşmaktadır. Her aşamada yapılması gereken üç ana iş paketi vardır ve bu iş paktlerinin altına on görev belirlenmiştir. Bu görevler her bir aşamada değişik yoğunluklarda tekrar etmektedir. Bu sayede metodolojinin esnekliğini koruyabileceği öne sürülmektedir. Birinci aşama gelişim aşamasıdır ciddi oyun sisteminin kendi varlığını değerlendirilmesidir. Hemen hemen her konunun oyunlaştırılabilmesi her konunun oyunlaştırılması gerektiği anlamına gelmemektedir. Bu nedenle hedef kitle ve çevresel etkenler üzerinden ciddi oyunun doğru bir seçim olup olmadığı birinci adımda değerlendirilir. Bu aşamanın devamında eğitim konusu ele alınır ve bu

konunun oyunlaştırmaya ve oyun mekaniklerine yatkınlığı değerlendirilir. Daha önce belirtildiği gibi her ne kadar hemen hemen her şey oyunlaştırılabilse de bazı konuların oyunlaştırılması ve eğlenceli hale getirilmesi diğerlerine göre daha zordur. Birinci aşamanın geliştirme ve test alt görevlerinde, en basit hali ile eğitimin oyunlaştırılması denenir aklıdaki temel oyun dinamikleri basit bir prototip haline getirilir ve denenir.

Bir sonraki aşama detaylandırma aşamasıdır. Bu noktada ciddi oyun gereksinimleri detaylı olarak belirlenir. Özellikle paydaşların katılımı ile eğitim hedefleri, oyun ve sistem gereksinimleri belirlenir ve projenin büyüklüğüne göre belgelenir edilir. Bu aşamada geliştirmenin yapılması için gerekli olan teknolojiler ve uygulamalar ele anır ve test edilir. Özellikle alternatif teknolojiler ve yöntemler arasında seçim yapabilmek için bu aşama önem taşımaktadır. Aynı şekilde, sistemin çalışacağı ortam, platform ve çevreye yönelik gereksinimler tanımlanır ve bu gereksinimlere bağlı tasarım kısıtlamaları oluşturulur. Detaylandırma sürecinde eğitim konusuna göre sistemin karşılamadığı konular ele alınır ve ciddi oyunun hizmet ettiği eğitim amaçları net bir şekilde belirlenir. Sistem fonksiyonları ve/veya oyun mekanikleri yedinci aşamada belirlenir. Oyun tasarım kısmı tam olarak bu aşamada sonlandırılır edilir. Oyun tasarımı dışarısında kalan ama ciddi oyun sisteminin gerçekleştirmesi gerektiği sistemsel fonksiyonlar yine bu aşmada tasarımsal olarak son hale getirilir. Bu aşamanın tasarım iş paketinde yapılacak işlemlerin hepsi önem sırasına göre planlanmaması gerçekleştirilir ve tasarım dokümanları gözden geçirilir özellikle geliştirme ekibi ile bu aşamanın gerçekleştirilmesi yapılacak işlemlerin anlaşılırlığı veya yapılıp yapılamayacağı konusunda yol gösterici olacaktır. Bir sonraki aşamaya geçilmeden önce tasarım fonksiyonları ve mekanikleri belirleyen tasarım dokümanlarının özellikle paydaşlar ile birlikte ihtiyaç ve gereksinimleri analize tabi tutulur. Yapılacak işlerin doğru olup olmadığı bu aşamada değerlendirilir. Bu aşamada yine sistemin tasarımsal olarak netleşmesinden yararlanarak bakım ve destek konseptleri belirlenir. On ikinci aşamada bu ana gerçekleştirilmiş tüm işlemler tek bir tasarım dokümanında toplanır.

Yukarıdaki işlemlerin tamamlanması sonucunda inşa aşaması başlar. Bu aşama sistem geliştirme, test ve uygulama aşamasıdır. On-günlük toplantı döngüsü üzerinden geliştirme bu adımın içerisine entegre edilmiştir. Oyun geliştirme

döngüsünden farklı olarak konu uzmanları ve paydaşların sürece dâhil edilmesinin öneminin altı çizilmiştir.

