Safety does not Happen by Accident, can Gaming Help Improve Occupational Health and Safety in Organizations?

Cameron Chodan, Pejman Mirza-Babaei, Karthik Sankaranarayanan

University of Ontario Institute of Technology (UOIT)
2000 Simcoe St N
Ontario, Canada

Cameron.Chodan@gmail.com, Pejman@uoit.ca, Karthik@uoit.ca

Abstract. In 2015, the Association of Workers' Compensation Boards of Canada recorded around quarter-million workplace injuries, a staggering figure which does not include incidents that go undocumented. A lack of health and safety training and/or lack of safety awareness can lead to workplace injuries and in the worst cases a workplace death. It is imperative that organizations make Occupational Health and Safety (OHS) one of their top priorities.

In this paper, we explore the implementation of an adaptive personalized learning support system within a game that is centered on health and safety training. 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 evolutionary i.e. it is designed to adjust the challenges given to the player in order to focus on improving the player's underperforming skills. This game is a step towards overcoming a lack of health and safety training observed in small and medium enterprises. Through this game we try to create a fun and motivating environment where workers are being exposed to the health and safety mindset and learning through relevant challenges.

The game is made in collaboration with the public services health and safety association (PSHSA) based in Toronto. The learning challenges aim to better the player's health and safety performance in the organizational performance metric (OPM) and hone their underlying health and safety skills.

Keywords: User-centered design; Game development; Serious games; Adaptive learning; Case study.

1   Introduction

Employees are an integral part of an organization and their skills can be considered a competitive advantage. In most scenarios, organizations train their employees in order

to equip them with a skillset(s). Health and Safety forms an important cornerstone in such trainings. In spite of this training and attention, employees are still prone to injuries. According to the Association of Workers' Compensation Boards of Canada, there were around a quarter million recorded workplace injuries in 2015[1]. One needs to keep in mind that many workplace injuries also go unrecorded.

Health and safety prevention is a very broad field, covering a wide range of organizational sectors. Preventing health and safety issues is not a new concept and is often done through training, but new techniques, resources and tools are being researched. There is a plethora of resources available for organizations and employees to educate themselves. These resources include textbooks, and training courses.

With the current development in digital media many organizations are exploring the potential of digital resources (such as e-learning and serious games) for training. E-learning could be generalized as interactive educational tools in a digital format. Closely tied to e-learning are serious games, which are often defined as games with the main objective being teaching or training players how to react to certain situations [8]. Various research studies showed that both e-learning and serious games are effective at teaching players [14, 8]. Previous efforts in e-learning and serious games in health and safety focused to tackle a small portion of the overall sectors.

Our current research focuses on building a serious game that adapts its content based on users' industry sector as well as what they need to learn with respect to health and safety.

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. Adaptive systems are focused on increasing learner satisfaction, effectiveness and engagement [10].

Studies showed that adapting to the user's feedback could make a major impact on user's satisfaction and motivation [17]. Video games can be considered as powerful medium to explore adaptive learning systems. Imran Zualkeman et al. [19] constructed an adaptive game that changes the content and delivery of the content based on the player's abilities [19]. Such a design may provide a more motivating approach to learning for the audience.

In the following sections, we elucidate and explore the above-mentioned topics in detail. We describe game design efforts with the focus on adaptive learning followed by our case study in collaboration with Public Safety and Health Service Association (PSHSA). PSHSA is located in Toronto, Canada and dedicated to providing easily accessible client-focused solutions for eliminating workplace injuries, illness and fatalities. Through their regional offices scattered around Ontario, PSHSA serves more than 10,000 organizations that employ more than 1.6 million workers[2].

---

[1] http://awcbc.org/?page_id=14
[2] http://www.pshsa.ca/about-us/

2   Adaptive Games for learning

According to Entertainment Software Association (ESA), fifty-four percent of Canadians are gamers with the average age of the Canadian gamer being thirty-three [5]. Not only are there a large number of gamers in Canada there is also a growing interesting in game companies. From 2013 to 2015, Canada saw 143 new companies raising the overall number to 472 [5]. With the growing number of games and gaming companies, there is also growing academic interest in the potential applications of games. Games serve a wide gamut of objectives ranging from, entertainment, education, and aiding physical rehabilitation [12, 16].

