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An Investigation into Serious Games for Smoking Cessation

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## **ABSTRACT**

Smoking is one of the leading causes for preventable illness and death in the UK. This is an investigation into how theory-based serious games can help people quit smoking.

The conducted research focuses on how behavioural change can be achieved through serious games. Several behavioural change theories are explored, as well as serious game design frameworks that integrate both game principles and behavioural change elements (Verschuere, Buffel and Stichele, 2019). This paper looks at developing and evaluating the usability of a product for smoking cessation and at the direction of future improvements and how obtained results could be built upon.

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## CHAPTER 1: AN INVESTIGATION INTO SERIOUS GAMES FOR SMOKING CESSATION

### 1.1 Introduction

In 2017, smoking was identified as the cause for 16% of all adult deaths in England (National Health Service, 2019), and in 2018, it was reported that 14.7% of the UK's population were smokers (Office for National Statistics, 2019). Additionally, the number of successful self-reported quitters decreased by 11% from 2016/17 to 2017/18 (National Health Service, 2019). With smoking being a persisting health issue, serious games present a great potential in helping educate smokers about the consequences of smoking and in changing their behaviour, as well as reducing the burden on health service providers caused by smoking-related illness (Department of Health, 2017).

The term *serious games* refers to digital games designed for purposes beyond entertainment; to achieve health, educational, training and communication objectives (Zyda, 2005). Smoking cessation requires a change in behaviour and attitude towards smoking, which serious games can achieve, as demonstrated in studies such as (Marin-Gomez *et al.*, 2019)'s study on the game Tobbstop. The study's intervention group used Tobbstop, and their average days without smoking was 4.2 times higher than that of the control group, suggesting the success in helping them quit.

The efficacy of serious games is also backed up by theories such as Self-Determination Theory (Ryan and Deci, 2000), which states that relatedness, competence and autonomy contribute to a person's decision of behavioural change, all of which are integrable into serious games through the use of game mechanics, narrative, goal-setting and giving rewards (Cheek *et al.*, 2015).

With smoking being a persisting health issue, and the increasing experimentation with serious games for behaviour change, there is great potential that games could help people quit smoking. This project investigates serious games' potential in providing a solution to aid in smoking cessation, through the merging of game design principles and the implementation of elements supported by behaviour change theories (Kelley *et al.*, 2017).

### 1.2 Research aim and objectives

The aim of this research is to assess the usability/efficacy of serious games for smoking cessation. The following objectives outline how this will be achieved:

1. Research. This stage involves the collection and examination of academic resources to identify techniques and frameworks that will inform the design of the product.
2. Design. The design of the product is informed by the examined research and will use (Starks, 2014)'s Cognitive Behavioural Game Design (CBGD) model, which is a theory-based model combining two psychological theories; Social Cognitive Theory which focuses on achieving behavioural change (Bandura, 2006), and the Theory of Multiple Intelligences for the improvement of the learning experience within the game (Gardner, 1983). These theories are incorporated with game design principles to produce CBGD. The deliverable will be a game design document that will inform the development of the game.
3. Development. The development of this product will make use of scrum methodology (Dingsøyr *et al.*, 2012) and the final deliverable will be a serious

game that implements the elements outlined by CBGD and that is ready for testing and evaluation.

4. Evaluation. This objective will involve the testing and evaluation of the product from objective 3, through carrying out user acceptance testing using (Pandit and Tahiliani, 2015)'s framework.

*Table 1. Summary of objectives, methods, deliverables and expected duration*

<b>Objective</b>	<b>Method</b>	<b>Deliverable</b>	<b>Duration</b>
Research	Research will examine secondary data available from academic journals and conference proceedings from IEEE, EBSCO, ACM and Science Direct databases	Theories, frameworks, statistics, and design methods that will inform the project's direction	5.7 weeks
Design	CBGD framework will be used.	A game design document outlining the theme and features of the game	8.1 weeks
Development	Development will be based off the game design document produced and will be executed through scrum methodology.	Serious game functional prototype in-line with features set out by CBGD	13.7 weeks
Evaluation	The final product will be evaluated through two rounds of user acceptance testing.	Report of the findings and feedback received from the user acceptance testing sessions	17 weeks

### **1.3 Research approach**

The research objective is achieved through the secondary data analysis of journal articles and conference proceedings, especially looking at qualitative evaluation of serious games for smoking cessation within the past 5 years. In addition to that, design models created specifically for serious games are examined. This phase will take 40 days to complete.