Metodoloji fonksiyonel geliştirme süreci için bir çerçeve sunmaktadır ancak görüleceği üzere iyi bir sistem geliştirmenin yöntemi aşısında bir yol göstericiliği yoktur. Bu nedenle metodoloji insan odaklı tasarımdan feyz alan yol gösterici değerlendirme yöntemleri ve soruları ile sürece destek olmaktadır. Bu değerlendirmeler prototip aşamasından, geliştirme testlerine kadar tekrar tekrar kullanılabilecek ve kullanılması gereken testlerdir. Sorular tasarım kalitesi, içerik, grafik ve kullanıcı ara yüzü ve geri bildirim aşamalarını ele almaktadır. Ciddi oyunun eğlenceli olup olmadığını ölçmek için metodoloji Octalysis yöntemini kullanmaktadır. Yöntem, oyunu eğlenceli kılan sekiz ana motivasyon olduğunu belirtmektedir; Anlam, güçlendirme, sosyalleşme, şans, kaybetmekten kaçınma, sınırlı kaynaklar, sahiplik hissi ve başarı kazanımı. Analiz yöntemi her bir başlığa denk gelen oyunların uyguladığı yöntemleri listelemektedir. Kendi sistemini test eden kişi bu listelere göre kendi sistemini değerlendirmektedir. Sonunda çıkan puanlar sektör bazında hesaplanır ve oyunun hangi yönden ne kadar motive edici olduğu analiz edilir. Yöntem değerlendirmenin nasıl yapılması gerektiği kullanıcıya bırakmaktadır. Ancak, metodoloji Delphi metoduna benzer bir yöntemi veya ciddi oyun kullanıcılarına uygulanacak anket üzerinden bu değerlendirmenin yapılabileceğini savunmaktadır. Değerlendirme sonunda puanların hangi başlıklarda yoğunlaştığına göre Octalysis yöntemi oyunun tarzına dair açıklama sunmaktadır. Örneğin Klasik Süper Mario oyunu incelendiğinde, ateri konsollarının arkadaşları bir araya getirmesinden ve iyi bir Mario oyuncusu olmanın statü getirmesinden dolayı sosyalleşme puanın yüksek olduğu görülmektedir. Aynı zamanda şans öğelerinin ve ara bölümlerde oyunu kaydetme imkânın olmayışından dolayı kayıp önleme motivasyonun fazlalığı analiz edilmektedir. Metodoloji Octalysis yönteminin her ne kadar doğrudan iyi oyun geliştirme konusunda yol gösterici olmasa bile geliştirilen oyunun kalitesi hakkında bilgi sunma potansiyelinden dolayı kullanımın teşvik etmektedir.

Tez çalışmasının son kısmında metodolojinin fiilen uygulandığı iki farklı vaka çalışması ele alınmaktadır. Önceki kısımlarda vurgulandığı gibi metodolojinin oyun geliştirme sürecinin esnekliğine uyması gerekmektedir. Bu nedenle seçilen iki vaka

çalışmasında bir tanesi orta-büyüğe yakın askeri eğitimde kullanılmak üzere geliştirilen bir ciddi oyun iken diğeri iki-üç hafta gibi kısa bir sürede geliştirilen kart oyunu tabanlı eğitim uygulamasıdır. Bu vakalar metodolojinin her bir adımının nasıl uygulandığını ele almaktadır.

El yapımı Patlayıcılara Karşı Eğitim Ciddi Oyunun geliştirme aşaması eğitime ve ciddi oyuna ihtiyaç ile başlamaktadır. Bu aşamada el yapımı patlayıcı sorunu ve istatikselleri incelenmekte ve eğitim için kritik olan unsular ortaya koyulmaktadır. Sonuç olarak EYP'lerin ciddi bir sorunu teşkil ettiği ve mücadele aşamasında taktik sahada görev yapan personelin farkındalığının artırılması ve eğitilmiş göz yetiştirilmesinin önemi ortay acıkmaktadır. Birinci aşamada bu eğitim oyunlaştırılabilir mi sorusu ele alınmıştır. Bu sorunun cevaplanması için saha uzmanları ile basit bir eğitim senaryosu geliştirilmiş ve hızlı bir prototip oluşturulmuştur. Bu prototip paydaşlara gösterilerek sorunun cevabı için görüşleri alınmıştır. Detaylandırma aşamasında sistemin beta versiyonun geliştirilmesi için çalışmalar başlatılmış ve çoklu oyuncu altyapısı kurularak birden fazla eğitim maddesi sisteme yansıtılmıştır. Yine bu aşamada paydaşlardan, saha uzmanlarından ve mevcut EYP ile mücadele eğitim kaynaklarından eğitim ihtiyaçları ve hedefleri çıkarılmıştır. Takiben silahlı kuvvetlerin hedef kitlesine ve çalışma ortamlarına göre sistem ihtiyaçları belirlenmiştir ve listelenmiştir. Liste sistem gereksinimlerine ve oyun tasarı dokümanına dönüştürülmesi başka bir ekip tarafından yine bu basamakta gerçekleştirilmiştir. Aynı şekilde detaylandırma sürecinde artırılmış ve sanal gerçeklik kullanımı üzerine testler gerçekleştirilmiştir. Sistem ve eğitim ihtiyaçlarına geri dönülerek bu teknolojilerin uygunluğu test edilmiştir. Altıncı aşamada geliştirme ekibinin katkıları ile tasarım dokümanında oluşturulmuş sistemin platform ihtiyaçlarına göre gereksinimler belirlenmiş ve silahlı kuvvetlerin platform envanteri ile karşılatılmıştır. Bu aşamada net bir şekilde sistemin eğitim ihtiyacının hangi kısımlarını neden karşılamayacağı vurgulanmıştır ve oyun tasarım dokümanı tamamlanmıştır. Detaylandırma aşamasının tasarım görevinde ihtiyaçlar, fonksiyonlar, gereksinimler ve mekanikler analiz edilmiş ve tüm maddeler arasında takip edilebilirlik sağlanmıştır. Yapılabilirlik analizi gerçekleştirilmiş ve ilgili değişiklikler gerçekleştirilmiştir ve eş zamanlı olarak ilgili görevin gerçekleştirilmesi için doğrudan benzer sistem bakım ve destek konseptinden yararlanılmış ve uygulanmıştır. Son olarak tüm belgeler tek bir formatta birleştirilerek tüm paydaşlar

