Adaptive Learning Game to Personalize Occupational Health and Safety Training

By

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Abstract

In 2012, the Association of Workers' Compensation Boards of Canada recorded approximately a quarter-million workplace injuries, a staggering figure keeping in mind that some incidents go undocumented. It is important that organizations continue make Occupational Health and Safety (OHS) one of their top priorities.

In this thesis, we discuss an implementation of an adaptive personalized learning support system within a game that is centered on health and safety training to promote the understanding of health and safety material. The design of the game incorporates a feedback loop that constantly evaluates the player's performance while they complete learning challenges. As the players proceed within the game's environment their profile is constantly updated thus providing an insight into their strengths and weaknesses. The game is designed to adjust the challenges given to the player to focus on improving the player's underperforming skills. The goal of this game is to promote health and safety in small and medium enterprises. Through this game we created a motivational designed application that helps to teach targeted health and safety information to the workers.

The game was made in collaboration with the Public Services Health and Safety Association based in Toronto. The game aims to better the player's health and safety performance in the Organizational Performance Metric and hone their underlying health and safety skills.

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Publications

List of publications related to this thesis:

1. C. Chodan, P. Mirza-Babaei, and K. Sankaranarayanan, "Safety Does Not Happen by Accident, Can Gaming Help Improve Occupational Health and Safety in Organizations?," *Digit. Hum. Model. Appl. Heal. Safety, Ergon. Risk Manag. Heal. Saf. 8th Int. Conf. DHM 2017, Held as Part HCI Int. 2017, Vancouver, BC, Canada, July 9-14, 2017, Proceedings, Part II,* vol. 10287 LNCS, pp. 321–332, 2017.

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Publications

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Acronyms

AI	Artificial Intelligence
HCI	Human Computer Interaction
HSA	Health and Safety Association
IWH	Institute for Work and Health
IWH-OPM	Institute for Work and Health Organizational Performance Metrics
OHS	Occupational Health and Safety
OPM	Organizational Performance Metric
PSHSA	Public Services Health and Safety Association
SDT	Self-Determination Theory
SME's	Small and Medium Enterprises
UCD	User Centered Design
UOIT	University of Ontario Institute of Technology

Chapter 1: Introduction

1.1 Overview:

Throughout this thesis we will be discussing the need for an adaptive game to teach health and safety information and procedure. Through our research, outlined below in Chapter 2, we determined that a serious game with an adaptive system would be most applicable to teach health and safety knowledge. A serious game is an application where education and play are integrated together to create a gamified learning experience [10]. As Health and Safety education has an extensive knowledge base, it requires personalized occupational training, and the use of a serious game could increase the motivation and retention of health and safety information. The advantage of using serious games is that the application can provide immediate feedback on the concepts being learned.

In this thesis, we explore the use of a serious game with the elements of adaptive learning [17], and User Centered Design (UCD) [34] with the aim to help workers learn about health and safety content through targeted educational material. In this introductory chapter, we will discuss the motivations that started this project.

1.2 Motivation:

PSHSA needs an encompassing digital tool to teach health and safety. This target audience required a large variety of information with knowledge that could apply only to specific subsections of the user base. With this, we saw potential for using a digital application

that immersed the users in their relevant health and safety information. PSHSA saw the potential for exploring the use of a video game to teach this health and safety knowledge.

Video games are often seen as a form of entertainment. In addition to entertainment, video games offer an escape from reality for some users [29]. Games excel in immersing the player into the game world and holding a user's attention for long periods of time [30]. In games that use adaptive Artificial Intelligence (AI), the content in the game is made relevant to the user [33]. The game adapts to the user's play and can provide a unique experience or drive the flow of a game. These games provide a unique experience for the player, and gives the player an opportunity to learn a new way to play and expand their knowledge of the game mechanics. In addition, games create their own environment and rules, with a focus on entertainment rather than pure learning. However, due to the intrinsic learning opportunities within a virtual environment like a game, video games open an opportunity to teach real world skills within a virtual world [14]. These virtual worlds provide a safe space for users to test their understanding of information. Within this space, users can make mistakes without the real world implications that mistake would have. All games force the user to learn the rules of the game, may these be how the world work or its mechanics.

Within games, serious games focus on teaching a range or a specific skill or procedure in a virtual environment while maintaining the interest of the user [53]. Serious games can be tailored to specific fields, or generalized to teach overarching expertise.

Health and safety training is comprised of several methods for training such as: traditional classes where the workers train in a classroom setting [4], Mentorship, where the worker

is guided by a mentor in their work environment [23], Workshops, where the workers receive training in a closed environment to reduce risk for the workers, Onsite training, where the worker learns about their job in an authentic environment, and Webinars/ e-learning, a form of online class with questionnaires and testing [27]. Each of these training methods teach the worker the health and safety skills needed for their work environment. However, this does not limit the training opportunities, and the use of a serious game application provides an additional medium to train members of a workplace in health and safety knowledge.

Through our partnership with PSHSA, we found the need for a tool to aid in health and safety training in a multitude of specific work environments. Health and safety training is mandatory over multiple sectors of work, in many different workplaces. Due to the large number of work fields that require health and safety training, and the mundane nature of current health and safety training, we determined that integrating education and play would help motivate those learning health and safety in their workplace and retain the learnt information. Currently, the methods for teaching health and safety tend to fall along the lines of mentorship, or classroom learning opportunities as explained above. Given the importance of health and safety in a workplace, a tool to promote the learning, and increase retention of the information would reduce the risks that could arise in a workplace environment. A serious game with the addition of an adaptive system can make the information relevant and interesting to a user.

There is a gap in the learning in small to medium sized organizations [40]. The creation of an easily accessible and motivational tool such as a serious game for health and safety

training could have the potential to decrease the risk of injury or illness at these organizations. As more training increases awareness for health and safety problems in the workplace, potential dilemmas are more likely to be prevented before they occur. Additionally, as the user is introduced to these virtual situations, the user can become more familiar with health and safety concepts.

1.3 Thesis Statement:

We created a serious game learning tool utilizing an adaptive system that personalizes teaching health and safety information in a multitude of workplaces, while creating a motivational and fun learning experience for the users.

1.4 Thesis Outline:

Through this chapter we have discussed how the need for a health and safety training tool has risen. We have also discussed that the target of this thesis is to describe the decisions and path taken to create a solution to the health and safety problem. The next chapter will cover a literature review of the surrounding academic environment related to game design and serious games. In chapter 3, we will describe how we arrived at an understanding of the needs of both the end users and our industry partner. Chapter 4 describes how we approached the game design of our initial prototype and discuss the feedback we received. Chapter 5 discusses the final design and the feedback we got from it. Chapter 6 will cover the summative evaluation of the game, including the assessment of the clients needs, and the meeting where feedback and discussion occurred based on

the design of the serious game. The thesis will end with a discussion and conclusion rounding up all the information and main takeaway.

1.5 Summary:

Through this initial chapter, we have introduced that PSHSA wanted a video game training tool to teach users health and safety knowledge. We discussed the motivation for the creation of this project, ranging from the motivational medium that is videogames, to adaptive AI in games, to the useful tool of serious games. Throughout the chapter, we have touched on the problems in current health and safety practices and how a serious game application can have a positive effect on health and safety learning by using adaptive learning techniques similar to that of adaptive AI. As stated above, the intention is to create a tool to promote and motivate members of a workplace to increase health and safety understanding particularly in small to medium sized organizations where health and safety is understated. With our partner and end user in mind, we concluded that the outcome of a health and safety tool would be achieved through an educational serious game. We have discussed the layout of this thesis, and will further describe techniques, research and tools used to promote health and safety training through this thesis.

Chapter 2: Literature Review

2.1 Overview:

Games are a part of everyone's life. In today's world, people not only play physical games like soccer and football but also play games in the virtual world. People can now play digital games on many devices such as computers, phones, TVs and gaming devices like consoles [32]. Fifty-four percent of Canadians are gamers, with the average age of the Canadian gamer being thirty-three [18]. Not only are there many gamers in Canada, there is also a growing interest in game companies. From 2013 to 2015, Canada saw 143 new game development companies raising the overall number to 472 [18]. With the growing number of games and game companies, there is also growing academic interest into other application of games. Games serve several different objectives, some entertain, some teach, some to reinforce wanted behaviours, and some help with physical rehabilitation [39][47][31][48]. Games can achieve these outcomes with specific content, applicable hardware or through explicit and implicit learning outcomes [20]. With different subject matter being covered, or hardware being used for disabilities, games open the doors for many learning styles and educational opportunities.

Games have part to play in teaching and provides a medium for entertaining and motivating the player. With a game providing enough intrinsic motivation for continued play and that people are more receptive to learning when motivated makes games a

powerful tool [47][45]. It is important to note that in practice when a player does not want to play the game motivation decreases [3].

Commercial games are products that have a focus on entertainment and enjoyment. Whereas in serious games, the focus extends further than entertainment and includes aspects education: teaching, training and informing [53]. In section 2.4 we will discuss current motivational game design techniques used when creating a game.

2.2 Games:

Over the years games have developed and taken many forms. Games can range from board and card games, to social games, to those in the virtual world and many more. Most of the games created in each medium were made for entertainment but all of them teach the players valuable skills and knowledge. The players of games are also very diverse and understanding the different perspective on players is at the heart of some research [59]. In games user research, the focus is on enhancing a game through measuring the players behaviours and experiences and enacting on the data received [38]. There is also a variety in the data received as some players are not experienced in creating balanced game play and others are [21]. The intent is to make sure the designers intentions are translated effectively into the game. human computer interaction considers the player among many other aspects of interactive applications [37].

Most games are developed to be entertaining and enjoyable for the players. Entertainment is not the only goal of a game; they also teach intrinsically. The intrinsic learning in games come from engagement and motivation [19]. It has been shown that

people are more receptive to learning while in this environment [47]. This is in part due to the motivational elements that can be integrated into a game, and the sense of achievement the player feels when receiving these motivational elements. This is shown as player retention, or how the player wants to, and does continue playing the game. This aspect is something that can be included in serious games to teach educational subject matter. While the user is engaged in playing the game, they are learning about the play of game and how the game world works. It is also not so far fetched to say that the player will be learning some useful skills, but in a game where there are no teaching goals it is hard so see if there is any useful learning happening [22]. Arnab et. al. [1] maps game mechanics to learning mechanics and describes some game mechanics that are typical of games and are also suited for serious games.

Games create a desire to play through the Self-Determination Theory (SDT) [46]. The self-determination theory is a theory on human motivation that requires three basic psychological needs to be satisfied. The first of this is the need of competence. Competence is the need to overcome problems and seek mastery. In terms of a game, this can be seen where players look to increase their score or push themselves to perform the game mechanic at a higher competency. The second need is relatedness. Relatedness is the want to interact with others. Within games, this is seen through social aspects of game design. These social aspects happen via leaderboards where players can compete with each other. A more direct example would be social games where players can directly interact with each other through in game chat or cooperative play. The last need is autonomy. Autonomy is the need to control one's own actions. In games, this is seen as

freedom. An example would be in role playing games where the player can use their own actions to act upon the world. Within serious games, this can be enacted by giving the players multiple options to complete a challenge. Commercial games use the SDT to promote continuous play by combining each to promote motivation of the user. Below is a self-authored Illustration to graphically show the relationship of SDT (Figure 1).
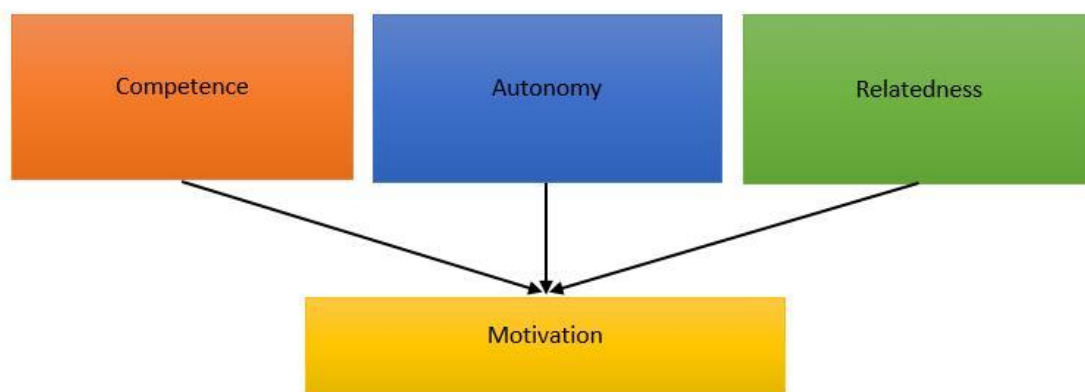
Figure 1: This is an illustration of the three basic needs and how they come together to create motivation.

From the use of problems introduced to make the game challenging and enjoyable, the player becomes more motivated but if the game is too challenging it becomes unenjoyable. Good game design wants the player to stay in the flow channel [7]. The flow channel keeps the player entertained and more focused. The goal of the flow channel is to keep the player in situations where they have enough skill to overcome the challenge in the game as shown in (Figure 2). If there is too much challenge and not enough skill the player will have anxiety. In contrast, if there is too little challenge, and ample skill, the player will get bored. This is just another point on how commercial games increase the motivation of players. Flow of the game means that the player is constantly engaged without feeling frustrated or anxious over their competency in the game. It is often

described as when the player is involved in the game to the point where the passage of time seems to accelerate. With this flow, difficulty is a tool for creating flow. If a player has a lower skill, difficulty can be reduced to keep them involved in the game. This works both with high difficulty and highly skilled player and low difficulty and lowly skilled player. Using the design elements that foster motivation in commercial games for learning brings us to our next topic on serious games.
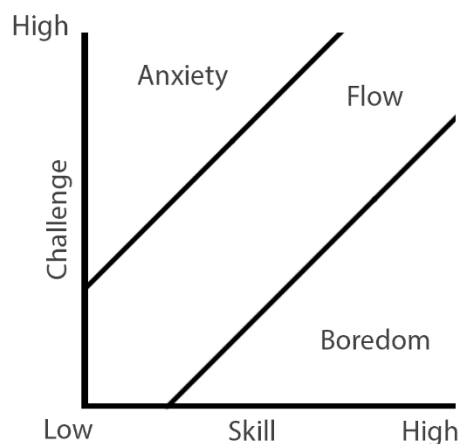
Figure 2: Challenge vs Skill flow chart proposed by M. Csikszentmihalyi [9].

2.3 Serious Games:

Serious games use play to create integrated learning through educational content in the game that focus on teaching the player a set of skills and/or knowledge. They are built on the game design elements used in commercial games [20]. The term serious is used to denote that the application of these games are for the more serious industries such as defence, health, education and many more [53][52].

One issue with serious games is at what point does playing the game stop being voluntary. At what point is the player being pushed to play the game instead of being motivated to play the game? For serious games to be motivating, we must not corrupt the basic principle that a game is voluntarily played [22]. Overall, being forced to partake in something is not a pleasurable experience. The same goes for games. When a player is forced into playing a game, they are less likely to enjoy the experience and their immersion and understanding of the game material is reduced greatly. If a player enjoys the game, they are more likely to continue playing, and have an increased knowledge of the material being demonstrated. In addition to the above, they are more likely to enter game flow, and become immersed in the virtual environment.

Serious games are designed to teach the players cognitive and psychomotor skills they will need depending on the field. The skills and knowledge is at the core of the game, and players need to use the newly learned knowledge to get through the game. Take into consideration a flight simulator, commercial airlines have all their pilots train thousands of hours on flight simulators before they get to fly a real airliner [8]. The same serious game could be used to train pilots in the air force.

Serious games are made for many fields using a wide variety of technology. R. Shewaga et. al. [49] created a serious game in virtual reality teaching epidural preparation in which he also made a comparison between having the player play seated or in room-scale. D. Panjwani et. al. [41] created a mobile application for emergency contraception awareness and both knowledge and methods used promoting the player to make an informed choice.

In serious games, there is a need for a level of fidelity. fidelity is the degree of which a game represents the real world with the use of graphics, audio, video and artificial intelligence [5]. The closer a to real life a serious game gets can create an immersive and exciting experience [24]. The degree of fidelity that the serious game requires is based on what the environment and situation call for. If engagement with real life replicas of equipment is required a high degree of fidelity is needed for authenticity, but if the leaning goals do not require such a level of authenticity a low degree of fidelity will work [26][58].

Players of serious games can closely relate their experiences from virtual events, to events that could happen in real-life. Each time a player trains with a serious game they become more capable and comfortable performing in the situation or reacting to an event.

Using serious games, it has been shown that information learned in game format is retained more effectively than if the information was learnt in a traditional format [43]. This has been shown in a serious game for military trainees. In this activity, the users were split into two groups. These groups were trained on a specific task, half in a test format and the other half using a training game. When tested later, those who were trained using a game achieved higher scores than that of their traditionally trained counterparts.