In education, games are suitable medium for entertaining and motivating students. With a game providing enough intrinsic motivation for continued play, studies have shown that people are more receptive to learning when motivated thus making games a powerful tool [16, 13]. Educators and game developers are looking into utilizing this strength and applying it to learning in games.

Many games create a desire to play through the self-determination theory (SDT) [15]. The self-determination theory posits that three basic psychological needs should be satisfied to trigger human motivation. The first is competence i.e. the need to overcome problems and seek mastery. The second is relatedness, the want to interact with others. The last is autonomy, the need to control one's own actions. Keeping this theory in mind when designing a game helps capture player's motivation.

Flow theory is another design principle many game researchers have discussed to keep players immersed in the game [1]. The goal of flow theory is to keep the player in situations where they have enough skill to overcome the challenge encountered in the game. This situation often referred to as the flow channel as show in figure 1. 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 one point on how commercial games try to motivate players. Many game-based learning applications are aiming to borrow similar design elements from commercial games.
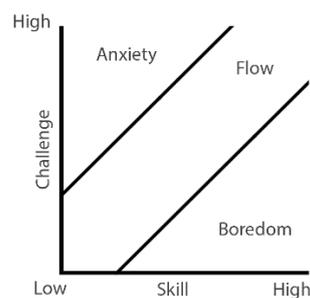

Fig. 1. Flow theory

Gamification is the application of game design elements in non-game context [3]. Thus gamification is designed to be a supportive and motivating factor that engage players to participate in performing non-game activities. Gamification's primary objective is to correct behaviour or creating desired behaviours [2]. Gamification helps the players to develop skills and behaviours through motivating and facilitating continuous play [7].

Gamification is designed to enhance an individual's intrinsic motivation [4]. For gamification to work there needs to be a drive to accomplish/achieve the desired outcome [6]. Gamification is very powerful when designed and applied intelligently. One of the more common designs for gamification is to award a player with meaningful rewards when the player performs the desired behaviour [11]. When the rewards have meaning to the players this will motivate them to want to complete the task the next time [9].

We followed user-centered design (UCD) process to focus our design on the user's needs and goals [18, 11]. PSHSA conducted various internal interviews and focus groups to determine user needs. We do not delve into the interviews and focus groups results as it is beyond the scope and focus of this paper. This paper focuses on our involvement in establishing the requirements for the game and prototyping different possible approaches. The next section explains the game prototypes as well as provides the current game flow framework and how we designed the adaptive system based on the data provided by users.

2.1 Case study: PSHSA Game prototypes

Although PSHSA has a wealth of resources and training materials for organizations, they realized a lack of utilization by small and medium enterprises (SME's). Through internal studies, PSHSA has identified a need for an engaging application to motivate SME's to learn about health and safety prevention. We are collaborating with PSHSA and its partnering associations to create a digital application for motivating SME's to learn and continue learning about health and safety prevention through the use of game design.

The digital application is based on the Institute for Work and Health Organizational Performance Metrics (IWH-OPM). IWH-OPM is an eight-question survey designed to assess an organization's occupational health and safety performance[3]. IWH-OPM uses a Likert scale questionnaire where each one of eight questions is targeted 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.

As mentioned before, we followed UCD process in this project. In order 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 identified three key requirements for this work: a) the main focus of the application would be to motivate users to perform better in the IWH-OPM questionnaire; b) Focus on

---

[3] http://www.iwh.on.ca/opm

motivation and retention of users for continued learning and c) The game must also be applicable to 16 public sectors[4] (in terms of learning objectives).

In order to create a digital application for promoting and motivating users to assimilate health and safety knowledge, the first step was to discuss the skills that the application needed to teach. We held brainstorming sessions to determine and discuss the skills related to each of the eight IWH-OPM questions. This included asking the collaborator's 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 a finite list of 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.