ile paylaşılmış görüşleri alınmıştır. Kazanılmış dersler açısından uygulanma incelendiğinde hızlı prototipleme ve versiyon tabanlı geliştirmenin paydaş etkileşimindeki çok kritik önemi öne çıkmaktadır. Özellikle ciddi oyuna uzak paydaşların ancak gördükten sonra yorum yapabildikleri tespit edilmiştir.

İkinci vaka entegre lojistik destek kavramının öğretiminde kullanılmak üzere geliştirilmiş bir kart oyunudur. Tek bir çalıştayda için sadece iki-üç hafta arasında kısa bir sürede gerçekleştirilmiştir. Birinci aşamada sistem duyulan ihtiyacın nedenleri belirtilmiştir ve klasik eğitimin dezavantajları dengelemek adına oyun destekli eğitimin tercih edilmesinden dolayı ciddi oyunun geliştirilmesine karar verilmiştir. Birinci aşama uygulama iş paketi için eğitim hedeflerine göre benzer oyunlara dayanarak kart oyunu tercih edilmiş ve oluşturulan basit protipler ile oyun dinamikleri denenmiştir. Geliştirilmesi gereken mekanikler tespit edilmiştir. İkinci aşama olan detaylandırma aşamasında gelişen prototipler üzerinden yeni gereksinimler belirlenmiştir ve bir sonraki versiyona eklenerek deneme süreci devam etmiştir. Grafik ihtiyacının karşılanması için hazır yazılım çözümleri beşinci adımda denemiştir ve kullanım kararı verilmiştir. Kartların grafikleri bu aşmada finalize edilmiştir örneklerden baskı alınmış ve prototip versiyonları yeni grafikler ile denemeye başlamıştır. Son olarak eğitim için ihtiyaç duyulan çevre ihtiyaçları eğitim merkezi ile görüşülerek giderilmiştir.

İnşaa aşamasında ise ayrı bir işlem olarak ele almak yerine oyna-geliştir metodu izlenmiş ve tüm adımlar geliştirme işlemenin parçası olarak izlenmiştir. Uygulama aşamasında ise eğitimin sonunda katılımcıların ciddi oyunla ilgili görüşleri alınmıştır ve geri bildirim döngüsü oluşturulması sağlanmaya çalışılmıştır. Son olarak geri bildirimler değerlendirilerek sistem geliştirme döngüsüne yeni ihtiyaçlar olarak eklenmiştir.

Sonuç olarak incelendiğinde metodolojinin basamakları iki vaka arasında aynı mantık içerisinde uygulanırken yarattığı iş yükü açısından ciddi farklar olduğu görülmektedir. Metodoloji birden fazla geliştiricinin karmaşık bir konuda çalışmasını sağlamak için gerekli altyapıyı sunarken aynı zamanda küçük bir ekibin hızla bir sistem geliştirmesinde yardımcı olmaktadır. Getirdiği katılar açısından incelendiğinde birçok geliştiricinin deneme ve yanılma yolu ile keşif ettiği

kazanılmış dersleri geliştirmenin ilk aşamasından sürecin içinde tekrar tekrar hatırlatarak hataları yapmaya engel olmaktadır. Aynı zamanda geliştirme aşamasında yapılan sistemin doğruluğu ve eğlence değeri içerisinde ikileme düşüldüğünde sunduğu değerlendirme yöntemleri ile alternatif cevaplar sunmaktadır.

İki vaka çalışması, metodolojinin iş yükünden daha fazla yarar sağladığına dair kanıt sağlamak için yeterli olmadığı belirtilmelidir. Diğer birçok fonksiyonel ve insan odaklı tasarım yaklaşımı olmasına rağmen önerilen metodoloji sistem mühendisliği ve davranış ekonomisiyle sınırlı kalmaktadır. Dahası, yaygın geliştirme sorunları zaman içinde değişecek ve artacaktır, bu nedenle metodoloji yaşayan bir belge olmadıkça, büyük bir olasılıkla çok hızlı bir şekilde yetersiz kalma olasılığı vardır. Son olarak, oyun ve eğitimin teknolojilerin geleceği son zamanlarda gerçekleşen teknolojik ilerlemelerle sadece hayal gücü ile sınırlı kalmaktadır. Ciddi oyun endüstri geliştikçe ve olgunlaştıkça kendi içinde bir denge kuracaktır. Ancak, oyunların tarihi dört bin yıldan daha fazla iken hala oyun geliştirmek için tek bir metod yokken belki de ciddi oyunlar içinde aynısı geçerli olacaktır.

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