2.4 Motivational Game Design:

An important aspect of a game is promoting and motivating through play. Through games, users can be motivated through game design that keeps the user wanting to play, and in the case of serious games, learn more [50]. Reward systems offer the user a reward that motivates them [57]. There are many options for the rewards offered in games [42]. These

can be in game visual changes such visual upgrades or personalization's. This can be seen in games like Smite [51]. On completion of a match, players have the chance to open a loot box granted to them by the game, and be awarded a visual change to a character in game. This visual modification can make the player feel special, and promote learning to play this character more [42]. Through that, they also continue playing the game and the cycle continues. Additionally, some visual upgrades act as a form of exclusive rewards (Figure 3). These may be unlockable through specific feats of skill performed by the player, or from a milestone in play. These visuals show that the player has overcome a challenge, and other players can see this achievement, adding a social aspect to the visual upgrades.
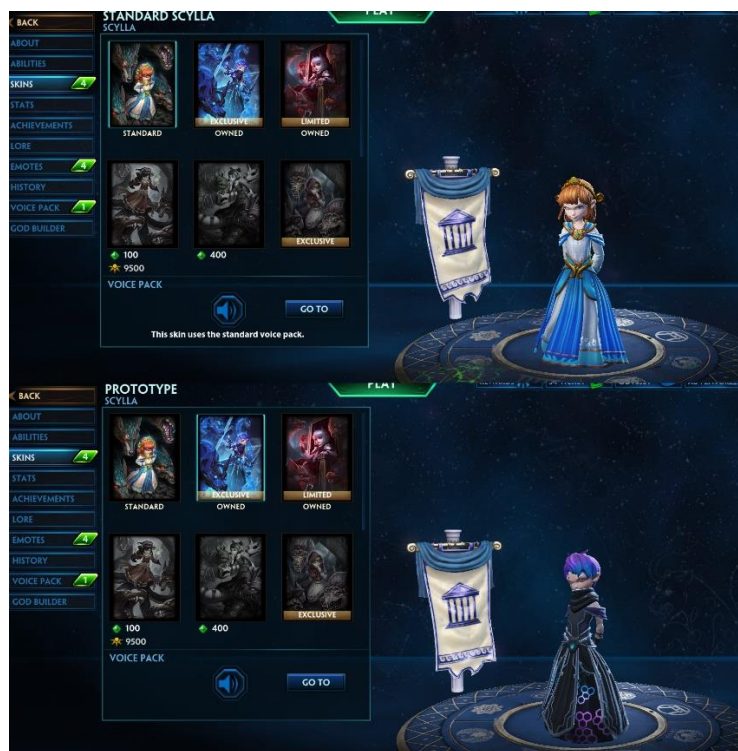
Figure 3: The difference between the standard (top) and an exclusive (bottom) character skin in Smite.

Another form of virtual rewards given through play is achievements/medals/badges [11]. This can be seen in games like Battlefield 4 [2], where the player is given a badge, called a ribbon, for their skill in the game. These ribbons are given for feats of skill, or unique interactions in game. These aspects of the game promote the player to continue playing as well as giving the player something they are proud of (Figure 4). Another form of reward are items or secrets given out during play. DOOM [15], a pioneer of the first-person shooter genre, offered secrets and items to their players when they explored areas in the game. This form of reward system promotes longer and more involved play, and keeps the player motivated to play. Many other games use items and secrets to continue play from Legend of Zelda [61], to Tomb Raider [44]. The final form of reward is game score. A score is a fundamentally used aspect to games where a set of numbers or a value given to the player for something specific. If the player performs better at the task in game, their score is higher. Scores go back as far as arcade machines, where the players could see how well they have performed along with all the previous players as well. A good example of this would-be Hotline Miami (Figure 5). In Hotline Miami [28], the player receives points based on their actions within the game. This is based on number of kills, how a kill is enacted and combos of their actions in game. Score is fundamentally how well the player has performed in the game, and can be an incredibly motivating tool for designing a game. With the use of score, you can push your players into aiming for the next high score. This motivates players to do better as well as stay motivated to complete more and more tasks.

Figure 4 Battlefield 4's end of round awards.

Figure 5: Hotline Miami's leaderboard with global ranking for Friends.

An aspect of score is that of game statistics. These are in game accomplishments or data about the users play. Games like Battlefield 4 show a wealth of statistics for public showing (Figure 6). These statistics not only give the player bragging rights but also provide the player with a goal to improve upon. Statistics are featured in many online and social games that promotes play and boosts their self-confidence. With statistical information available to the player, they can see where they want to improve, and motivates them to want to change it.

Figure 6: Battlefield 4's Player statistics pulled from their 'battlelog' website.

Along with rewards and statistics, games utilize challenges to push and motivate players to better themselves. As well as being a motivational factor, challenges act as a tool to show the user where their skill and understanding of the game mechanics lie [7]. Using challenges in a game can give the user a sense of understanding and a goal to move towards. Even if the user cannot pass the challenge at their first attempt, simply attempting the challenge can help the user learn and grow to tackle this challenge again. This can be seen on a smaller scale in mobile games where small puzzles are played. An example of this is Toy Blast [55], a mobile puzzle game where the player solves individual small puzzles (Figure 7), while being able to play multiple puzzles in a session. The player may not solve the puzzle in their first attempt, however they have a better understanding of how to complete the challenge and through this learn more about the basic mechanics and play. This also helps to promote the exploration of the game and its mechanics. As

the player does not succeed in the first attempt, they can use a different approach to try to solve the challenge. This can range from a different playstyle to varying their approach in play. Challenges can be a great motivator additionally when the player overcomes this challenge, they receive a boost in self-confidence, and will continue to play more as they feel skilled at this activity.

Figure 7: Toy Blast, a match 3 puzzle example.

With these systems, a designer can also combine motivations to create unique motivational systems for design. For example, challenge and score can be combined into the form of a competitive season, like that of in Tom Clancy's Rainbow 6 Siege [54] (Figure 8). In this, the player completes specific matches that awards them a skill rating or score. These seasons of play only last for a specific time period meaning that they want to pursue a high score in the limited time. This creates a score that promotes the player to try for a

higher value, and gives the player a challenge that they want to complete within the time period.
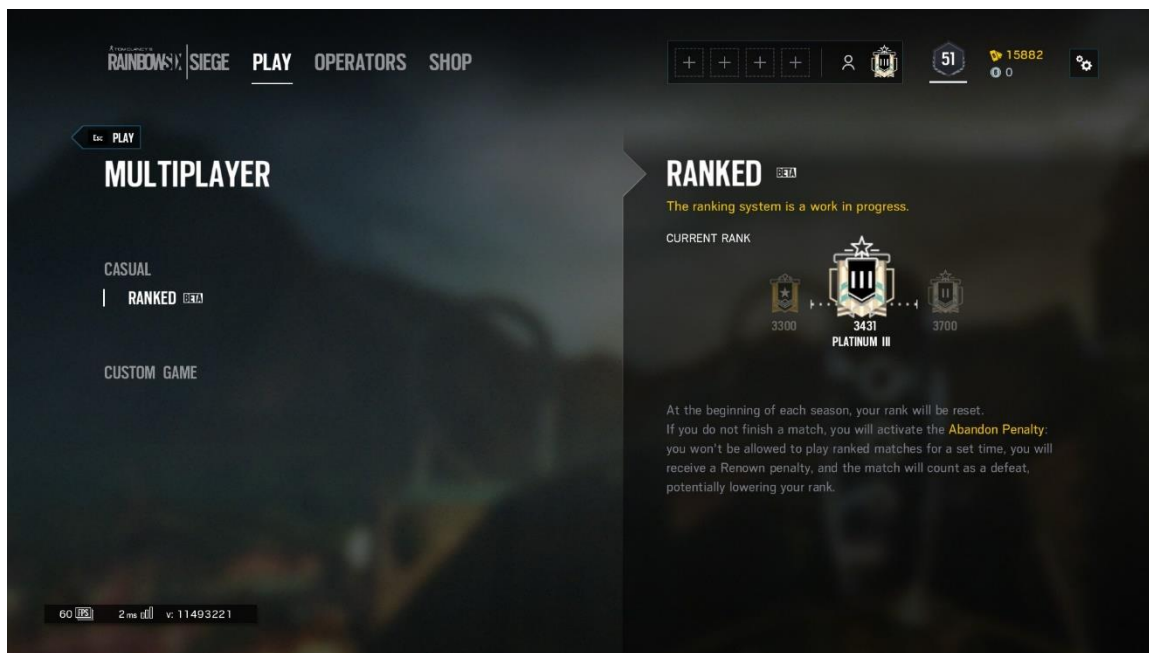
Figure 8: Tom Clancy's Rainbow 6 Siege ranked season score.

In addition, retention is a motivating tool designed to make the player want to continue playing the game. These can be anything from a periodical reward to a daily challenge. This tool helps keep the players coming back. Retention of players can mean that players who are moving away from the game or beginning to become disinterested can be pulled back in by this design element. The use of periodic rewards - like that of the chests in Clash Royale, or a daily challenge like in Blizzard's Hearthstone will keep the player wanting to come back and complete these aspects of the game.

Designers can employ all of the above designs to promote player motivation in their games. Any combination of the above designs can be used to retain players, and promote dynamic play.

2.5 User Centered Design:

We followed user-centered design (UCD) process to focus our design on the user's needs and goals [39]. With the UCD stages, the first of these are understanding user's needs. This is determining the solution for the problem in terms of what the user requires in the solution. This is a plan for what the designers intend to solve based on research of what the user requires. The second is getting the requirements for the design. These are general requirements for the project, and are outlining what is needed to be designed. The third is prototyping a solution for the user defined problem. This is creating a quick prototype to quickly iterate over a solution possibility to solve the problem. These quickly iterated solution may not work initially, but the cyclical method allows for the solution to be found with the needed prerequisites. Finally, the fourth is evaluation of the prototype. This involves testing the prototype and determining if it meets the user needs, uncovers any new requirements or needs further iteration. If the design requires further iteration, the designers will return to step one and re-evaluate the design. UCD is a cyclical design pattern where iteration is key. These iterations mean that designers can aim to best meet the users' needs through design.

2.6 Adaptive Learning in Games:

Games utilize adaptive learning techniques to allow players to interact with the game as they feel most comfortable. This can be allowing players to complete challenges as they see fit, challenge a user in a specific skill they lack experience in, or giving the user a sense of freedom in the game. A way to achieve such a goal is to implement a system that adapts and personalizes based on user's needs. Adaptive systems are a departure from the 'one-size-fits-all' approach and aims to tailor the environment around the user. A 'One-size-fits-all' approach creates a generic product that is the game [36]. Unlike that of adaptive systems, the larger the scope of the game, the more the 'One-size-fits-all' approach becomes more generic and less applicable to the goal. With adaptive systems, the system allows you to target specific sections where generalization will case a lack of depth for some users. This system allows for an application to have a breadth of information while retaining the depth required by specific users. Adaptive systems are focused on increasing learner satisfaction, effectiveness and engagement [36]. Adaptive systems complete these needs by learning about what the user prefers, and presents or challenge the players preferences.

Studies showed that adapting to the user's feedback could make a major impact on user's satisfaction and motivation [56]. Video games can be considered as powerful medium to explore adaptive learning systems as they allow a degree of autonomy that can be utilized by an adaptive algorithm. This means the algorithm can adapt to the user and show the user content that would be applicable to them. Imran Zualkeman et. al. constructed an adaptive game that changes the content and delivery of the content based on the player's

abilities [60]. Such a design may provide a more motivating approach to learning for the audience. This is because the game can adapt to how the user wants to play, meaning the player is more likely to enjoy the game. If the user played a specific way that was favored by them, the system could adapt to their preference.

2.7 Summary:

Throughout this chapter we discussed the literature researched to support the development of our application. We have discussed multiple design practices used within games. With commercial and serious games, researching the aspects of motivational game design is key to determining effective design for any game application. Motivation plays a key role in retaining players, and providing education through a serious game. With the use of motivational tools, players have the ability to intrinsically learn the material being presented to them. The use of SDT within games means that the information presented in games is relatable and meaningful for the user. This also helps to increase user retention.

In addition, Motivational game design is an advantageous tool for designers. With the use of motivational elements in game, the users can increase immersion, in addition to player retention. The use of motivational elements is not restricted to commercial games, but can also be used in serious games to increase the understanding of subject matter material. This tool, when used in a serious game, can retain the users, and promote their understanding of the educational content in the game.

When designing motivational tools to be used in a game, the relevance of the reward or challenge must be valid to the user. The reward given, or challenge posed needs to motivate the user. With the use of motivation, the game must provide a setting where the player can be comfortable playing. This ties in with adaptive learning of the game, where the game provides the option for the user to play as they see fit.

Finally, we discussed the use of UCD in game design. UCD is a cyclical design pattern where iterations of the current design can be made to advance the development while keeping the user's needs at the forefront of development. UCD aims to make the designer as user friendly, and user focused as necessary.

Chapter 3: Understanding the Needs of the Clients and Users

3.1 Overview:

Although the Public Service Health and Safety Association (PSHSA) has a wealth of resources and training materials for organizations, they realized a lack of utilization of these training materials by Small and Medium Enterprises (SME's). Through internal studies , PSHSA identified a need for an engaging application to motivate SME's to learn about health and safety prevention. Through collaborating with PSHSA and its partnering associations we aim to create a serious game for motivating SME's to learn and continue learning about health and safety prevention using game design. With game design, an application can be developed with the users and client's needs in mind while creating an engaging serious game that teaches health and safety. In addition, the game also needs to present relevant health and safety information to the players while having a short game loop so players can play when they have small windows of time.

The serious game is based on the Institute for Work and Health Organizational Performance Metrics (IWH-OPM). IWH-OPM[1], which is an eight-question survey designed to assess and improve an organization's occupational health and safety performance. IWH-OPM uses a Likert scale questionnaire where each one of eight questions is targeted

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[1] https://www.iwh.on.ca/opm

to determine the performance of an organization in a specific area. IWH-OPM provides a benchmark for organizations within the same sector to compare their performance.

3.2 IWH Organizational Performance Metric

Institutions can gauge their health and safety performance by using the IWH-OPM questionnaire. The IWH-OPM questionnaire is an evidence-based, eight component questionnaire (Figure 9) used to help organizations large and small to identify, assess and improve their health and safety performance. This questionnaire provides a score from which the organization can determine where improvements in health and safety policies or practices needs adjusted or changed. The IWH-OPM was developed by the Institute for Work and Health, in collaboration with health and safety professionals in the province of Ontario. These questions cover a large number of workplace sectors, and those who score highly on IWH-OPM questions can be directly correlated to lower injury and illness in the workplace.

Health and Safety Practices	80%-100% (4)	60%-80% (3)	40%-60% (2)	20%-40% (1)	0%-20% (0)	Score (4-0)
1. Formal safety audits[1] at regular intervals are a normal part of our business.						
2. Everyone at this organization values ongoing safety improvement in this organization.						
3. This organization considers safety at least as important as production and quality in the way work is done.						
4. Workers and supervisors have the information they need to work safely.						
5. Employees are always involved in decisions affecting their health and safety.						
6. Those in charge of safety have the authority to make the changes they have identified as necessary.						
7. Those who act safely receive positive recognition.						
8. Everyone has the tools and/or equipment they need to complete their work safely.						

Sum

OPM final score = Sum divided by 8

Figure 9 IWH-OPM Questionnaire[2].

3.3 Finding the Problem/Gap:

Creating health and safety training that the worker finds engaging has been on PSHSA's mind for a while. Internally in PSHSA they had an eureka moment after playing the brain game Lumosity[3]. The client determined that there might be an opportunity to create a health and safety game that is entertaining, short and simple like Lumosity. This game application would support existing information and learning materials, and promote users learning about health and safety in a digital environment, rather than learning it through

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[2] Found on Institute for Work & Health website: https://www.iwh.on.ca/system/files/documents/iwh-opm_questionnaire_2016.pdfB

[3] Lumosity's website: https://www.lumosity.com/landing_pages/970?gclid=EAIaIQobChMIn9OYi-uH1wIVnrjACh2DjwWWEAAYASAAEgJHvvD_BwE

text, seminars or other educational methods. The client particularly liked how luminosity showed the users results, progress and their standing with others in luminosity.

With this knowledge, PSHSA wanted to develop a better understanding of how the leaders within a workplace made occupational decisions about health and safety. With the use of a serious game, they deduced that this would assist in dissemination of health and safety practices within Ontario workplaces when teaching said materials.

In addition to retaining and teaching the workers about health and safety, the application created needed to be motivating, engaging and have relevant health and safety concepts/information. As a game-based application has the objective of learning, engaging the users can be hard to achieve. Player engagement is key to keeping the player immersed in the game. In games there are several ways we do this but some may not fit well into a serious educational games. A method for promoting player engagement is using pleasing visuals and animations rather than plain text. Another way to keep a game engaging is giving players rewards, talked about in 2.4. Giving a reward like a badge to add significance to the players action. Each of these techniques helps keep the player invested into the game and willing to play.

To make a game about health and safety, we not only need to engage the player, but the game must also be relevant to the players work environment. With this in mind, health and safety needs to be made relevant to the player, and meaning we will need to learn some basic information about them before play. The sector their organization works in, their role in the organization, and their skill level in health and safety. Given this key

information about a user we can create a game that teaches the user about health and safety.

When creating a game, the developers must keep in mind the target audience's availability to play the game. Creating a game for health and safety leads to the issue of users playing the game while at work. In our approach, we aimed to keep the game loop short, meaning an iteration of a mini-game would only take about 5 minutes. The advantage to a short game loop is that the player can play the game in between meetings or while they have time in between tasks.

Part of PSHSA's motivation for this project was that they want to promote the use of OPM questionnaire. They've shown that this questionnaire is useful for indicating health and safety risks for an organization. The serious game was developed based on the on this questionnaire. By taking this questionnaire and transforming it into a serious game, they could potentially receive more of a concrete response to their health and safety concepts. When the OPM questionnaire is used, the user can get a response from an organization to know how well the health and safety training has been conducted. The OPM is completed on their site and get a response from them. PSHSA wants to utilize the OPM questions through the medium of a serious game to see the learning experience users have from this game training.