First prototype

Our first design iteration of the project was to focus on retaining the player through the use of 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 or inherently teaching the user both health and safety skills and concepts. The mini-games were designed to be abstracted from the sectors in an attempt to make them apply to all the sectors. In order to excel at the mini-games the users would need to be demonstrating their skills. Health and safety concepts would be interjected as the contents of each mini-games in an attempt to keep the play relevant.

We prototyped one of the small games, this game aimed to teach users time management, assessment of validity and attention to detail skills (aforementioned first IWH-OPM question). This game borrowed game design elements from the game '*Cook, Serve, Delicious!*'[5]. *Cook, Serve, Delicious* is a restaurant simulator that tasks the player to take, prepare and serve orders from non-player character (NPC) entering the player's restaurant. The game has an emphasis on time management, as the player needs to quickly complete orders. In addition, assessment of validity and attention to detail are present, as the player needs to correctly prepare orders as the NPCs wishes.

The prototype created tasked the user to play as a project manager assigning priorities and completing task. Similarly, to how '*Cook, Serve Delicious*' tasks the player to fill out orders and make sure they are completed in the specified way, in the prototype the player has to finish a task. A task is an item that the player needs to complete. Completing the task requires the player to read a description about the task and assign specifics requirements mentioned in the description to the task.

---

4 Sectors: Pulp and Paper, Forestry, Mining, Construction, Transportation, Electrical and Utilities, Agriculture, Tourism and Hospitality, Retail and Wholesale, Office and Related Services, Vehicle Sales and Service, Industrial and Manufacturing, Health and Community Care, Education and Culture, Emergency Services (Fire, Police and Medical), and Government and Municipal.

5 http://www.vertigogaming.net/blog/

Extending from *'Cook, Serve, Delicious'* the player starts the day by reading the agenda for the day, noting down the in game company's priorities and assigning time frames for major tasks to be completed. After the day setup is completed, the player would have to prioritize, prepare, and hand in tasks. The player needed to recognize the prioritized task put forth by the agenda and make sure those tasks were completed first. Completing a task, made the player check if all the elements of the challenge were completed correctly before submitting the task to who assigned the task. An example task for the player could be, 'Select the proper audit for warehouse safety and conduct it'. The prototype got its relevance to health and safety from the tasks it assigned the player while the game design was more focused on fun gameplay.

Reviewing the design and prototype with PSHSA found that the prototype would not work for the intended goal. 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 would have made a motivating game and taught the players the identified skills, having these taught intrinsically left little to be relevant to health and safety. The lack of relevance to the player, make the game hard for the player so see the point of playing. This failure prohibits the player from finding intrinsic motivation to continue to play the game. Another major problem with the first prototype was that it could not be adapted well enough to player needs from different sectors. Therefore, we decided to try a different design with a large focus on relevance and adaptability to different sectors.

Second prototype
The second iteration of the prototype shifted the game design to focus on directly teaching health and safety to the player by implementing a large database of health and safety challenges. Each of these challenges would be tagged to identify their relevance towards a certain need. Challenges have the ability to be tagged to show their relevance towards an IWH-OPM question, an identified skill, and/or other relevant identifiers. The shift from mini-games to challenges also meant a shift from intrinsic style of learning to an extrinsic style. The challenges are much more direct in their teaching. Each challenge can be setup to be played in a standard way of multiple choice, etc.; but some can also be played in a more gamified way.

Another addition that came with the second prototype of that game is inclusion of an adaptive personalized system. The goal of the system is to learn from the user's performance and change what challenges are presented to the player. In order to get this system to work from the start each player is now required to fill out a short profile to give the system some context of the user's skills before presenting any challenges. The system also learns from the user performance while they play the game.

A large focus is still on motivation and retention. Motivation is kept high through the use of gamification. 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. Retention is captured from the use of quests. Quests are used to give more reason to come back and play the game. A quest tasks the player with playing a number of challenges in a row, complete a number of challenges in a day, or in a week, or

month. Each quest is designed to increase retention and motivation in the time period it is needed most.

The second iteration fits better with PSHSA's needs. Through the use of gamification with meaningful rewards the requirement for motivation will be satisfied. The use of adaptive personalized system user retention can be obtained by the use of quests. 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.