Finally, when creating the application we needed to keep PSHSA's strategic plan in mind (Figure 10). This included transforming the business model and developing solutions, collaborating and structuring for growth and understanding, and innovating to better serve the market. This was the overarching strategic plan and a main requirement for us

to keep in mind during development. This aimed to support research and development along business lines. Due to the content and medium of this application, this project would impact both the consulting business line and likely the training business line in addition.

Figure 10: PSHSA's strategic plan[4].

3.4 Determining what the Industry Partner Wants:

With any project, the needs of all collaborators is required to move forward in development. With this, our project consisted of group oriented meetings with many organizations collaborating towards the end goal of an application to teach health and safety skills. To create a digital application for promoting, as well as motivating users to assimilate health and safety knowledge, required that we discuss the skills the application

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needed to teach. Consequently, we held a few brainstorming sessions to determine and discuss the skills related to each of the eight IWH-OPM questions (discussed in chapter 4). This included asking all the collaborators a series of questions such as: "if the output of the task is 'x' what skill is needed to carry out the task?". These sessions were effective in generating the underlying skills for each IWH-OPM question. For example, the first IWH-OPM question "Formal safety audits at regular intervals are a normal part of business" the resulting key skills identified were: Time management, Assessment of validity and fit with organization, Organization Skills and Attention to detail. This will be further discussed in depth in chapter 4.

We received an initial request from PSHSA for collaboration on development for a serious game health and safety training application. The request was to use serious game methods to improve leadership skills and information retention in terms of the health and safety training. They requested taking gaming techniques to develop an application for other uses in education, scientific research and public policy. The application would also cover the 8 IWH-OPM questions and the Ontario Leading Indicators Project(OLIP) - a project to identify organizational and management measures to predict and prevent workplace injuries and illnesses.

With this request, the objectives of this project were brought to our attention. PSHSA requested we address the following questions

A. How do organizational leaders use benchmarking information in making OHS decision making?

B. What are the facilitators and barriers to using the benchmarking data and how can this be improved?

C. What other types of information do leaders use to inform OHS decisions?

D. What knowledge and features should a performance dashboard provide for leaders?

E. What information should an application with follow-up activities provide to engage leaders to make decisions to support change, reduce hazards and improve health and safety?

Along with these questions, PSHSA posed two more objectives with the project. These being that they requested the use of focus groups and interviews to obtain information to help move leadership along the innovation curve in terms of the application's activities. These focus groups and interviews were conducted by PSHSA and/or HSA researchers. Finally, they requested a pilot test of the application to examine the tools when used by organizational leaders and how the tools influenced their decision making. These pilot tests would consist of a small sample of firms, and completed by IWH as they have access to the end users.

With the development and planning of the creation of this tool, we needed to identify the sectors that would have access to this application and therefore also benefit from its use. Through the evaluation of our initial prototype (see chapter 4), the requirement was determined that the application needed to have information relevant to all of the sectors that would be using this game. This meant that through development we needed to redesign the next prototype to have knowledge specific to any one of the sectors. This

was so that the application was applicable to be used for any of the 15 sectors. We will discuss the sectors below in 3.4. In addition, a user in a specific sector would need to have access to the relevant knowledge related to their sector only. For example, this meant that a miner using the application would only have access to health and safety knowledge relevant to mining operations, rather than having access to information from unrelated sectors. This meant we needed to develop a system that could handle many sectors at once, creating a broad application with specific relevant information per sector.

3.5 Determining the Needs of the End User:

As mentioned before, we followed UCD process in this project. To better understand the user needs, PSHSA had conducted interviews and focus groups. The focus groups and interviews highlighted features that needed to be covered in the game and how the application would perform. Based on these initial studies PSHSA defined three key requirements for the project:

a) The focus of the application would be to motivate users to perform better in the IWH-OPM questionnaire.

b) Focus on motivation and retention of users for continued learning.

c) The game must also be applicable to all the 15 public sectors (in terms of learning objectives).

As mentioned above, Institute for Work and Health (IWH) performed a focus group experiment to see what people in the industry would want if an application existed. They conducted research by speaking to members of a workplace who held management

positions, those in specific health and safety careers, and to general line workers. This collected data was then amalgamated into the above list. Overall the feedback stated a commonality for a pleasing game aesthetic.

The focus group was useful as it provided us with the target end users. However, the specific feedback wasn't entirely useful for development. The focus group data we received was very basic in information, ranging from opinions to general information that would be normal for an application to have.

In addition, we found out after the first prototype that we needed to keep the 15 public sectors in mind when developing. As stated previously in this thesis, that means keeping the game general so that every sector had applicable information, but specific so that each sector only had access to their pertinent information. If a sector is overlooked a user in that sector will have trouble finding relevant health and safety information in the game. These sectors are included in Table 1:

With our application, each individual sector required access to specific health and safety training information. Although some information was common between the fields, each sector required their own specific training based on what was applicable to their sector. Having the information about each sector available aiding in development of the health and safety training application.

Sectors
Pulp and Paper
Forestry
Mining
Construction
Transportation
Electrical Utilities
Agriculture
Tourism and Hospitality
Retail and Wholesale
Industry Manufacturing
Health and community Care
Vehicle Sale and Service
Emergency Services
Fire
Police
Emergency Response
Educational and Cultural
Governmental - Municipal

Table 1 The 15 public sectors

Mid way through the development after the initial prototype was created, we held a meeting where a proposed route for the application occurred. The proposal contained more aspects of a commercial game rather than a serious game. This game integrated general health and safety training elements with the entertainment aspect of a game, with our expectation that this would thereby motivating the users to learn more about health and safety whilst enjoying their time immersed in the game. This meeting was

essential, as we had finished developing the first iteration of the prototype game. This developed prototype taught the user intrinsically to teach the skills identified in the OPM - which will be discussed in chapter 4. These skills were relevant to all sectors but generalized. This first prototype contained information that was skill related but the health and safety content was not sector specific, but a general look into health and safety concerns.

Through this meeting we discovered two key aspects that were important in development. These were: We needed to switch from intrinsically teaching subject to an extrinsic method, and we determined more relevance towards sector specific subject matter was required. These key aspects where shown through the first prototype when the connection between the game and health and safety were too subtle. In addition to determining the two above aspects, this meeting also allowed for all parties involved come to an understanding of the application that being developed.

Through this meeting, we determined what the end goal was in terms of application development and the direction we needed to pursue. This meant that all members involved were at an understanding of the direction that the serious game was moving towards and found clarity in future development as the needs of the application changed. As stated above, we found that the game needed to shift from intrinsic learning to extrinsic learning. This realization allowed for us to see that the game needed to become applicable to all 15 sectors and directly teach the users about health and safety. Through this meeting we were able to determine what was wanted from all members from a serious game application for Health and Safety. With the first iteration, PSHSA could

explain what was wanted out of the final application. As with many projects, the first prototype is often a tool to determine the end product. In the case of this application, our first prototype allowed all participants to determine what they wanted as a final project, and what could be built upon or removed from development.

Finally, this meeting also aided in the UCD of this project as we were able iterate on current design. As UCD is cyclical, the realization for change allowed us to re-iterate on our design and reevaluate the requirements for the application. This process enabled us to strengthen our final deliverable for project to meet the goals of the end users.

After this meeting, PSHSA reflected on the content and proceeded to research the new needs that had arisen from this meeting, as stated above. Shortly after we held an additional meeting where PSHSA presented a current serious game for health and safety training developed in New Zealand called WorkplaceSim[5]. With this demonstration, we discussed the aspects we wanted to integrate into our application and dissected what elements of the game could be integrated into a future prototype. This included the game elements to be utilized and the educational elements required for health and safety training. However, the presented game was more time consuming than that of the first prototype and due to the resources required to create a serious game for all 15 sectors of that depth. In short, a game with such a large subject matter would be too time consuming for development at this stage in the project. As a result, we discussed the possibility for the creation of a health and safety game based on the relevant information from the

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[5] https://www.ema.co.nz/events/calendar/Pages/WorkplaceSIM.aspx

presented game. With this being discussed in the meeting, we determined three possibilities for proposed serious games. This was three routes which we could follow to create a serious game. The first of which was the initial prototype that we presented in the previous meeting with alterations to meet the needs found in the previous meeting. The second being 'the classic serious game' defined in previous chapters. This game would integrate the health and safety training elements with the entertainment aspect of a game, thereby motivating the users to learn more about health and safety whilst being immersed in a 3D environment. This was along the line of the proposed game from New Zealand, WorkplaceSim. The third game proposal would be an amalgamation of the two previous. This was the design we determined would be the most applicable and ended up developing. This proposal would take elements dissected from WorkplaceSim, specifically the tests and challenges presented to the user, and took the general structure and OPM skills from the initial prototype. What we learned from development of the first prototype was integrated with the favorable learning challenges from the WorkplaceSim. What we took away from the game WorkplaceSim gave us the tools to create a library of health and safety tasks and challenges for each individual sector thereby creating a more applicable health and safety application for teaching relevant skills.

3.6 Exploring Solutions:

PSHSA determined a grading scheme to test the open-ended ideas found through meetings. This was to maintain the direction of development to align with all partners. This grading scheme was to test the proposed ideas and determine their validity. This occurred with the use of two categories: strength of the idea and fit with the project.

Within the two categories, two main questions were posed. These were: What score is to be achieved for the user to move forward? and What is missing in the proposed idea?

With this we created a graded response scale from 0: being poor, to 3: being very good. For the scoring, If an idea was to pass it would need to have a score of 18/21 when all the individual scores were added up. The list below shows the grading criteria in full.

❖ Strength of idea

- Is it clearly defined?

- Is it a motivating factor to continue/return to the game? Fun to play exciting?

- Will it make a difference? The engagement will lead to change in the organization? The individual?

❖ Fit with Project

- Does it meet the requirements of the research proposal?

- Does it align with using serious games to improving leadership skills?

    - Is it easy to do?

- Will this create / undo strain on resources, exceed budget.

This grading scheme, created PSHSA, helped to filter the proposed ideas using the think-aloud method. This meant all present could help determine the validity of a proposed idea. Ultimately, this meant that we could narrow down potential solutions for future development.

3.7 Summary:

Through this chapter we discussed the formulation of this product was sparked from an existing educational game such as Luminosity[6]. This brought to light the feasibility of an educational health and safety game to be developed. As there is a gap in health and safety knowledge from workplaces small and large, an educational game would be a tool of great advantage for many work sectors. By taking the OPM questionnaire we created a fundamental pillar to build the health and safety game from. The baseline of OPM allowed for us to formulate a prototype for early development with the featuring of the OPM skills. Furthermore, we looked into the needs of the industry through our industry partner. With the use of meetings to determine goals and subject matter requirements we determined the direction of development for our application. In addition, we determined the 3 key aspects needed to be designed for the end user of our application.

Finally, we created a grading scheme to better facilitate ideas proposed during meetings. This allowed us to further focus the development of the game and direct ideas and information into an applicable state for development. This allowed us to take information posed by our partners and create relevant content within the serious game.

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[6] https://www.lumosity.com/

Chapter 4: First Prototype

4.1 Overview:

In this chapter, we will discuss our first design iteration of the project. This project focused on retaining the player using mini-games each covering a few skills needed to perform well in the IWH-OPM. The project was designed to be a small collection of mini-games that motivate the player for continued play while intrinsically teaching the user both health and safety skills and concepts. The mini-games were designed to be generic, so that they could apply to any of the various sectors while maintaining the depth of information for the specific sector related health and safety information. To score high in a mini-game the users would need to demonstrate a high degree of competency in the targeted skill. Health and safety concepts would be included as the content of each mini-games to keep the play relevant.

4.2 Designing the Game:

The first game iteration our focus was more on making fun and engaging game elements, but we still needed to be aware of what we were going to teach in each mini-game.

To know what we needed to teach the players of our game we needed to know what are the underlying skills of the IWH-OPM indicators. Through several meetings with PSHSA we came up with the simple question 'If the output of the task is "x" what skills is needed to carry out the task?'. The team asked this question to each of the 8 IWH-OPM questions coming up with a lot of skills for the first two IWH-OPM questions. After Going through

two of the IWH-OPM questions we found that we were identifying more skills than we thought and that some of the skills were becoming too granular. It became clear that we needed to focus on three to four skills that most affect the ability for a person to perform at the IWH-OPM question.

To make picking the fundamental skills for each IWH-OPM questions fit with the team there were long discussion periods to make sure that everyone was onboard with the key skills. While discussing the key skills, it was helpful to sometimes consider what part of the skill was important. The tables show all the identified skills for each of the IWH-OPM questions (Table 2)(Table 3)(Table 4)(Table 5)(Table 6)(Table 7)(Table 8)(Table 9).

1. Formal Safety audits at regular intervals are a normal part of business.
Time management
Assessment of validity and fit with organization
Skills to be organization
Attention to detail

Table 2 IWH-OPM question 1 skills

For safety audits to become a regular component of workplace one need to manage time effectively. Without effective time management, the availability to seek out the right audit is not the only aspect of the auditing process that is required. Without time management, the worker could easily be overrun by other work required while conducting the audit. To reiterate, without planning out the time required to complete their audit the worker could find other work overwhelming as the audit takes a large amount of their knowledge and time. It is not only that time is an issue, but selecting the right audit for the job can also be hard. One needs to understand the job and what they want to find out with the audit

only then can they search for the most optimal audit. Being organized also affects one's performance in a large way. When conducting an audit can include many different departments in the workplace, staying organized will help in efficiency. Finally, attention to detail is critical for audits, it is important to get the details right to give a complete audit.

2. Everyone at this organization values ongoing safety improvement in this organization.
Communication
Motivation
Planning / Ability to be organized

Table 3 IWH-OPM question 2 skills

Communication in the organization helps safety improve. You need to be able to listen to the problems that are arising with the workers. You need to be able to tailor your message to the intended recipient. Communication needs to be open ended as this can help the speaker speak their mind and hold genuine conversations. Good communication skills help the speaker stay on message and stay true to their message to prevent misunderstandings and keep the message from drifting away from health and safety improvements. It's also important to participate in active listening. Active listening is when a person concentrates, understands, responds and then remembers what has being said.

Motivation is a key factor in creating and managing safety improvements in a workspace. In order to create an environment for effective motivation, you need to build a consensus

among the workers. This consensus is a form of collaborative problem solving when conflicts occur within a workplace

Another factor of motivation is positive reinforcement. This is because motivation can allow for the workspace, or members within a workspace to celebrate small victories. With motivation being useful in this way, we wanted to include motivation, and celebrating small victories within our development. This was because when a user is motivated in play, they are more likely to retain more information from the application.

In addition to communication and motivation, planning takes a large role in valuation of safety improvements. Planning is a tool where opportunities for success can be identified. Being able to act on and plan a proposed idea, allows for members of the workplace to more organized and succeed in their workplace. As a workplace is composed of multiple departments, being able to plan out an approach to your safety solution allows for expedited and efficient workflow within your departments.

3. This organization considers safety at least as important as production and the quality in the way work is done.
Support, fostering support
Liaising
Recognizing the priorities/Prioritizing Safety
Empowerment of Workers/Safety Culture

Table 4 IWH-OPM question 3 skills

An organization must hold the health and safety of their workers to the same standard as the production of goods and services. A manager in this organization should listen and support the workers when a concern over health and safety is voiced. By being supportive,

the company shows their understanding and compassion for the workers in this environment. By liaising an observation of a safety concern to the correct departments, the worker feels more connected to the organization, and feel that their safety is being prioritized.

To help handle voiced concerns the managers can create safety checklists to prioritize keeping the work environment safe. These checklists aid in safety management and allow members of the workplace to determine if they have a valid safety concern to voice to management. These checklists can help to empower the workers to take part in managing the workplace safety. This creates a culture where every member of the workplace has a responsibility for the workplace safety.

4. Workers and supervisors have the information they need to work safely.
Communication
Continuous improvement
Validity of information
Knowledge management

Table 5 IWH-OPM question 4 skills

Workers have access to health and safety information relating to their position within the workplace. A manager of a workplace manages and dispenses the health and safety information required for the specific job. As this information changes and can be interpreted differently, the health and safety information should be readily available to the members of a workplace.

Given the variation of workplace environment, the validity of specific health and safety concerns can change. Within a workspace members should have access to the information

that is valid for their work environment as well as any lessons or tools required to complete daily jobs. With the improvement of instruments and tools used in daily work, employees need to have access to information to improve and understand the developing work environment. Being able to evaluate new technology and techniques used in their work can help aid in maintaining a safe work environment.

With these emerging changes in a work environment, multiple methods can be used to teach safety regulations to employees. A company can use institutional learning, such as classroom lessons or manager run safety tutorials to aid in the understanding of safety in the workplace. As not all information can learned from a taught lesson, helping employees through an instructive tutorial where they gain hands-on experience with the support of a manager or mentor can help the employee gain a better understand of safety protocols. This also will impart safety knowledge more efficiently onto the employee and aid in promoting a safe work environment.

5. Employees are always involved in decisions affecting their health and safety.
Communication
Engagement, Social IQ
Emotional IQ
Decision making

Table 6 IWH-OPM question 5 skills

When discussing health and safety within a workplace, the employees should have an opportunity to convey their understanding of the health and safety implications of a job or tasks in their workplace. When discussing the concerns of a worker, all members involved should listen and recognize what concerns are being posed. As a leader in this

work environment, utilizing emotional information and discerning from concerns and feelings can aid in solving a workplace hazard. The use of emotional IQ, where one recognizes their own and other's emotions towards a situation can help to evaluate potential options to solve issues surrounding hazards.

When a dilemma occurs, options should be evaluated while understanding the logical and emotional stances of those involved. Solution development must be realist and fall within the means of the organization. This means that a solution must be associated to the problem while being realistic for the situation. Health and safety concerns are specific for each problem. There is not all-encompassing solution or result that is the 'right answer'. For example, within a small grocer, their store room would be small. An unrealistic solution to moving heavy objects would be a forklift, where a pallet jack would be better sized for the job and less bulky.

6. Those in charge of safety have the authority to make the changes they have identified as necessary.
Ability to recognize change is required
Identify potential solutions, select solutions
Exercise/Delegate Authority

Table 7 IWH-OPM question 6 skills

Necessary changes within the work environment requires the capacity to recognize change, identify solutions, and delegate. When leading health and safety decisions, the ability to recognize and evaluate required changes is an advantageous skill. As a health and safety leader recognizing these changes, and then evaluating supporting data can add to a safe work environment.

When a problem has been identified, the health and safety lead must be able to identify potential solutions and determine what solution is most viable given the current situation. This form of problem solving and management can aid in workers wellbeing and can further promote health and safety in the workplace.

Within a workplace, the employees work together to create a safe work environment. As a leader of a workplace, being able to identify importance of health and safety within a workplace can help with the delegation of responsibilities. Every member of a workplace has a role in keeping their spaces safe and orderly. Maintaining a system for delegation and understanding what roles are necessary can greatly improve the health and safety of a work space. In addition to delegation, utilizing an Internal Responsibility System(IRS) within your workplace can facilitate a safer work environment. With the use of an IRS each worker has role to play in keeping the workplace safe.

7. This organization considers safety at least as important as production and quality in the way work is done.
Formal Recognition
Informal Recognition
Performance Reviews and Promotions

Table 8 IWH-OPM question 7 skills

Those who act safely can receive positive recognition through 3 main channels. Any form of recognition should be tied to a behaviour or activity that the workplace wants to reinforce. The first form of recognition to be discussed is formal recognition. Formal recognition requires the use of communication when reporting feedback, using equipment correctly, and following processes or procedures. With formal reporting, an

organization will receive both positive and negative feedback. As a health and safety environment, both forms of feedback are useful for increasing the prosperity of safe workplace. However, the communication system that promotes formal reporting requires a role model. This role model will support other workers whilst also displaying active work safety practices.

Formal recognition also promotes motivation within a workspace. Motivation is important as a motivated workspace is more likely to bring future health and safety concerns to light. This reporting will also mean that members of a workplace are more aware of health and safety concerns, making them identifiable before the concern becomes a problem.

When looking into formal recognition methods, a system should be set up to plan out who should be recognized. Workers that formally report a concern need to be recognized for their contribution. Planning out assessment for ideas and sessions to discuss cost effective solutions is part of an effect formal reporting system. This use of planning can help to bolster a safe work environment.

Along with formal recognition, informal recognition can also aid in communication in a workspace. Unlike formal that includes professional meetings, and forms, informal recognition is an everyday acknowledgement of individuals, teams or workgroups within your workplace. As informal recognition aligns with everyday activities, listening in the workspace provides a direct link to the problems and events that go on daily. This passive listening can bring to light problems that may not be formally reported as to a general worker, they seem inconsequential. With conversations in the workplace, informal recognition benefits from the speaker tailoring their message to the specific audience they

are addressing. The speaker should offer open ended questions to allow the workers to speak openly. This open communication, while staying on topic, provides an avenue for open and exploratory conversation between the workers and speaker.

Finally, to provide positive recognition to members of the workplace, performance reviews and promotions can help promote a safe work environment. Performance reviews, when done positively, can motivate the workers to continue the safe work practices that provided the positive recognition. Promotions are very useful for this as they are a strong reward for workers who aim to better the workplace. However, continual promotions, reduce the impact of this reward.

8. Everyone has the tools and/or equipment they need to complete their work safety.
Evaluation
Culture
Knowing how to use the tool
Housekeeping, provision of tool

Table 9 IWH-OPM question 8 skills

Within a safe work environment, the tools and equipment needed to perform to the situation is available to the workers. In Layman's terms: it's finding the right tool for the right job. With the availability of these tools, evaluation must be performed to determine not only what tools should be used but also to access and reduce risk in the workplace.

The culture of a workplace changes dynamically as innovation and change in the industry occurs. As the culture shifts the workplace must be setup to promote progressive change, and to promote the modification of tools as the requirements for these tools change.

For a workspace to maintain safe for the workers, training must occur for workers to discern how to use the tool safely. Education of the use and misuse of tools for workers promotes a safe work environment and reduces safety concerns in the average work day. As well as education on use, works should utilize good housekeeping in which tools must be kept secure and orderly. This form of housekeeping verifies that tools are stored safely and are easily found for the next shift.

With the above understanding, we determined we needed to design a simple way to have the players play the game. At the time of creating the first prototype we had thought that the game needed the player to directly take the IWH-OPM questionnaire during play in the virtual environment. In addition to taking the IWH-OPM questions, the player would also be shown their IWH-OPM results within their industry sector. These results would then be compared against the sectors standard results, and show the user their understanding of the health and safety knowledge.

The idea of the game would be that there are five mini-games that the player could choose from. Each of these mini-games would teach a small selection of the OPM skills. We grouped skills together, based on commonalities and by what skills could potentially work well together in a game setting. For example, one of the five mini-games would focus on: attention to detail, assessment of validity, organizational skills, ability to recognize change, identify potential. Another one would focus on: engagement social IQ, emotional IQ, knowledge management, knowing how to use a tool. At the time, we were not worried about how well the skills groups fit together as we needed to test the idea of a mini-game teaching a group of the skills with health and safety content. We decided that we would

make a prototype game that would teach the player: planning, time management, continuous improvement, decision making and housekeeping.

4.3 Prototype: Safety Time:

As stated above, we explored the aspects of each individual OPM question and the related key skills. These skills were then placed into groups that formed the basis of the mini game structure of the game. With this understanding, we prototyped one of the mini games. This game aimed to teach users skills such as: time management, assessment of validity and attention to detail. When conducting research for these skill based mini-games, we researched examples of similar games that featured game design elements revolving around time management.

With our research, we borrowed game design elements from the game 'Cook, Serve, Delicious!'[7], which is a game available through the online digital game distributor Valve, more commonly known as the Steam Store. We chose 'Cook, Serve, Delicious' as it created an environment where the user must manage multiple sub tasks while completing a main task such as the (Figure 11) shows. This promoted effective time management strategies for the user to utilize during play. As 'Cook, Serve, Delicious' forces the user to prioritize sub-tasks sequentially based on their time to completion and time required to complete the task, the user must plan out how they will complete tasks, and what tasks can either be given more or less attention. The player must also mange tasks while under a multiple time limit pressures, such the current task completion time, and additionally other task

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[7] http://store.steampowered.com/app/247020/Cook_Serve_Delicious/

timers for either completion of the task or time until the task is no longer valid. The time

management mechanics used in 'Cook, Serve, Delicious' were something we could utilize

to promote time management in our game.

Figure 11: The multiple tasks the player must manage is shown in this figure along the left side of the play space. The current task that player is focusing on is on the right with the graphic showing their progress (picture taken from gameplay).

'Cook, Serve, Delicious' is a restaurant simulator that tasks the player to take, prepare,

serve, and clean up orders from non-player characters entering the player's restaurant.

The game has a considerable emphasis on time management, assessment of validity, and

attention to detail as mentioned above. This is seen through the player managing what

tasks to do immediately, what tasks can be run in parallel, and what tasks can be deemed

invalid. The planning the player conducts to manage their tasks would be based on

complexity, time allowance, and the importance of the task. When analyzing 'Cook, Serve,

Delicious' we determined that we could use its time management mechanic as a template

for our initial prototype. We planned to utilize the management of tasks to promote intrinsic learning of the health and safety material.

With the time management aspects of 'Cook, Serve, Delicious' in mind, we developed a prototype that tasked the user to play as a project manager assigning priorities for certain tasks and arranging the tasks based on their urgency and required completion time. The prototype's gameplay was segmented into two stages, the agenda stage and day stage. When the player starts with the agenda stage, the player is tasked with planning their virtual day in game. This means they can assign what primary tasks to do at what time, while receiving secondary tasks only during the day stage. The player is assigned an organizational focus at the beginning of play to direct how they prioritize tasks in the day. This focuses the player to prioritize specific tasks when managing their daily play. The player can assign their primary tasks to a specific in-game schedule, which acts as the 9 to 5 work day. This schedule follows the full in-game work day, in a short virtual play time spanning 5 minutes. The primary tasks require the player to manage their time, as well as commit in game resources to finishing the task. As these primary tasks are larger and more time-consuming the player must plan out their day to effectively oversee the completion of these tasks.

Once the agenda stage is completed, the player then enters the day stage. In this stage, the players simulated work day begins and the player would have to prioritize, prepare, and submit tasks in real time. A task being an item that the player needs to complete. Completing the task requires the player to select the task, read a description and assign specifics requirements needed for task completion, which is mentioned in the task

description (Figure 12). The player can select tasks without making a commitment to complete the task upon immediate selection. This allows for the player to manage which tasks are more important for them to do immediately, and what tasks can wait in the backlog. When the player must keep in mind the primary objective from the agenda stage to aid in their overall task management when selecting a task to complete. When the player has selected the task they wish to complete, they must assign it to one of the three work-boards to begin the process of completion. The player must then manage what tasks they need to address at what time with the un-used work-boards. This promotes time management in addition to resource management. Once a task is ready for review, the player must assign the required elements for the task to be completed. These elements are specific combinations of health and safety materials which teach the player health and safety knowledge through play. This prototype showed relevance towards health and safety by the context which would be displayed to the user.
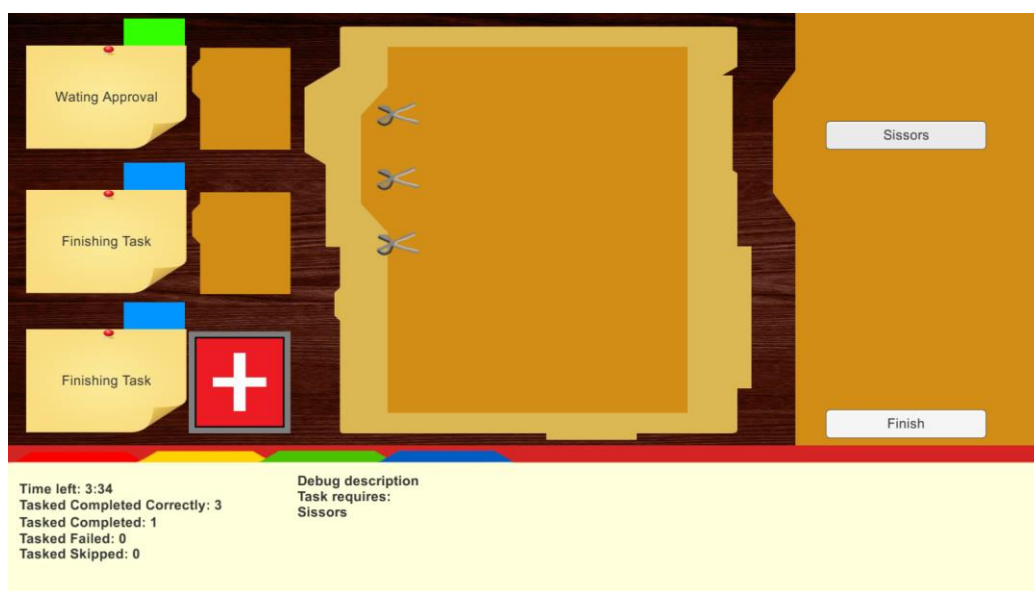

Figure 12: First prototype picture of gameplay. The user is tasked to finish a task by filling it the requirements displayed.

Within this prototype, the player was scored in the game by how many of that tasks were completed, and of those completed tasks how many were completed to the specification of the task requirements. The player only has a certain number of tasks which they could have active at a time through the work-boards. Due to this, if tasks are continuing to be assigned, and the player didn't have enough physical area (work-boards) to take on the new task it would be put into a backlog that they can later pull from when one of the work-boards frees up. At the end of the day all tasks in the backlog are considered incomplete. The work days in this prototype were designed to last around 5 minutes with the design intention to shape the play to accommodate player's real-life work schedule. The tasks presented to the player must be completed in a certain way, if the player deviates from the requirements described in the task by their assignee they will not be awarded points.

4.4 First Prototype Review:

After we developed a major component, including the initial mechanics of the first mini game, we held a meeting where we demonstrated the prototype to PSHSA and their partners. In this meeting, it started to become clear that a previously unknown requirement had been brought up (discussed in 3.5). Ultimately the failure of the first design came down to the abstraction and the struggle of the design to be relevant enough to health and safety. While the design was made to be a motivating game, and taught the players the identified skills, having these taught intrinsically left a disconnect in relevance to health and safety knowledge. The lack of relevance to the player resulted in the player

not understanding how playing the game would be applicable to them. This failure restricts the player from finding intrinsic motivation to continue the game. Another quandary with the first prototype was that it could not be adapted well enough to the needs of the players from different sectors as the gameplay was to be generalized. With future plans for this prototype, we looked to personalize the information to pertain to each of the 15 sectors. By doing this we would have a prototype that would be able to relate to a specific sector while holding the breadth to be applied to any of the 15 sectors. Therefore, we decided to try a different design with a considerable focus on relevance and adaptability to different sectors.

4.5 Summary:

In this chapter, we have listed and discussed the 8 OPM questions required for specializing the development of our health and safety game. With section 4.2 we comprehensively explained the individual OPM skills and their pertinence to health and safety training with the lens of serious game development. These OPM skills range from time management, attention to detail, and communication to fostering support and prioritizing safety, to decision making and solution identification, as well as many others. These skills relating directly to the OPM questions allows us to dissect the requirements needed to teach OPM related content to our users through the health and safety serious game.

Continuing with our research, we developed an initial prototype as discussed in 4.3. This prototype followed the design of 'Cook, Serve, Delicious', a time management restaurant simulation where the player manages tasks while working under each tasks time

requirement. The design elements recognized from this game provided us with a potential outline to design our game around. However, due to the unknown user needs we discovered during the presentation of this prototype, we learned that we needed more extrinsic learning to be integrated into our game. Additionally, we learned that the game must cover enough breadth to apply directly to all 15 sectors, while still maintaining depth to be relevant to a specific sector and their needs. With this understanding, we started development on our second game.

Chapter 5: Safety Rocks

5.1 Overview:

With continued development and recognition of the draw backs from the first prototype, the second iteration of the game came to fruition. With further development, and with the new user needs in mind (presented in 3.5), we developed the new game that keeps health and safety relevance in mind. Our aim with the new iteration was to apply specific health and safety knowledge in any of the 15 sectors. Within this serious game, we designed a set of challenges in the form of mini-games, following five different archetypes (discussed in section 5.2.2). These challenges have tags to identify their relevance towards a user's educational need. Challenges can be tagged to show their relevance towards an IWH-OPM question, an identified skill, and/or other relevant identifiers. With this shift away from the larger mini-game structure found in the initial prototype, we also created a shift towards an extrinsic style of learning as opposed to an intrinsic style. This meant the educational content learned would be more in the style of directly testing the learning goals. The challenges were designed to be more direct (extrinsic) in their teaching style rather than using a teaching style that taught the user indirectly (intrinsic). Each challenge can be setup to be played within the five archetypes. Additionally, to increase the relevance of each challenge, a health and safety association team was involved in creating and reviewing of each challenge.

Another addition that came with the second prototype is inclusion of an adaptive algorithm to personalize the game to the user and their health and safety educational needs. The adaptive nature of the second prototype was our way of putting emphasis on relevant health and safety content to the user. The goal of this system is to learn from the user's performance in terms of the score they achieve in each tag and change what challenges are presented to the user. For the user to utilize the adaptive algorithm system the player is now required to fill out a short profile (discussed in section 5.2.1) to give the system some context of the user's skills and needs before presenting any challenges. The system also learns from the user's success and losses while they play the game.

With our application a large focus was on motivation and retention in game play. Even though they is an external motivation to learn health and safety we aimed to additionally keep the player motivated by using game design elements, as discussed briefly in Chapter 2. These design elements involved such as giving meaningful rewards to user when desirable actions are completed, such as the successful completion of a challenge or by meeting goals set up by the game. As discussed in 2.4, quests are used to give the user more reason to come back and play the game and a motivation to complete all their quests. A quest tasks the player with playing several challenges in a row, completing several challenges is a day, week, or month. Each quest is targeted to increase retention and motivation in the period it is needed most. There are quests that target play sessions in one day, or play periodically over a week. We implemented a system that promoted periodical play, and thereby increasing the motivation for the player to come back to the

game and play often over weekly periods. This system also incorporates daily play so players that cannot play periodically still have quests to do.

With the implementation of the second serious game we addressed PSHSA's needs more effectively. Using game design elements the requirement for motivation was satisfied (more detail in 5.2.3). The use of adaptive algorithm for user retention can be obtained using quests (discussed in more detail in 5.2.1). The system captures relevance to the user's learning needs by keeping the challenges to health and safety, while also only presenting the challenges that will most help the user learn. An Earlier version of Safety Rocks was submitted to the 2017 HCI International conference at Vancouver [6].