2.2 Game flow

Figure 2 shows the flow of the game and how the game design functions. The entry point of the game is the user profile. To reiterate, the user profile is a set of basic information the user enters before starting the game. 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, and some generic information. The user profile is crucial to the start of the personalization of the game. As the user plays the game their profile is constantly updated with the score from the challenges. The user can get a glimpse of how well they are performing from graphs and statistics displayed in their home page.
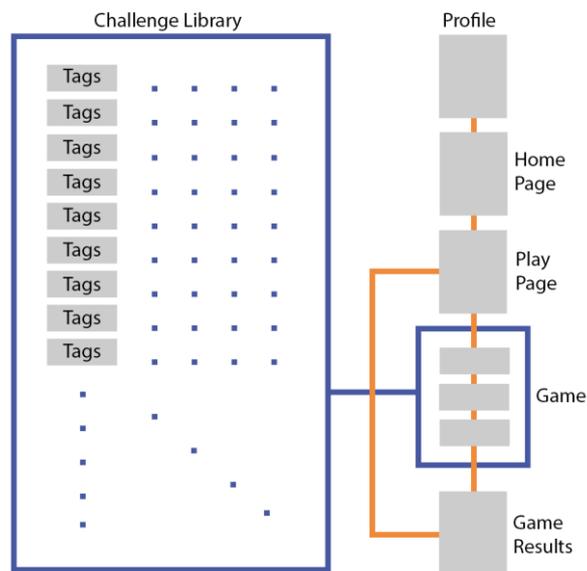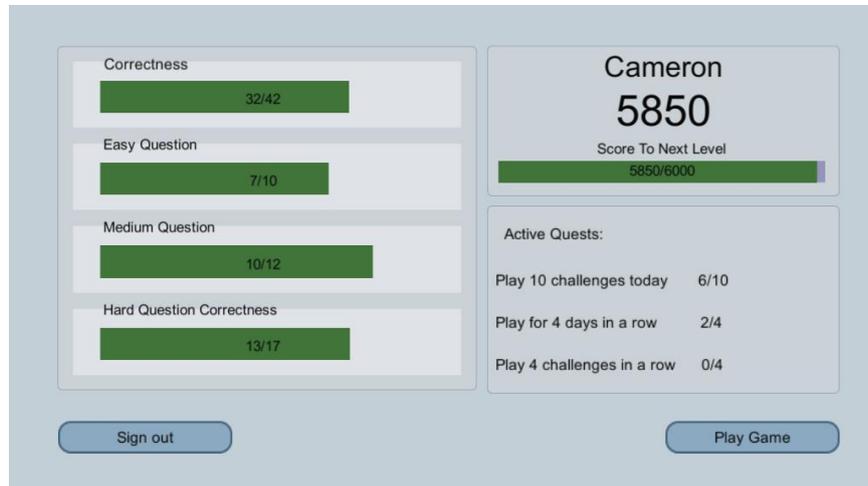

Fig. 2. Game flow

Fig. 3. Home page

The home page (Figure 3) is the screen from which the user can see graphs showing their performance multitude of different metrics. The metrics are to showcase the user's stats in a wide array of areas from the amount of points awarded in a week compared to the last week, to the amount of correctness achieved in a week compared to the last week. The home page is targeted to be a motivator for the user wherein it shows improvement as well as quests completed. Challenges as mentioned briefly before are tasks that the user can complete for extra points. The main focus of the challenges is to increase the retention of the user by the promise of potential large rewards if the task is correctly completed. From the home page the user can enter the play page.