5.2 Safety Rocks Design:

With the understanding from the initial prototype, motivational game design elements, and the OPM questions and skills in mind, we created the "Safety Rocks" (Figure 13), an educational health and safety serious game that can be applied to all 15 sectors while maintaining the depth to apply to specific users. To aid in creating a user experience that is specific to the user, the entry point of the game is the user profile. The user profile is a set of basic information the user enters before starting the game. There are three categories that the information provided by the user falls into: demographic information, user skill information, and relevance information. The entered data includes the following: user's information about their organization's IWH-OPM score in each of the eight questions, the sector that the organization is grouped in, the role the user has in that organization, if the user knows about the hazards in their organization, the confidence the user has in their health and safety knowledgebase and some generic demographic

information. The demographic information is used for determining who is playing the game in the large scale. User skill information includes the user's self- identified knowledge in health and safety and their confidence with health and safety information. Lastly, the relevance information describes the user's health and safety sector and is used to determine what challenges the user will be presented with. The user profile is crucial to the start of the personalization of the game as it allows the game to adapt the experience to that user's specific educational needs. As the user plays the game, their profile is constantly updated with the score from the challenges. This includes statistics which is contained in the user profile. These statistics are captured during gameplay as the user progressed through the challenges. The user can review how well they are performing in the game from graphs and statistics displayed in their home page.
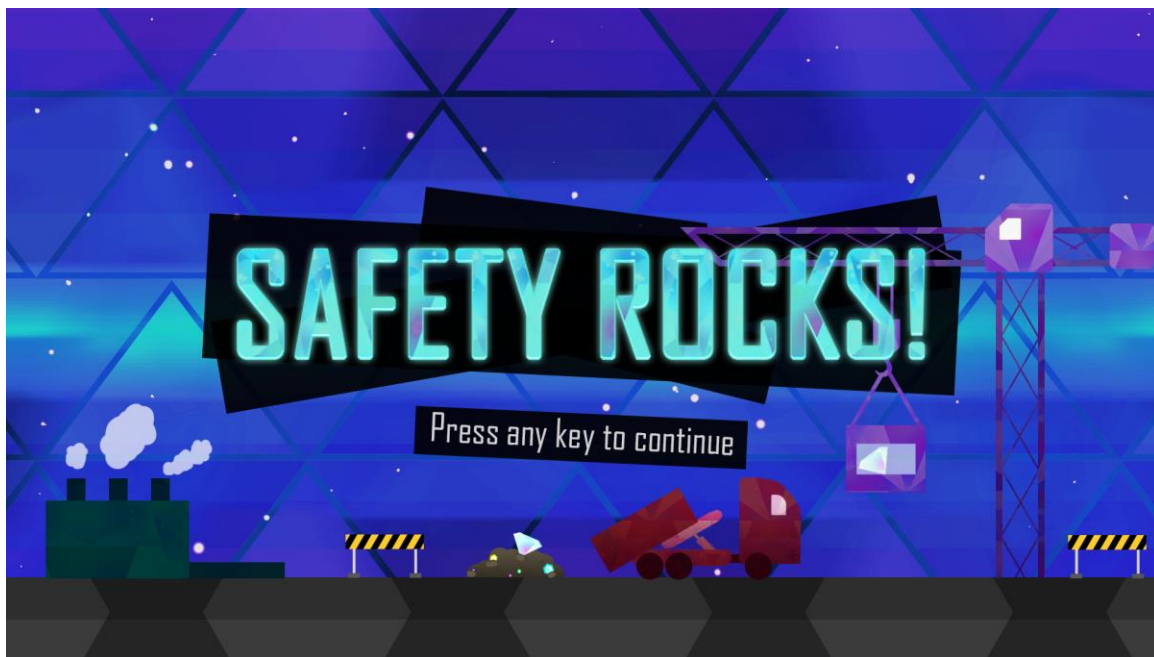

Figure 13 Safety Rocks tittle screen.

After completion of the user's profile, they login to the game, and are given access to the homepage. The user's profile is stored locally on their computer. The stored files had no need for encryption of security. The files do not contain and sensitive information. The inside of the files are not labeled which creates a layer of obfuscation. On this screen, the user can select whether to play, to view their profile, look at their game achievements through the medals tab, or to logout and leave the game. Additionally, the user can scroll through their homepage (Figure 14) to see their quests and statistics related to play (more detail on the homepage in section 5.2.3). On the main homepage screen the user can scroll through their profile to see graphs showing their performance through a multitude of different metrics. The metrics showcase the user's statistics in a wide array of data. The homepage showcases the user's improvement, the user's score and level as well as displays their quests. Quest's use challenges which, as mentioned before, are tasks that the user can complete for score points. The focus of the challenges is to increase the retention of the user by the promising the potential of large rewards if the task is completed correctly. From the homepage, the user can select from a set of mini-games as found on the play page.

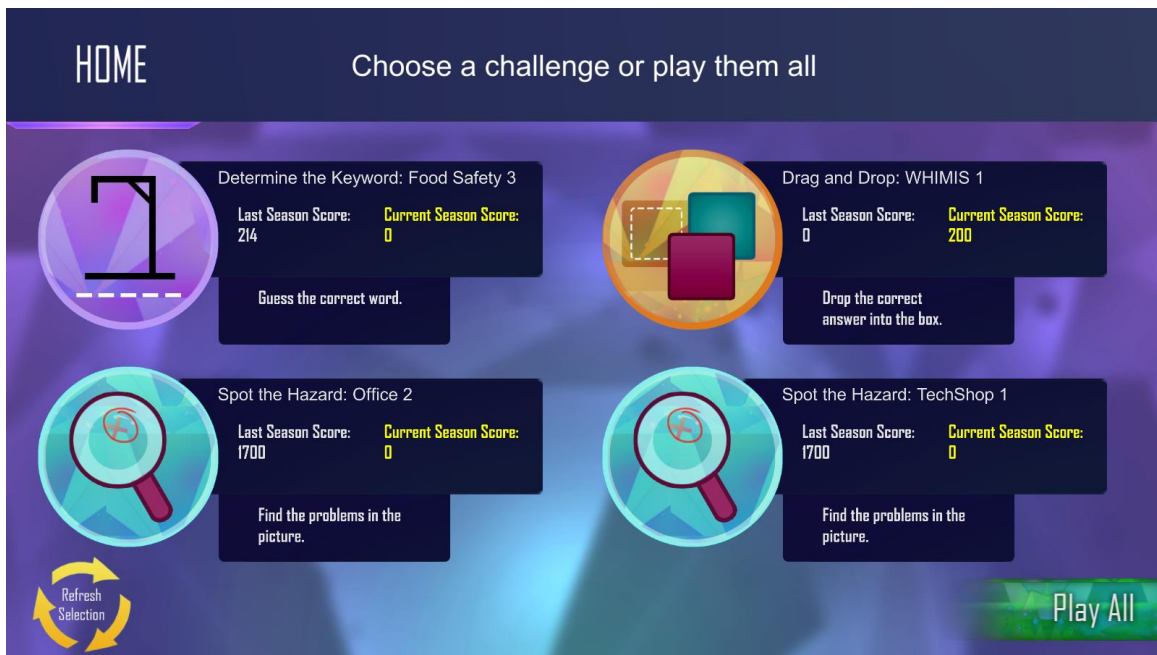**Figure 14 Safety Rocks home page.**

Figure 15 Safety Rocks play page.

On the play page, the user is confronted with the list of challenges picked by the game

(Figure 15). The game picks relevant challenges based on the user's profile and presents

four for the user to play keeping the gameplay short. Each Challenge is presented with a name giving context to what the challenge is about in health and safety, a descriptor of how the challenge plays, and the score for the last time played. Additionally, this page shows the seasons high score for the user for the specific mini-games. A season is a week-long period where the user can reach a high score. When the season ends, the user can see last seasons' high score along with this week's current score for each mini-game, further elaborated below. There are two ways that the user can play the selected challenges, single challenge and challenge campaign.

Addressing single challenges first, the user can enter single challenge mode by simply selecting and clicking on the challenge. When the player selects a single challenge to complete, they are given a quick overview of how to play the mini-game. This tutorial makes the user complete an action that will be required to complete the mini-game, thereby teaching the user how to play the game. The tutorials are mandatory before each mini-game but are short enough that a user who knows how to play can proceed unhindered. Additionally, these mini-games were designed to be easy to learn so a user with any level of experience with games could play it. With this, the games were also designed to be short, lasting only 30 seconds to a minute at a time but if a user needs more time there is no time limit. This enables the user to play multiple mini-games in a play session even if that session only lasts five minutes. With the second form of challenge, the user can play a challenge campaign by clicking on the 'Play All' button. Challenge campaign tasks the user to play all the displayed challenges in a row. To discourage demotivation a 'Refresh Selection' button is present to refresh challenges and

pick a new group of selected challenges. The new group of selected challenges will still be focusing on the user's shortcoming. When the user selects a challenge, or clicks to play a challenge campaign they are now tasked to play that challenge/s.

As discussed above, a challenge is when the user plays a short mini-game within the application. The small playtime benefits the user that may not have the availability of committing 30 to an hour of time to play, as they can play without having to allocate a large portion of time. This means that the player can complete at least one iteration of the game loop in its entirety during a play session and build up their health and safety knowledge. The game loop for the game presents the user multiple options of challenges to play, or as stated above, the option to play all four challenges at once. The user then completes the selected single challenge or the multiple challenges selected with the 'Play All' button. Once all challenges are completed a new list of challenges will be generated hence the loop. As mentioned before, these challenges are played through a variety of ways as discussed above, there are five architype mini-games being: Drag and drop, determine the keyword, spot the hazard, match symbol to description, and a puzzle game. These mini-games were chosen because of their simplicity. Each of the mini-games provided variation in gameplay so the user could learn multiple aspects of health and safety in different settings.

After the user has completed the game they are moved to the final session rewards page, which also contains their scoring for the mini-game. This page is where the users are awarded points for successfully completed challenges and any progress made towards the achievement style badges and any earned badges. Additionally, if users have completed

any of their quests, they are awarded the points allocated to the specific quest. Once the user has had time to review their score and performance in the challenge, they can move to the homepage to continue the game loop and their game session.

5.2.1 The Adaptive Algorithm

The previous section explained how the user interacted with the game elements. In this section, we will elaborate on how the game uses the collected information from each player to personalize the gameplay. The game personalizes the gameplay based on key aspect: user skill. In the next section, we will discuss this aspect in more detail.

The first aspect is the user's knowledge and abilities, defined above as user skill. This process starts at the creation of the user profile. The user is instructed to complete a profile containing 3 sections of information. The first is demographic information. This is information that PSHSA wanted to capture about the users and includes: the user's role in their organizations, if they have worked as a health and safety professional and for how long, who they report to, how many employees work in their organization and worksite, their age and gender. The seconds section of information contains the users score (scores ranging from 0.0 to 4.0) in the 8 OPM questions. The last part of the profile holds the player information, which contains the users organizational industry (the sector they work in), the profile name, their level of experience in health and safety, if they know the hazards in their organization and if they have the ability to influence health and safety changes. The user's score for each of the IWH-OPM questions is used to construct a rough estimate of the user's knowledge (IWH-OPM website will calculate this score then give it to the user) by converting their score from 0.0 - 4.0 into a percentage. This percentage

describes the user's ability in that area, where 100% is perfect performance and 0% means the user is unknowledgeable in the area. Within the IWH-OPM identified skills overlap into multiple IWH_OPM questions. With this, to determine a rough estimate of the users ability to perform the identified skills we take an average of score for each of the IWH-OPM question which were identified to require that skill (in some cases, this being more than one of the 8 questions contains the same skill). With this averaged score, the average is then converted into a percentage using the same scale as the IWH-OPM. The initial profile value will be inputted into the game for use in determining the required information to teach the user. Each of these skills and the IWH-OPM has a correlated tag. The tags are contained in the challenges, meaning that specific skills are linked to their applicable tag. The skills have a specific value tied to them, based off of the user's performance. If the user completed challenges correctly, the skill value increases. If they answer incorrectly, the value decreases. Throughout gameplay, the algorithm will adapt the health and safety content the user can access based on iterations from these initial rough estimates and the applicable skill values. The iterations from the rough estimates are done through the user playing a challenge that requires the specific skill or health and safety knowledge to complete. When the user first enters the profile information the prototype only has an initial estimate of the user's abilities. The advantage of initial profile is that we will be able to test the user's knowledge and abilities in the areas that have the lowest estimate. Making the first 30-50 iterations of the game loop feel relevant and personalized to the user's needs. After a few gameplay sessions, the game will be able to

get a real sense of the user's knowledge and abilities. When this stage is reached, the prototype is personalized to the user's needs.

The selection function takes the users profile stats as an input and outputs challenges that focus on the areas that the user is weak at. In the program, the user has different point values for their competency in specific skills. Each challenge has a set of tags, which determine the relevance of the challenge to the specific skill. The value for each challenge tag is added to create a value relating to the relevance of the challenge. As the player will rank lower in tags they do not understand, picking the challenges that have the lowest value will have the highest relevance to the player. In the next iteration of play, the player will see four challenges available to play. When the user completes a set of challenges the selection is refreshed from ten possible challenges, where four would be shown to the user. Four challenges are selected so that there is variation in the challenges shown to the user, and the selection of challenges is different even if the user is not advancing in the area. These tags describe what the challenge teaches and what the challenge is relevant to. For example, if we have a challenge tagged with: IWH-OPM 1, IWHOPM 3, time management, supervisor, and healthcare. From the tags, we can see that the challenge is focusing on teaching health and safety knowledge indicated in the first and third questions in the IWH-OPM as well as teaching time management. The relevance of the challenge is indicated in the last two tags showing that the challenge is for supervisors and for the healthcare sector.

Due to the nature of this algorithm it has two limitations. These being: When the user has no base knowledge or when the user has high base knowledge in all IWH-OPM questions.

If the user has a high skill level, the relevance of information being displayed is low as the user has a high competency in all the skill values. If the user has a high baseline for information, the algorithm cannot select what is most relevant to the user. However, as we randomly select four of the ten possible challenges, the randomness of the displayed information can be used as a refresher for the user. Alternately, if the user has no base knowledge, the algorithm cannot select the information to focus on as the user is underperforming in all the skill values. The algorithm cannot focus on specific skills, and the algorithm will need to teach the user the health and safety content. This user needs to be exposed to all the information in the program.

The game personalizes and adapts to the user by tracking and promoting the user's ability. As the aim is to keep the user at a correctness of 70-90%, the user must be exposed to challenges that properly identify their needs. Through focusing on the IWH-OPM and identified skills the user is under performing in we hope to increase his skills in these areas. When the profile stats are updated it changes how the challenges are selected. To simplify, when the user performs better at a certain area, the likely hood of receiving challenges pertaining to that area goes down. In contrast, if the user starts to perform worse in an area, the likely hood of getting challenges focused on that area increase. This is to keep the flow of the game engaging and challenging while still promoting learning in the user.

5.2.2 The Mini-game Archetypes

Within 'Safety Rocks' we created 5 archetype mini-games found on the play page. Each archetype follows a pattern of explanation of play, gameplay, and finally scoring. The

scoring at the end of play shows the player the question or challenge posed and the correct answer to this question or challenge. This means that even if a player does not meet the learning goals, they can see what the correct solution is. This done so that, even with a failure, the user can learn the material.

The first Archetype is Drag and Drop (Figure 16). This archetype is a game where the user drags a description into a set container. This is dictated by the topic questions given to the user at the top of this mini-game's page. Drag and Drop gave the user a more traditional test style game that all users would be familiar with.
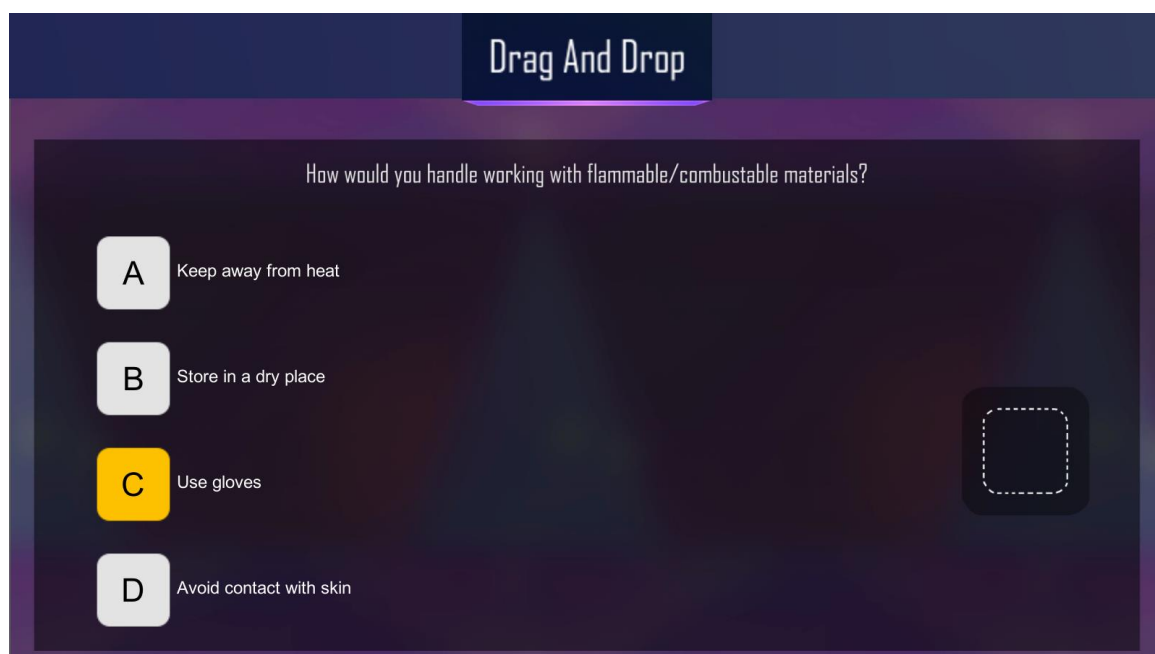

Figure 16 Drag and Drop game archetype.

The second archetype is Determine the Keyword (Figure 17). This game was designed after the traditional hangman style fill-in-the-blank game. In this game mode, the user must accurately determine the phrase or word related to the health and safety question given

during this mini-game. Like the above example, this game also provided the traditional gameplay that a user would be used to from a non-digital format.
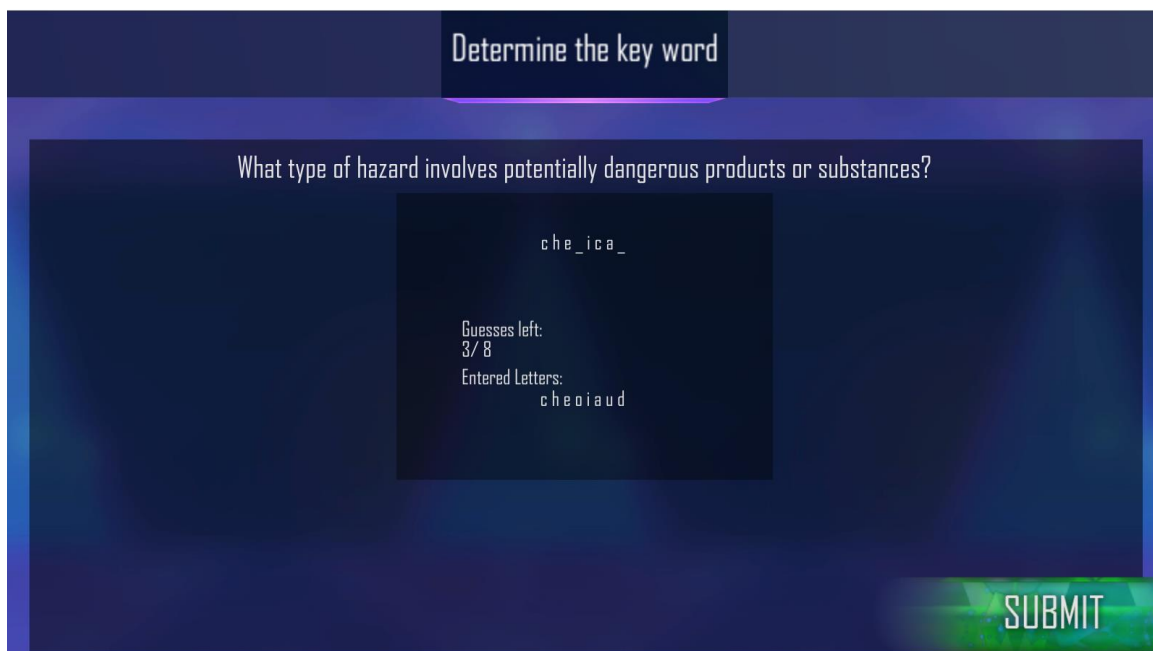

Figure 17 Determine the key word game archetype.

The third archetype is Match Symbols to descriptions (Figure 18). This game has the user drag a connection between two columns: health and safety images, and their description. This archetype was a merge between a traditional testing style question and a game, giving users more experience with game mechanics. This game gives direct feedback when the user submits their answer, before the common score screen that is seen at the end of each mini-game.
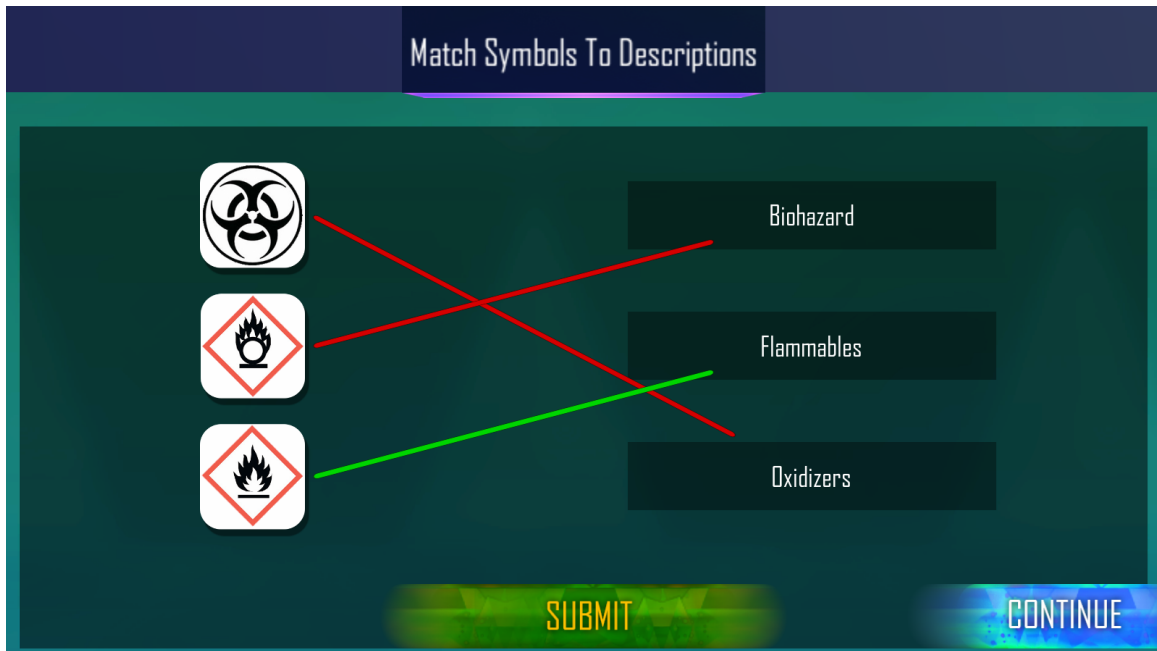
Figure 18 Match Symbols to Descriptions game archetype.

The fourth archetype is Spot the Hazard (Figure 19). This game type shows the player an image and prompts them to select regions of the image that show a hazard. This can be any potential health and safety hazard the user might encounter in their job. The user is told how many problems are hidden in the image, giving them a prompt to continue looking if a hazard has not been found. When the user finds a hazard in the picture, feedback is given to explain the hazard and a circle appears on the image where the hazard is located. If the user is unable to find a hazard, they have the option to select the 'Show Answers' button. This means if the user is unable to complete the challenge they can still learn of potential hazards that were unknown to them, and the reasoning behind the hazard.
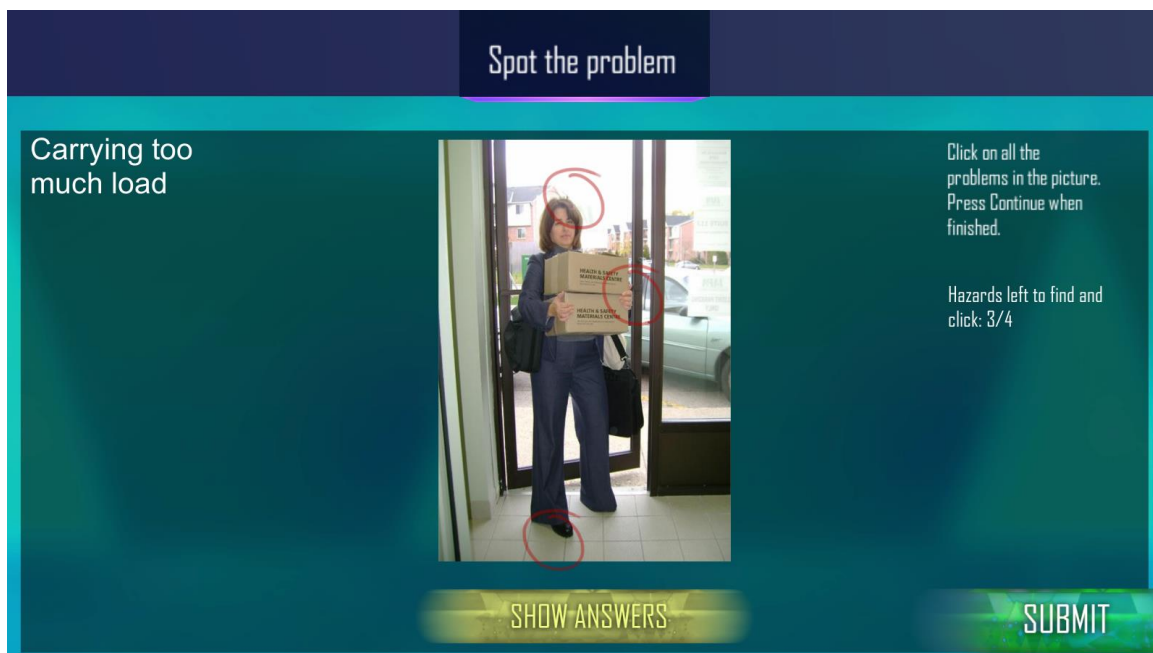
Figure 19 Spot the hazard game archetype.

The fifth archetype and final archetype implemented was the Puzzle game. This archetype allows the user to build an image from a set of puzzle pieces. This form of archetype gives variation to the learning styles of the other archetypes and provides a strong emphasis on visual learning styles.

Finally, with the development, we designed other potential archetypes that were not included in 'Safety Rocks' due to time constraints. These archetypes are as follows:

Clean the spill: The user has the option to select various cleaning tools, and a spill shown to them. This archetype would have the user select the correct cleaning tools for the specific spill. Thus, teaching the user safety information about dealing with potentially hazardous spills.

Card Matching: This is a common memory game, where the user must 'flip' cards to match an image with its description. Order the Steps: The user would be presented with a set of steps. These steps would be a set of instructions or steps to complete a task or manage a situation. The user would then need to put the steps in the correct order.
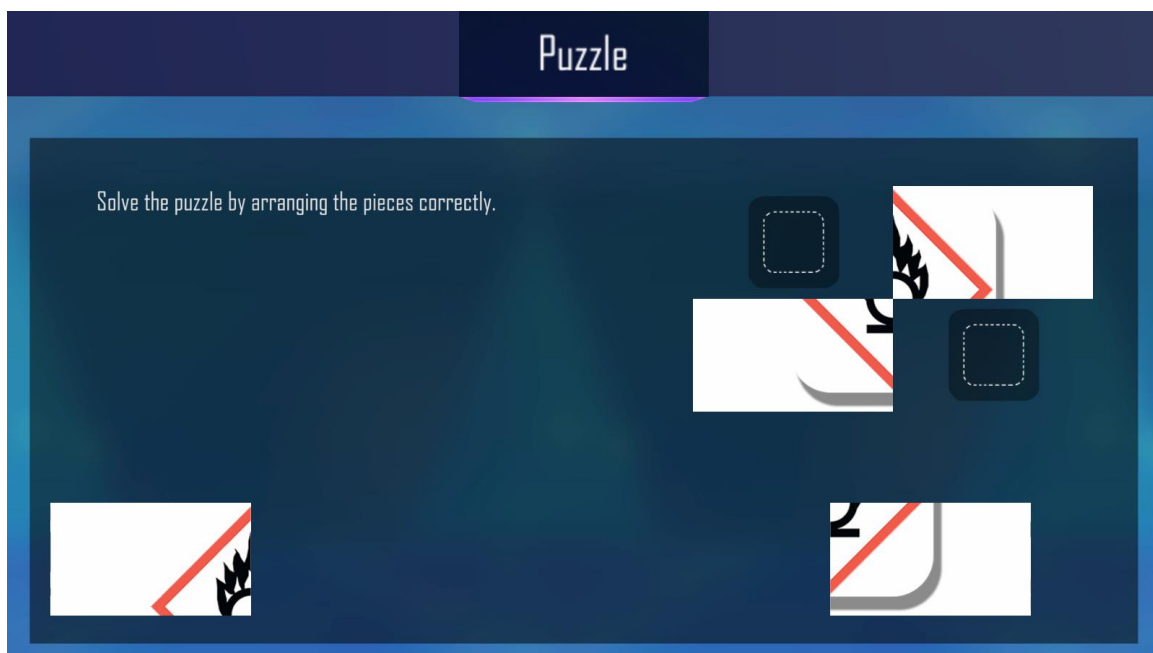
Figure 20 Puzzle game archetypes.

5.2.3 Motivational Design

With the motivational design elements in mind, we looked to design 'Safety Rocks' to motivate the player to play more and be exposed to more of the health and safety material.

Through 2.4 we discussed motivational design elements, and how they could be implemented into a game. With 'Safety Rocks' we implemented multiple motivational design elements. Firstly, we implemented a character level emblem which would become

more impressive and grand depending on how far the user progressed in the game. As they reach higher levels, the level emblem will change (Figure 21). This motivates the user to try to complete more challenges, and score higher in the mini-game challenges. Additionally, the medals the user wins by completing specific in game tasks also go through these changes. As the user achieves these medals, the icon changes to look more impressive and show that the user has completed this goal multiple times.

Figure 21 The progression of the player level emblem.

As stated above, Safety Rocks uses medals in game to commemorate the user's achievements in game (Figure 22). These medals promote the user to play, as they can see their past achievements, and specific events discovered in play. These medals, and their visual progression means the player is more likely to want to play multiple sessions to advance their score and thereby increasing their medal count. Additionally, some of these medals were not known nor shown to the user from the achievements page. These

were only obtainable through specific actions in game. This promotes exploratory
behaviors in the players, and promotes more gameplay.

Figure 22 Display of the user's medals.

Within Safety Rocks, we utilized a quest system where the player would complete three
daily quests (Figure 23). These quests are: "Play 10 challenges today", "Daily Campaign",
"Daily Level up". These quests tasked the player with a daily activity to complete. This
meant that if the user wanted to complete all their weekly quests, they would have to
play periodically every day.

Figure 23 Quests displayed on the Home page.

As mentioned above, score is use throughout the game as a benchmark for what the player has achieved. In Safety Rocks, score is used to show progression in player levels and skill in any of the challenges. Score is achieved by the correctness the player has in any of the challenges, and the completion of any quests. This score adds to the player level emblem, and leads to the emblem having a visual change.

With the use of score and quests, we also made use of another periodical tool we called Seasons. These seasons were a week-long period of time where all of the users score and challenges completed were logged and compared to the previous weeks. This provided the player with a visual representation of their understanding of the health and safety material. The season display would show the user how their score may have varied from the last week, and what they have completed in comparison. Seasons provide the player

with a motivation to play and achieve a higher score in subsequent weeks. This promoted periodical play sessions and means the game is more likely to retain its user base over week long periods.

Finally, last motivational tool designed into Safety Rocks was statistics. As discussed earlier in 2.4, statistics help motivate players by showing the player what areas they can improve upon and what areas need little to no improvement. It also allows the user to track their own process through the game. Within Safety Rocks we use statistics to show the users level and progression to the next level (Figure 24), their scores in their best season, current season and overarching lifetime score. Additionally, statistics were also used for showing scores across the seasons, scores for the specific game archetypes, their scoring in different difficulties of the games, correctness in the archetypes and overall correctness in the game (Figure 25). The statistics also show the distribution of played difficulties (Figure 26), and what IWH-OPM questions they have covered. Finally, line graphs are shown to the player to explain their score earned daily over the season, their score earned daily versus their last seven play sessions (Figure 27), the difficulty of challenges they played during the week and finally the IWH-OPM questions they have completed in the week.