On the play page (Figure 4) the user is provided with a list of challenges picked by the adaptive game engine. The game picks relevant challenges and presents only a handful for the user to play. Alongside the challenges presented will be potential score for each challenge if completed correctly. In order to discourage demotivation a 'Refresh Selection' button is present to refresh unwanted challenges. When the user selects a challenge they are now tasked to play that challenge.
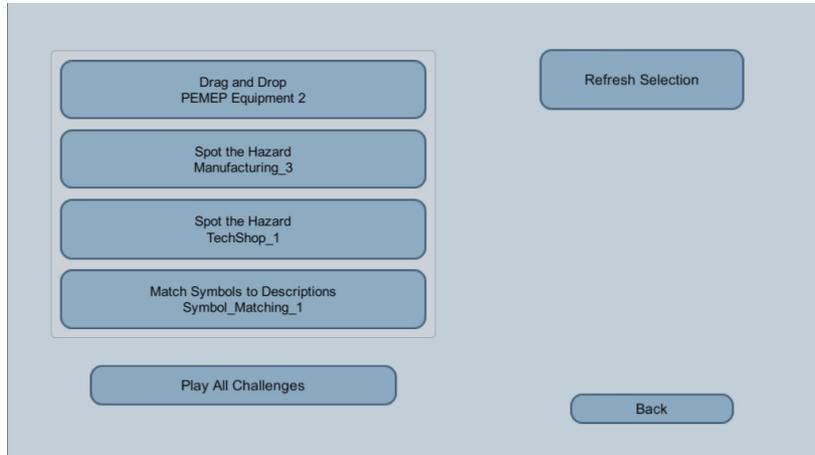
Fig. 4. Play page

Play All Challenge is when the user plays a short game. These games last from 20 seconds to a minute. The reason for the short playtime is to keep users engaged. Another benefit of the short playtime is that the user can play without having to allocate a large portion of time to ensure they can play the game in its entirety. As mentioned before, these challenges are played through a variety of ways. From classical multiple choice, true or false; to games like finding problems, finding safe paths (Figure 5). After the user has completed the game they are moved to the game result page.
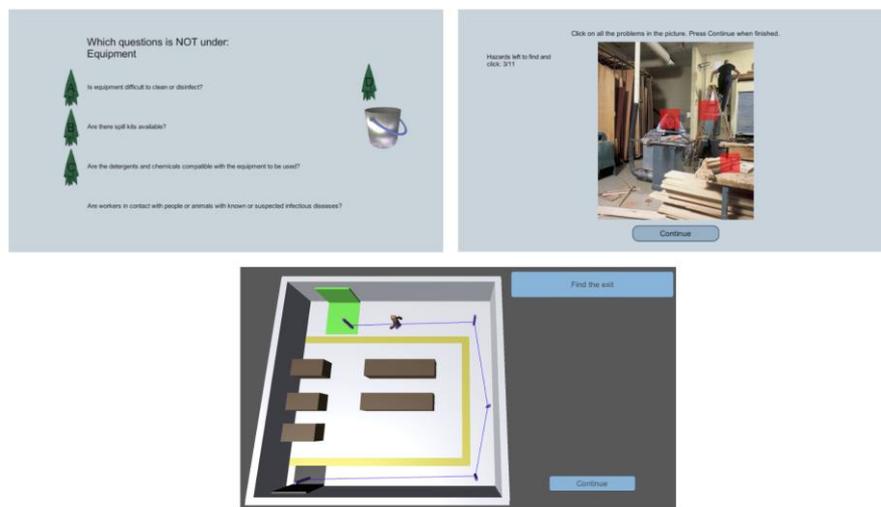

Fig. 5. Multiple choice (top left), Find the problems (top right), Find the safe path (bottom)

The game result page (Figure 6) is where the users are awarded points for their performance in the game. In addition, if users had completed any of their quests they would

be awarded the points. In summary, this page is where the user is given their rewards or incentives for playing the challenge. Once the user has had time to review their score and performance in the challenge they can move to the play page to continue the game loop and their game session.
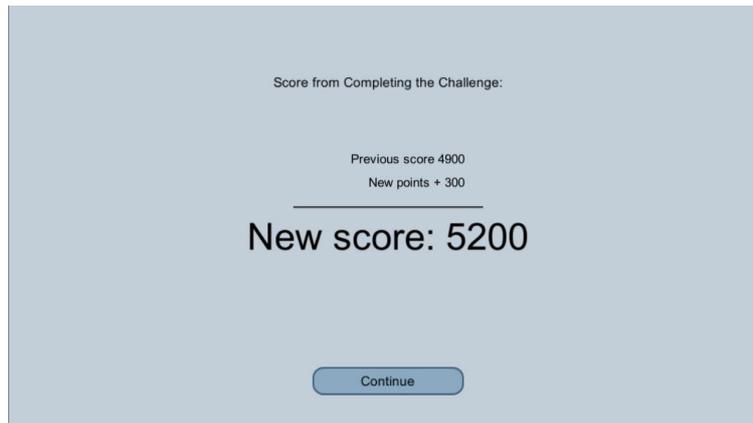

Fig. 6. Game result page

2.3 Adaptive System

The previous section explained how the user interacted with the game elements. In this section we elaborate on how the game uses the collected information from each player. The game personalizes three main aspects at its control: a) user skill; b) motivation; c) learning style. Below we look at these in more details.

The first one is the user's knowledge and abilities. This process starts at the creation of the user profile. We take the user's score for each of the IWH-OPM questions and construct a rough estimate of the user's knowledge by converting their score into a points system. The scores from IWH-OPM range from 0 to 4. When converting the IWH-OPM score to the points system the process is as follows: change the range to 0 – 1, then multiply the resulting number by 1000 points. For getting a rough estimate of their ability to perform skills we take an average of all of the IWH-OPM question scores that relate to the skill and convert it into a points. For example, if an identified skill is only present in 2 of the IWH-OPM questions and the user got 2.4 and 3.6 for those questions the user would get a point score of 750 i.e. $(((2.4+3.6)/2)/4 * 1000)$. The initial profile statistics will need to have the game confirm if each of the rough estimates are true. Testing an estimate is done through getting a user to play a challenge that requires the specific skill to complete. Over a liberal amount of iterations, we will be able to get a real sense of the user's knowledge and abilities. The advantage of initial profile statistics is that we can start to test the user's knowledge and abilities in the areas that have the lowest estimate making the game personalized right out of the gate.

The game attempts to personalize and adapt to the user by tracking and promoting the user's ability and the user's motivation. In addition, the game also personalizes,

when it can, the type of challenges presented to the user, more on this later. The key factors we are looking for is if the user has the ability to correctly complete challenges related to the IWH-OPM questions and the identified skills. Through focusing on the IWH-OPM and identified skills the user is under performing in we hope to increase his skills in the areas. The correctness of the user is calculated in an overall scope and a weekly scope. The overall scope helps display any improvements during the entirety of the user's interaction with the game. While the weekly scope helps identify if the user's skill is improving on a week-to-week basis. The objective is to keep the user at an overall correctness of 80-90%. Keeping the user in this correctness range we hope to keep the game motivating and challenging why keeping the user in the flow channel we discussed earlier.

Adapting to the user's retention means identifying when the user plays the game and for how long. The game will capture the player's usage in days, weeks and months. We need to determine the user's schedule to find out if it is a desirable schedule. The goal of the game is to normalize the user's schedule. The game achieves this by using a number of different quests. Quests are used to make the user feel motivated to play the game at different schedule. If we determine that the user plays the game for one week out of a month, we can interject quests that motivate the user to play every week in the month. Similarly, if we find that the user only plays the game 2-3 days every week, we would want to bring that up to 4-5 days every week by introducing quests that reward playing every day of the week.

The last adaptive trait of the game is based on the user's ability to complete a specific type of challenges. As discussed before, the type of challenge refers to the way a challenge is played. If we store how the user scores for each challenge type, we can determine if the user is having problems with a specific challenge type. If difficulties are detected, the game can shy away from the identified challenge type and give the user challenge types they can comfortably perform.

3   Conclusion and Future work

In this paper we have shown how through the use of 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.

Finally, as a part of future work we 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.