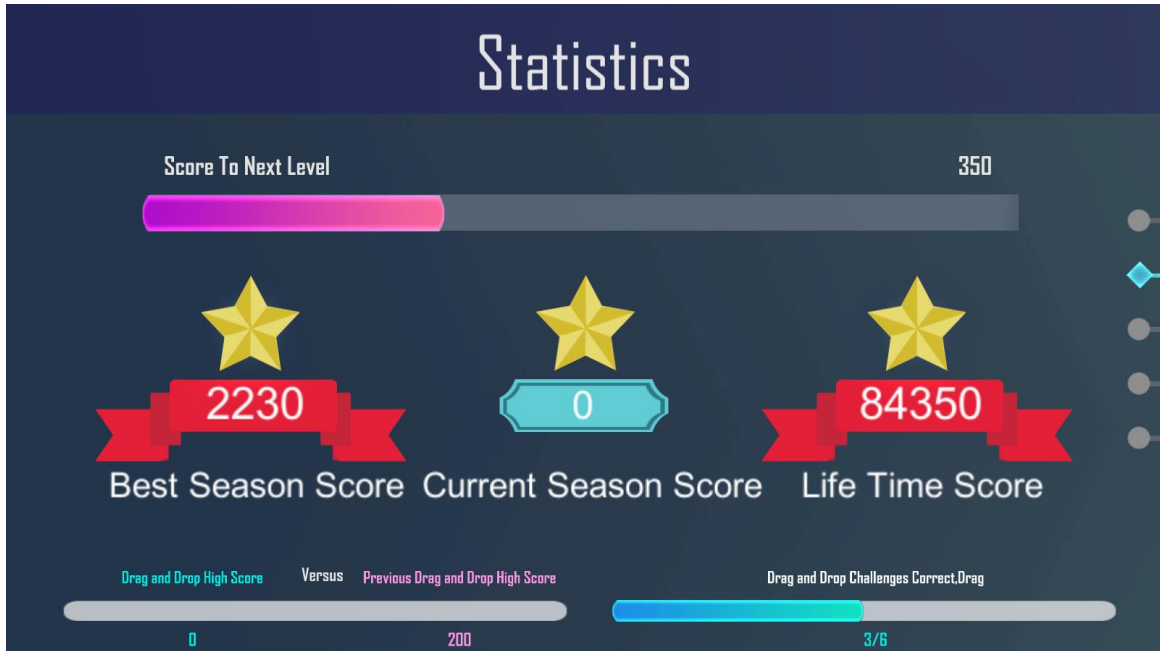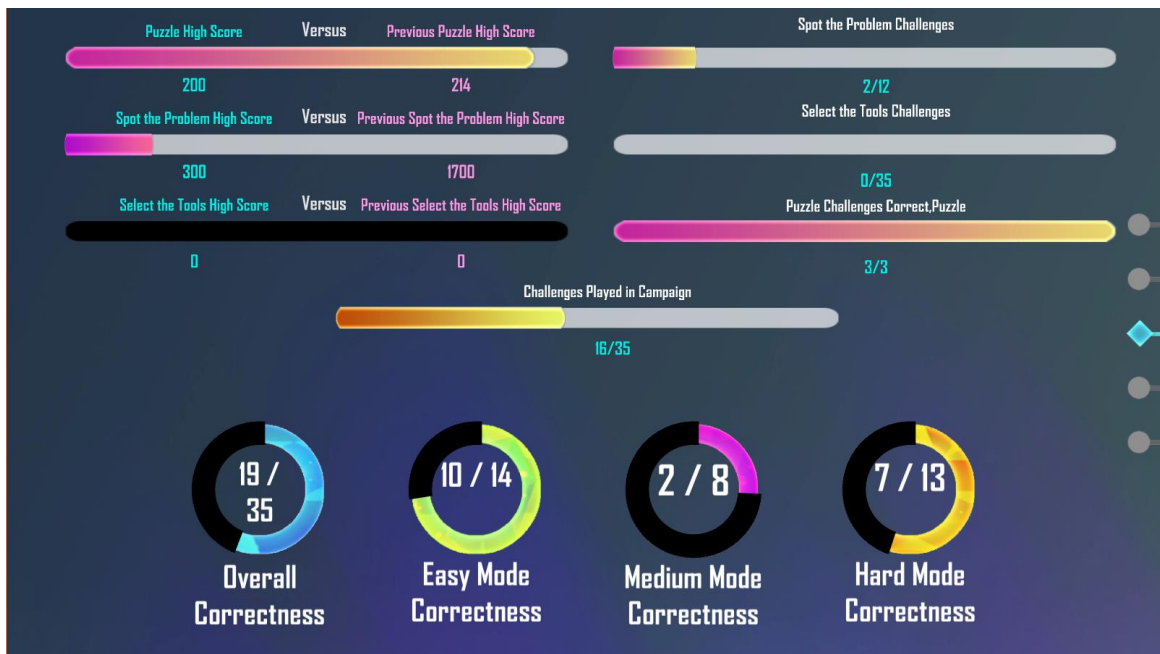**Figure 24 level and season score on the home page.**

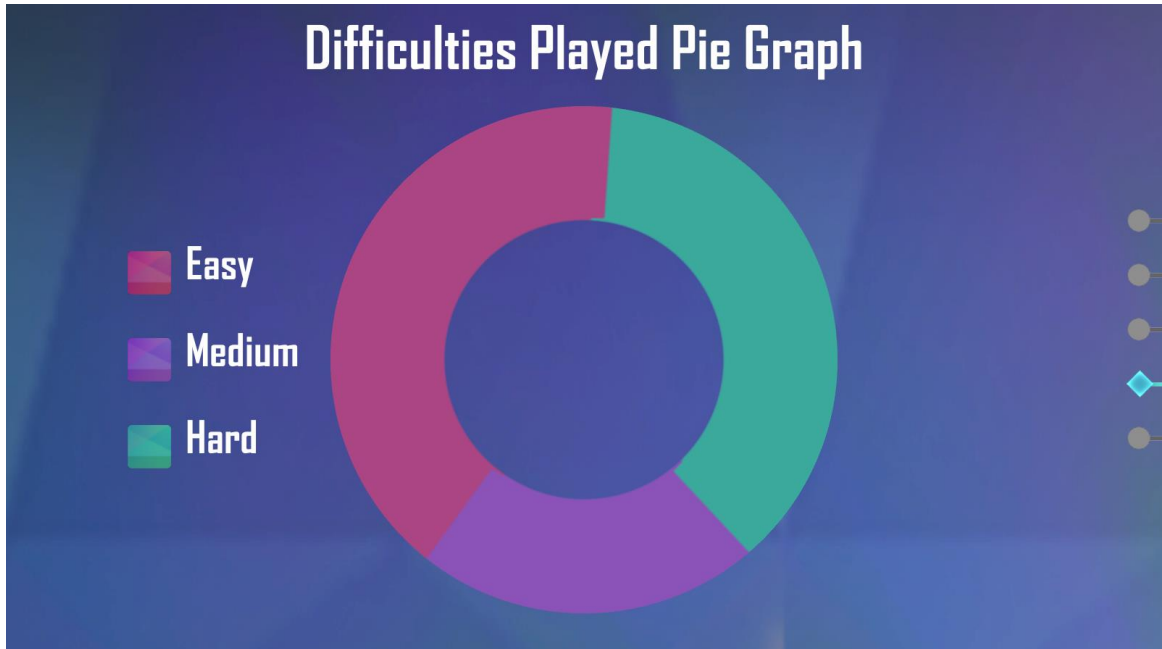**Figure 25 Continuation of statistics presented on the home page.**

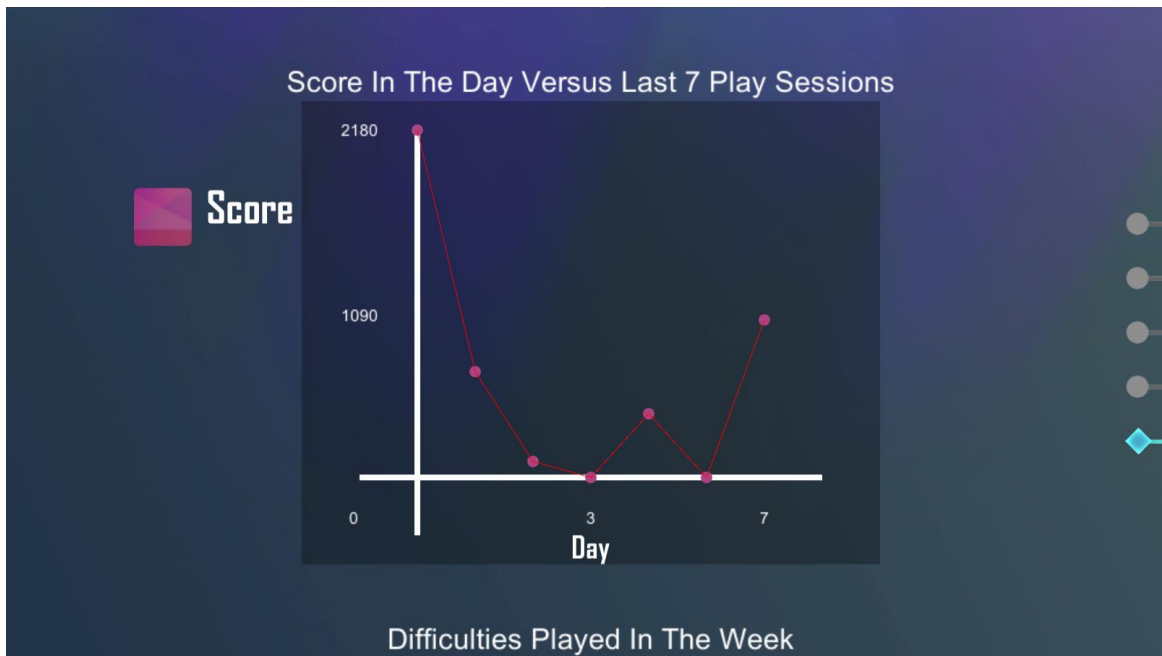**Figure 26 Distribution statistic shown on the home page.**

Figure 27 Line graph shown in the statics on the home page.

5.3 Review:

After a large portion of the game was completed we showed this design to PSHSA and their partners. With this presentation, no problems in the design were found during the meeting. All member present at the meeting found this game design to be useful and applicable to training health and safety. This was a prototype of the current game, and only around 60% of the game was implemented. The unimplemented aspects of the game could be easily explained and extrapolated upon by the attendees. With this meeting, we determined that the game could consider along its current path. The prototype at this time was what expected and fit the needs of the users from a health and safety serious game.

After further development, we held another meeting when the prototype of the game was near completion, approximately 80%. This version of the game with further implemented features was found to still be on the correct course of direction, and would continue development unhindered.

5.4 Summary:

In this chapter, we discussed how we adapted the current game to fix the problems found in the previous prototype. As these problems required a reevaluation, we developed a new mini-game challenge based game that is built upon 5 archetype games. Additionally, we discovered with the pervious prototype that the game must have the breadth to cover all 15 sectors, while maintaining the depth to be applicable to individual workplaces.

These 5 archetypes, and the mini-game structure provided us with the potential depth needed to be applicable in any of the 15 sectors.

With the development of Safety Rocks, we implemented the proposed mini-game archetypes, with the use of motivational design. These designed elements to promote player engagement and immersion creates a game that promotes user retention. The use of score, aesthetic changes, statistics and more gives motivation for the player to play the game periodically.

In review, the game was found to be on course in terms of its development. The new development of Safety Rocks was found to meet the users' needs as well as PSHSA and its partners. The development change to focus on user needs and motivational design creates a product that can aid in teaching health and safety in a work environment.

Chapter 6: Summative Review of the Second Prototype

6.1 Overview:

In this chapter, we will discuss our final showing of the game to PSHSA and their partners. In the meeting, we recap the development up to this point and hold the latest showing of the serious game. This meeting discussed the overall development in terms of prototype development, health and safety skill integration, the team involved and a general refresher of the game concept.

We will explain and discuss the presentation of the health and safety prototype to the PSHSA team, as well as how the health and safety skills discussed in previous chapters has been broken down and integrated into the application. We will further explain our development process from concept to production to post production to polish of the application. The presentation also gave a walkthrough of the application and its content to the party's present allowing for discussion. Finally, our presentation also gave PSHSA and their partners a build of the application that they could test out on their own after the meeting. This build of the game allowed the attendees of the meeting to try out the game and give any feedback for further development opportunities.

6.2 Presentation:

With the application in a state near to completion, we looked for final additions, tweaks and suggestions that could be added to create the final build of the application. We went

to PSHSA's headquarters to present the current build. This presentation covered the overview of progress, the current project walkthrough - from an expert's point of view. Within the presentation we provided a recap of the development, allowing all members present to get up to speed on the current build's content and allow for all members to recall previous information on the subject matter. The recap included what the current build of the game has adjusted.

After the recap, we guided those in the meeting through a walkthrough of the current build to present how the game would play and how the subject matter was applied to the application. In depth, the walkthrough showed aesthetic updates as well as all paths the player could take. Within the game we implemented the motivational tools discussed in chapter 2, the OPM skills subject matter explained in chapter 4, as well as all elements discussed in chapter 5.

Presenting this walkthrough was to display that requested aspects were integrated into the application. In addition, the presentation was to press for remarks and criticism to advance the final game product and aid in the completion of a working tool for health and safety training. This walkthrough included a demo of the initial ten minutes of gameplay a user would experience within the game. This demo allowed for the creation of a profile, the steps for a user to play the game, and finally an overview of all possible challenges a user could progress through laid out using archetypes.

With this presentation, we collected feedback from the members of the meeting using multiple methods. The first of these being open-ended statements. This was collected

using an audio recording of the meeting, as well as written statements that arose during the meeting.

In addition to the open-ended statements, we used a questionnaire to address any feedback or statements from the members of the meeting. This provided us with a broad basis for generalized statements about the meetings contents, and allowed the members to write down any comments or statements that had not been discussed during the meeting.

Our final method of collecting feedback was the use of additional notes from PSHSA and their associates. These notes gave us a review of the meeting from the point of view of PSHSA and their partners, as well as specific feedback related to the meeting and further feedback from members testing the game. This feedback gave us a window into their perspective of the presentation and game, meaning we could understand where their comments originated from. This also gave us background into statements found in the recording.

Overall, the audio recording proved the most fruitful in terms of feedback as we were able to directly hear and see what went on during the meeting. This included what was said, and what slides were shown in the meeting at what time. This recording showed the direct and unfiltered responses from members of the meeting that was applicable to the application and its presentation.

6.3 Discussion:

With our presentation, we uncovered advantages with our application. As the game hold multiple forms of archetypes, a non-developer could create challenges using these archetypes. This means that the application is extendable, and can hold future problems to be tested upon by health and safety leaders. With this, the application could even adapt to new health and safety concerns that arise in the future.

Within the meeting, our partners could see how the game was applicable to teach health and safety in multiple sectors. This was evident as the educational material shown to the partners was extrinsic, and readily present for our partners to directly see. The game obviously taught health and safety training to the user. This direct educational route provided the extrinsic learning the partners had requested in previous meetings.

As the game was easy to learn, and intuitive to pick up, the members of the meeting could see that the game had potential to teach health and safety over many sectors. The game provided a general layout of all the sectors available whilst making it so that a user would only see the information relevant to their own sector. This meant that the game was easily usable for a multitude of sectors while being valid for workers in an individual sector.

As our game used the motivational elements mentioned in chapter 5, the members of the meeting were able to see how the game would motivate and retain the users. This motivational retention allows for the game to keep the attention of the user, and increase their intrinsic learning of the subject material. As the goal of this game was to keep the

user learning the health and safety material, this motivational element was incredibly important throughout development. The integration of this motivational element was visible to the members of the meeting, and showed the use of the game in a work setting.

With all development, no application is perfect. We aimed to cover the feedback and past issues with the previous prototype. With our iterations, we didn't account for accessibility such as color blindness. This means, with future iterations of the game some of the visuals in the game would need adjusted with colour palettes to prevent issues with colour blind players. The game also does not include a mode for users with low or poor vision. This could be rectified by adjusting the font and icon size to make the content in game more visible.

Through our feedback we also discovered the request for a mobile port of the game. As the application is currently a desktop game, it is unavailable for apple computer and mobile use. This desktop application was the most common to be used and was the agreed upon device for developing the game. Through further development we could create a mobile and apple computer application to meet the above feedback. This provides an area for future expansion of our application through further development.

With the feedback received, much of it was small changes that were requested by the members of the meeting. This feedback included changes in language from experts in health and safety, potential future work, as well as small feature adjustments to make information in the game easier to understand. These adjustments also made the game easier for the end user to utilize in learning health and safety as the information presented

we in a jargon they understood more readily. This feedback allowed us to make quick adjustments to the final game during the remaining development time.

6.4 Summary:

Through this chapter we have discussed the findings from the final meeting with PSHSA and their partners. This meeting provided us feedback into the final presentation of the game as well as its current development. This meeting allowed us to finalize our development in addition to see how our industry partners viewed the serious game.

Additionally, we discussed how our product design showed extendibility beyond the initial included materials. This includes the ability for non-developers to add emerging health and safety material to the application. We also discussed how the motivational elements seen within the presented game showed the potential for player retention throughout play. This also provided confirmation of health and safety learning outcomes.

Through this chapter we discussed the feedback received from our industry partners and how that feedback impacted the final stage of development. With this discussion, we explained the methods of how feedback from the meeting was collected and how we acted upon the pose suggestions. Additionally, we discussed how the feedback would influence future development and the potential for a port to mobile and apple devices for more usability in a workplace

Chapter 7: Discussion and Conclusions

7.1 Overview:

Throughout this thesis we have explained and discussed the need for a tool to teach health and safety in a workplace that provides motivation to learn the content as well as promote teaching the educational content. Through this chapter we will discuss how the use of UCD aided in the creation of a deliverable tool for teaching health and safety in the workplace. In addition, we will discuss the use of an adaptive system to select relative learning material for the user.

In addition, we will elaborate on the future opportunities for development of this tool and its design. With that, we will also discuss the prospect to conduct user testing for further iterations of the health and safety serious game.

7.2 Discussion:

From conception, through development to the final product, this project has reflected the use of adaptive learning and user centered design in a serious game tool for the purpose of teaching health and safety knowledge.

First, we will discuss the use of UCD, and how it promoted the educational content in the serious game as well as creating a foundation for motivating the user. UCD was used to maintain direction during development to cultivate a product that was to the expectations of the client. An auxiliary effect of this was that it also meant that the product was

designed to provide the best experience for the user to meet their educational needs. Through iterations utilizing UCD, we strengthened the effectiveness of our application, as we could keep the needs of the user in mind, as well as uncover needs that we were unaware of in early development. This allowed us to make a product that was sounder that our initial prototype and met a multitude of needs for the users.

Additionally, with the design, we kept our partner, PSHSA, in mind. We created a challenge editor which allows PSHSA to create new challenges without a developer or programmer as the user will not need to touch code. This means the editor is easy to use as it is selecting buttons and entering text to create a challenge and then saving the challenge to use later. In addition, the editor checks that the information entered is valid and can be used to create a challenge. If the information is incomplete or invalid it will promote the user to fill the missing text fields or select applicable elements. With this, the potential for human error is reduced as the editor creates the challenge from presets the user selects. This tool means PSHSA can create numerous challenges in the form of the five current archetypes and input future health and safety information in an easy to use editor format. This means the game can be used further into the future and expanded upon with use and as the industries covered expand their health and safety requirements.