References

1. Cowley, B., Charles, D., Black, M., & Hickey, R. (2008). Toward an understanding of flow in video games. Computers in Entertainment, 6(2), 1. http://doi.org/10.1145/1371216.1371223
2. Deterding, S. (2012). Gamification: designing for motivation. Interactions, 19, 14–17. http://doi.org/10.1145/2212877.2212883
3. Deterding, S., & Dixon, D. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." MinTrek 2011, 9–15. http://doi.org/10.1145/2181037.2181040
4. Domínguez, A., Saenz-De-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. Computers and Education, 63, 380–392. http://doi.org/10.1016/j.compedu.2012.12.020
5. Entertainment Software Association of Canada (ESAC). (2015). 2015 Essentail Facts about The Canadian Video Game Industry. Retrieved from http://theesa.ca/wp-content/uploads/2015/11/ESAC_2015_Booklet_Version02_14_Digital.pdf
6. Francisco, A., Luis, F., González, J. L., & Isla, J. L. (2012). Analysis and Application of Gamification. INTERACCION '12, 17:1–17:2. Retrieved from http://doi.acm.org/10.1145/2379636.2379653
7. Glover, I. (2013). 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 (pp. 1998–2008). Retrieved from http://shura.shu.ac.uk/7172/
8. Guillén-Nieto, V., & Aleson-Carbonell, M. (2012). Serious games and learning effectiveness: The case of It's a Deal! Computers and Education, 58(1), 435–448. http://doi.org/10.1016/j.compedu.2011.07.015
9. Mekler, E. D., Brühlmann, F., Opwis, K., & Tuch, A. N. (2013). Disassembling Gamification: The Effects of Points and Meaning on User Motivation and Performance. CHI '13 Extended Abstracts on Human Factors in Computing Systems on - CHI EA '13, 1137. http://doi.org/10.1145/2468356.2468559
10. Mulwa, C., Lawless, S., Sharp, M., Arnedillo-Sanchez, I., & Wade, V. (2010). Adaptive educational hypermedia systems in technology enhanced learning: a literature review. In ACM Conference on Information Technology Education (pp. 73–84). http://doi.org/10.1145/1867651.1867672
11. Nicholson, S. (2012). A User-Centered Theoretical Framework for Meaningful Gamification A Brief Introduction to Gamification Organismic Integration Theory Situational Relevance and Situated Motivational Affordance. GamesLearningSociety 80.

12. Rego, Paula and Moreira, Pedro Miguel and Reis, L. P. (2010). Serious games for rehabilitation: A survey and a classification towards a taxonomy. Information Systems and Technologies (CISTI), 2010 5th Iberian Conference on, 1 – 6.

13. Ritterfeld, U., & Weber, R. (2006). Video Games for Entertainment. Playing Video Games-Motives, Responses, and Consequences, 399–413.

14. Ruiz, J. G., Mintzer, M. J., & Leipzig, R. M. (2006). The impact of e-learning in medical education. Academic Medicine, 81(3), 207–212. http://doi.org/10.1097/00001888-200603000-00002

15. Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. Motivation and Emotion, 30(4), 344–360. http://doi.org/10.1007/s11031-006-9051-8

16. Shute, V. J., Rieber, L., & Eck, R. Van. (2012). Games … and … Learning. Trends and Issues in Instructional Design and Technology, 1–31. Retrieved from http://myweb.fsu.edu/vshute/pdf/shute pres_i.pdf\nhttp://www.pearsonhighered.com/pearsonhigheredus/educator/product/products_detail.page?isbn=0132563584&forced_logout=forced_logged_out

17. Tsai, T.-W., Lo, H. Y., & Chen, K.-S. (2012). An affective computing approach to develop the game-based adaptive learning material for the elementary students. Proceedings of the 2012 Joint International Conference on Human-Centered Computer Environments - HCCE '12, 8. http://doi.org/10.1145/2160749.2160752

18. Zammitto, V., Mirza-Babaei, P., Livingston, I., Kobayashi, M., & Nacke, L. (2014). Player experience: mixed methods and reporting results. In *CHI EA '14*. ACM, New York, NY, USA, 147-150. DOI: https://doi.org/10.1145/2559206.2559239

19. Zualkeman, I., Pasquier, M., Jibreel, M. M., Zakaria, R. S., & Tayem, R. M. (2010). An adaptive learning RPG game-engine based on knowledge spaces. ICETC 2010 - 2010 2nd International Conference on Education Technology and Computer, 2(5), 223–227. http://doi.org/10.1109/ICETC.2010.5529397