As this editor allows for personalization and extendibility of the material presented to the target audience, opportunities arise for commercialization of the editor tool. As Safety Rocks is a free application, health and safety training is taught without a fee for general use. If a company wishes to personalize the training, commercialization of the editor tool can be done through selling the editor as a personalization tool for the purchasing

companies. This means they can modify the game challenges as they wish by paying for the editor, but still receiving the health and safety game for free.

With the development of this tool, we used a breadth of information for all 15 sectors, whilst giving a user a specific set of information relevant to them. This setup allowed us to create a serious game that was adaptive to all 15 sectors, while still showing the user information that was pertinent to their workplace health and safety education. This means that the application can be used consistently throughout the multiple sectors while providing an effective form of health and safety education that would be useful to their specific workplace.

With all discussed above, the current design practices in the video game development industry provides an effective platform to help facilitate the attention of a user. With this product we took the current design practices found commonly in video game design to promote user attention while playing the serious game for health and safety. As games focus on keeping the player's attention, this demonstrated an opportunity to increase motivation and player retention using game design practices. This was discussed in chapter 2 as the rewards, challenges, and feedback games provide to their users. Using these aspects - such as points awarded when a challenge is completed in game, increased the motivation for our users to grasp the subject matter more easily. With this, the serious game effectively teaches health and safety concepts while increasing the motivation of the user to expand their understanding.

Finally, the adaptive learning to show users applicable information for their sector also lead to more motivation for the user to learn the subject material. As the material they

would be learning applied directly to the user and their workplace, they were more likely to see the value in the information being presented, and understand how it connects to their health and safety training. This motivation promotes user retention, and increases the effectivity of the serious game. This also means that this application can be used broadly over many sectors, and provide the same level of education for workers, regardless of their sector specific work requirements.

7.3 Future work:

Finally, as a part of future work PSHSA will conduct an evaluation of the game design. Evaluation involves experimentation i.e. conducting pilot runs to see if the new design holds up to its expectations. We intend to collect user data after the pilots to see what part of the game design kept them motivated and what did not. Both qualitative and quantitative data will be collected from the pilot study to infer the effectiveness of our design. We envision multiple changes to the game design, which might include changes in the user interface as well as in the game flow.

With this data and with further development opportunities we look to implement more game archetypes to vary game experience and promote more play. Additionally, the algorithm can be expanded to take into account more variables in play. The algorithm could also be adjusted to increase player motivation by making the game react more individually to the player.

7.4 Conclusion:

This thesis shows how using personalization and adaptive learning principles a serious game can be made relevant, motivating, and captivating (help retain users better). We also show with the help of a case study how by using a user centered design (UCD) one can create a serious game centered on health and safety training. In the case study, we show how the requirements for the game was established from which a prototype was designed. The first prototype had its strengths but ultimately from the stakeholder's feedback, it was clear that it lacked relevance to the user. The feedback prompted the second design, which showed us that for PSHSA, an adaptive system can focus the gameplay around what is most relevant for the user and aids in learning. Moreover, we have shown how such a system can benefit from adapting rewards to increase both motivation and user retention.

References

[1]   Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., Freitas, S. de, Louchart, S., … Gloria,

A. De. (2016). Mapping Learning and Game Mechanics for Serious Games

Analysis in Engineering Education. *IEEE Transactions on Emerging Topics in*

Computing, PP(99), 1. http://doi.org/10.1111/bjet.12113.Mapping

[2]   Electronic Arts DICE 2013, *Battlefield 4*, Microsoft Windows PlayStation 3

PlayStation 4 Xbox 360 Xbox One.

[3]   Heeter, C., Lee, Y.-H., Magerko, B., & Medler, B. (2011). Impacts of Forced

Serious Game Play on Vulnerable Subgroups. *International Journal of Gaming*

and Computer-Mediated Simulations, *3*(3), 34–53.

http://doi.org/10.4018/jgcms.2011070103

[4]   M. J. Burke, S. A. Sarpy, K. Smith-Crowe, S. Chan-Serafin, R. O. Salvador, and G.

Islam, "Relative effectiveness of worker safety and health training methods," *Am.*

J. Public Health, vol. 96, no. 2, pp. 315–324, 2006.

[5]   Charsky, D. (2010). From Edutainment to Serious Games: A Change in the Use of

Game Characteristics. *Games and Culture, 5(2)*, 177–198.

http://doi.org/10.1177/1555412009354727

[6]   Chodan, C., Mirza-Babaei, P., & Sankaranarayanan, K. (2017). Safety Does Not

Happen by Accident, Can Gaming Help Improve Occupational Health and Safety

in Organizations? *Digital Human Modeling. Applications in Health, Safety,*

Ergonomics, and Risk Management: Health and Safety: 8th International

Conference, DHM 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9-14, 2017, Proceedings, Part II, 10287 LNCS, 321–332. http://doi.org/10.1007/978-3-319-58466-9

[7]   B. Cowley, D. Charles, M. Black, and R. Hickey, "Toward an understanding of flow in video games," *Comput. Entertain.*, vol. 6, no. 2, p. 1, 2008.

[8]   Crookall, D. (2010). Serious Games, Debriefing, and Simulation/Gaming as a Discipline. *Simulation & Gaming, 41(6)*, 898–920.

http://doi.org/10.1177/1046878110390784

[9]   M. Csikszentmihalyi. Flow and the psychology of discovery and invention. *New York: Harper Collins*, 1996.

[10]   A. De Gloria, F. Bellotti, R. Berta, and E. Lavagnino, "Serious Games for education and training," *Int. J. Serious Games*, vol. 1, no. 1, pp. 2384–8766, 2014.

[11]   C. Cruz, M. D. Hanus, and J. Fox, "The need to achieve: Players' perceptions and uses of extrinsic meta-game reward systems for video game consoles," *Comput. Human Behav.*, vol. 71, pp. 516–524, 2017.

[12]   S. Deterding, "Gamification: designing for motivation," *Interactions*, vol. 19, pp. 14–17, 2012.

[13]   S. Deterding and D. Dixon, "From Game Design Elements to Gamefulness: Defining 'Gamification,'" *MinTrek 2011*, pp. 9–15, 2011.

[14]   M. D. Dickey, "Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation," *Educ. Technol. Res. Dev.*, vol. 55, no. 3, pp. 253–273, 2007.

[15] Id Software 1993, *DOOM,* MS-DOS Sega 32X Atari Jaguar SNES PlayStation
3DO PC-9801 Sega Saturn Acorn Archimedes Game Boy Advance Xbox Xbox 360
iOS PlayStation 3.

[16] A. Domínguez, J. Saenz-De-Navarrete, L. De-Marcos, L. Fernández-Sanz, C. Pagés,
and J. J. Martínez-Herráiz, "Gamifying learning experiences: Practical implications
and outcomes," *Comput. Educ.*, vol. 63, pp. 380–392, 2013.

[17] L. El-Ghouli and F. Khoukhi, "Contributions of serious games on adaptive learning
systems," *SITA 2016 - 11th Int. Conf. Intell. Syst. Theor. Appl.*, no. Lim, 2016.

[18] Entertainment Software Association of Canada (ESAC), "2015 Essentail Facts
about The Canadian Video Game Industry," 2015.

[19] A. Francisco, F. Luis, J. L. González, and J. L. Isla, "Analysis and Application of
Gamification," *INTERACCION '12*, p. 17:1--17:2, 2012.

[20] Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, Motivation, and Learning: A
Research and Practice Model. *Simulation & Gaming, 33(4)*, 441–467.
http://doi.org/10.1177/1046878102238607

[21] Gerling, K., Wallner, G., Mirza-Babaei, P., Shearer, J., Linehan, C., & Hicks, K.
(2017). Exploiting players? Critical reflections on participation in game
development. *CHI PLAY 2017 Extended Abstracts - Extended Abstracts Publication
of the Annual Symposium on Computer-Human Interaction in Play*, 653–655.
http://doi.org/10.1145/3130859.3131441

[22] I. Glover, "Play as you learn : gamification as a technique for motivating learners
Play As You Learn : Gamification as a Technique for Motivating Learners," in

Proceedings of World Conference on Educational Multimedia, Hypermedia and Telemcommunications 2013, 2013, pp. 1998–2008.

[23]   L. M. Goldenhar, S. K. Moran, and M. Colligan, "Health and safety training in a sample of open-shop construction companies," *J. Safety Res.*, vol. 32, no. 2, pp. 237–252, 2001.

[24]   Gredler, M. E. (2004). Games and Simulations and Their Relationships to Learning. *Handbook of Research on Educational Communications and Technology (2nd Ed.)*, (d), 571–581. http://doi.org/10.1080/08935690701571045

[25]   V. Guillén-Nieto and M. Aleson-Carbonell, "Serious games and learning effectiveness: The case of It's a Deal!," *Comput. Educ.*, vol. 58, no. 1, pp. 435–448, 2012.

[26]   Hannafin, M. J., Hannafin, K. M., Hooper, S. R., Rieber, L. P., & Kini, A. S. Research on and research with emerging technologies. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology (pp. 378-402)*. (1996). New York: Simon & Schuster.

[27]   C. L. Ho and R. J. Dzeng, "Construction safety training via e-Learning: Learning effectiveness and user satisfaction," *Comput. Educ.*, vol. 55, no. 2, pp. 858–867, 2010.

[28]   Devolver Digital 2012, *Hotline Miami,* Microsoft Windows OS X PlayStation 4 PlayStation 3 PS Vista Linux Andriod.

[29]   J. Huizinga, "Homo Ludens: A Study of the Play-Element in Culture," *Eur. Early Child. Educ. Res. J.*, vol. 19, no. 2, pp. 1–24, 2007.

[30]   C. Jennett, A. L. Cox, and P. Cairns, "Being 'in the game,'" *Proc. Philos. Comput. Games 2008*, pp. 210–227, 2009.

[31]   Kamkarhaghighi, M., Mirza-Babaei, P., El-Khatib, K., & Gerling, K. M. (2017). Architecture guideline for game-based stroke rehabilitation. *World Journal of Science, Technology and Sustainable Development, 14*(2/3), 228–240. http://doi.org/10.1108/WJSTSD-06-2016-0039

[32]   Kirriemuir, J. (2002). Video gaming, education and digital learning technologies: Relevance and opportunities. *D-Lib Magazine*, 8(2).

http://doi.org/10.1045/february2002-kirriemuir

[33]   B. Mackinnon, "Adaptive AI in a racing simulator : a challenging and fun environment for any user," vol. 1, no. 1, pp. 71–89, 2012.

[34]   H. E. McLoone, M. Jacobson, C. Hegg, and P. W. Johnson, "User-centered design," *Work*, vol. 37, no. 4, pp. 445–456, 2010.

[35]   E. D. Mekler, F. Brühlmann, K. Opwis, and A. N. Tuch, "Disassembling Gamification: The Effects of Points and Meaning on User Motivation and Performance," *CHI '13 Ext. Abstr. Hum. Factors Comput. Syst. - CHI EA '13*, p. 1137, 2013.

[36]   C. Mulwa, S. Lawless, M. Sharp, I. Arnedillo-Sanchez, and V. Wade, "Adaptive educational hypermedia systems in technology enhanced learning: a literature review," in *ACM Conference on Information Technology Education*, 2010, pp. 73–84.

[37]   Nacke, L. E., Desurvire, H., Mirza-Babaei, P., Bernhaupt, R., & El-Nasr, M. S.

(2014). Games and entertainment community SIG: Reaching beyond CHI. 32nd

Annual ACM Conference on Human Factors in Computing Systems, CHI EA 2014,

1123–1126. http://doi.org/10.1145/2559206.2559216

[38]   Nacke, L. E., Moser, C., Drachen, A., Mirza-Babaei, P., Abney, A., & Zhenyu, Z.

(Cole). (2016). Lightweight Games User Research for Indies and Non-Profit

Organizations. *Proceedings of the 2016 CHI Conference Extended Abstracts on*

Human Factors in Computing Systems - CHI EA '16, 3597–3603.

http://doi.org/10.1145/2851581.2856504

[39]   S. Nicholson, "A User-Centered Theoretical Framework for Meaningful

Gamification A Brief Introduction to Gamification Organismic Integration Theory

Situational Relevance and Situated Motivational Affordance,"

GamesLearningSociety 80, 2012.

[40]   B. Nowrouzi, B. Gohar, B. Nowrouzi-Kia, M. Garbaczewska, O. Chapovalov, É.

Myette-Côté, and L. Carter, "Facilitators and barriers to occupational health and

safety in small and medium-sized enterprises: a descriptive exploratory study in

Ontario, Canada," *Int. J. Occup. Saf. Ergon.*, vol. 22, no. 3, pp. 360–366, 2016.

[41]   Panjwani, D., Cioca, E., Drenikow, B. J., Chodan, C., Fong, T., Li, S., … Dunn, S.

(2015). An Evidence-Based Mobile App for Emergency Contraception Awareness

and Education. *2015 International Conference on Interactive Mobile*

Communication Technologies and Learning (IMCL), (November), 66–68.

http://doi.org/10.1109/IMCTL.2015.7359556

[42]   C. Phillips, D. Johnson, and P. Wyeth, "Videogame reward types," *Proc. First Int.*
        Conf. Gameful Des. Res. Appl. - Gamification '13, pp. 103–106, 2013.

[43]   L. P. Rego, Paula and Moreira, Pedro Miguel and Reis, "Serious games for
        rehabilitation: A survey and a classification towards a taxonomy," *Inf. Syst.*
        Technol. (CISTI), 2010 5th Iber. Conf., pp. 1–6, 2010.

[44]   Square Enix Microsoft Studios, *Rise of the Tomb Raider,* Microsoft Windows
        PlayStation 4 Xbox 360 Xbox One.

[45]   U. Ritterfeld and R. Weber, "Video Games for Entertainment," *Play. Video*
        Games-Motives, Responses, Consequences, pp. 399–413, 2006.

[46]   J. G. Ruiz, M. J. Mintzer, and R. M. Leipzig, "The impact of e-learning in medical
        education," *Acad. Med.*, vol. 81, no. 3, pp. 207–212, 2006.

[47]   R. M. Ryan, C. S. Rigby, and A. Przybylski, "The Motivational Pull of Video Games:
        A Self-Determination Theory Approach," *Motiv. Emot.*, vol. 30, no. 4, pp. 344–
        360, 2006.

[48]   Sankaranarayanan, K., Mirza-Babaei, P., & Da Rocha Tome Filho, F. (2016). Video
        games to the rescue: Can game design make software based lab experiments
        engaging? *2015 IEEE Games Entertainment Media Conference, GEM 2015*.
        http://doi.org/10.1109/GEM.2015.7377240

[49]   Shewaga, R., Uribe-Quevedo, A., Kapralos, B., & Alam, F. (2017). A Comparison of
        Seated and Room-Scale Virtual Reality in a Serious Game for Epidural
        Preparation. *IEEE Transactions on Emerging Topics in Computing*.
        http://doi.org/10.1109/TETC.2017.2746085

[50]   V. J. Shute, L. Rieber, and R. Van Eck, "Games … and … Learning," *Trends issues Instr. Des. Technol.*, pp. 1–31, 2012.

[51]   Hi-Res Studios 2014, *Smite,* Microsoft Windows Xbox One Playstation 4 macOS.

[52]   Squire, K. (2003). Video Games in Education. *International Journal of Intelligent Simulations and Gaming*, 2, 49--62. http://doi.org/10.1145/950566.950583

[53]   T. Susi, M. Johannesson, and P. Backlund, "Serious Games – An Overview," *Elearning*, vol. 73, no. 10, p. 28, 2007.

[54]   Ubisoft Montreal, *Tom Clancy's Rainbow Six Siege,* Microsoft Windows PlayStation 4 Xbox One.

[55]   Peak Games grapes prod, *Toy Blast,* Android IOS.

[56]   T.-W. Tsai, H. Y. Lo, and K.-S. Chen, "An affective computing approach to develop the game-based adaptive learning material for the elementary students," *Proc. 2012 Jt. Int. Conf. Human-Centered Comput. Environ. - HCCE '12*, p. 8, 2012.

[57]   H. Wang and C.-T. Sun, "Game Reward Systems : Gaming Experiences and Social Meanings," *DiGRA*, pp. 1–15, 2011.

[58]   White, Barbara Y. "Designing Computer Games to Help Physics Students Understand Newton's Laws of Motion." *Cognition and Instruction*, vol. 1, no. 1, 1984, pp. 69–108. JSTOR, JSTOR, www.jstor.org/stable/3233521.

[59]   White, G. R., Lee, J., Johnson, D., Wyeth, P., & Mirza-Babaei, P. (2015). Crossing Domains: Diverse Perspectives on Players. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, 2349–2352. http://doi.org/10.1145/2702613.2702636

[60]   I. Zualkeman, M. Pasquier, M. M. Jibreel, R. S. Zakaria, and R. M. Tayem, "An

        adaptive learning RPG game-engine based on knowledge spaces," *ICETC 2010 -*

        2010 2nd Int. Conf. Educ. Technol. Comput., vol. 2, no. 5, pp. 223–227, 2010.

[61]   Nintendo Capcom Vanpool Grezzo 1991, *The Legend of Zelda,* Nintendo

        Entertainment System Super NES Game Boy Nintendo 64 Game boy Color Game

        Boy Advance GameCube Wii Nintendo DS Nintendo 3DS Wii U Nintendo Switch.