The design process, in accordance with the CBGD model, will reflect social cognitive elements: knowledge, goals, outcome expectations, encouragement and barriers, in addition to self-efficacy. This will be achieved through mechanisms derived from MI elements such as narrative, personal reflection, graphics, sound, the use of role models and humour (Starks, 2014). Designing a product and producing a game design document will take up to 57 days.

The software development process that will be used is Personal Extreme Programming (PXP), which is an agile software development framework (Agarwa and Umphress, 2008). It is an implementation of extreme programming practices for a single person team. PXP is suitable for this project due to the absence of a developer experienced

with serious games, in addition to the time constraint of this project (Agarwa and Umphress, 2008). These characteristics are accounted for in the development framework.

In addition to regular testing performed throughout the development phase, there will be regular milestones. These are demonstrated in Figure 3 in appendix B.

Going forward, the results obtained after the completion of the project can be refined and their validity can be evaluated to aid in future research on this topic.

### **1.4 Legal, Social, Ethical and Professional Issues and Considerations**

There are Considerations for General Data Protection Regulation (GDPR) (Information Commissioner's Office, 2017) that will be taken into account, ensuring that data is held securely with the player's consent, and that it is not shared with third-party unless consent has been granted. Data stored by the game to maintain a player's profile and allow them to track their progress will be stored onto a password-encrypted system. In addition to that, players should be given the ability to delete their account if they wish to.

To address an ethical issue pertaining to smokers – smoking is linked to various potentially fatal health conditions; with it being the cause for every 1 in 4 deaths from cardiovascular disease (U.S. Department of Health and Human Services, 2014). To avoid misleading smokers who need clinical intervention from relying fully on the game, the game produced should encourage players to seek professional medical help or contact their local smoking cessation helpline if the severity of their situation requires that. To further encourage that, helpline numbers could be offered in-game.

Another factor to be accounted for is the effect of stress on smokers in comparison to non-smokers, as smokers are more liable to prolonged agitation and feelings of anxiety when stressed. (Childs and De Wit, 2009), therefore they must not be subjected to induced stress as that could negatively affect their health.

### **1.5 Dissertation outline**

The rest of this dissertation will contain a critical review of literature about serious games for behavioural change. The methods used in reviewed pieces will be evaluated and common limitations and gaps in existing studies will be highlighted.

A product will be created in light of the research results, and there will be a section describing the design, development and evaluation of that product in relation to the research findings.

Finally, there will be a section describing how usability testing will be carried out on the product. The results obtained from this section will be analysed and evaluated.

## CHAPTER 2: EVALUATION OF SERIOUS GAMES FOR BEHAVIOURAL CHANGE

This chapter will cover how smoking cessation is traditionally addressed by smoking cessation services, and why serious games could be a better solution to help smokers quit. The efficacy of serious games for behavioural change will be determined through the examination of case studies. To determine the most effective techniques that contribute to behavioural change, the methodologies, methods, and evaluation techniques used in these studies will be also examined.

### 2.1 Case 1: Re-mission

Re-mission is a serious game for adolescent and young adult cancer patients aimed primarily at improving adherence to prescribed treatment, as well as secondary outcomes including: increasing self-efficacy to managing cancer, increasing cancer-related knowledge, reducing stress and enhancing quality of life.

The aim of the multicentre, multinational controlled study carried out by (Kato *et al.*, 2008) was to determine the effectiveness of the game in improving adherence and the secondary outcomes mentioned above.

The design of the game was based on principles from the social cognitive theory, learning theory and the self-regulation model of health. It is unclear whether this was achieved using a design framework or not.

The game involves the player controlling a nanobot that they use to destroy cancer cells with a young cancer patient's body. To win the game, players must destroy the cancer cells using the nanobot and ensure that the virtual patient strategically engages in appropriate self-care behaviour, such as taking the correct medication for a given symptom.

The trial comprised of 375 cancer patients aged 13 to 29 years old who were undergoing treatment that was expected to last for at least 4 months after their enrolment onto the trial. Participants were split into control and intervention groups. The control group was given a commercial game, while the intervention group received copy of Re-mission. Participants were asked to play for at least 1 hour per week during a 3-month trial period and their game use was recorded electronically. Their measurements would be later compared to their baseline assessment measurements.

Through blood tests, the results of the study showed that participants in the intervention group had statistically significant amounts of two out of three of the medications that were tested for in their blood ( $P=.002$ ). The third medication results showed a positive correlation that was not statistically significant ( $P>0.05$ ). Despite that, these results support the theory that adherence to medication can be increased using serious games, which is a result of behavioural change.

Additionally, the results were also statistically significant for increase in cancer-related knowledge ( $P=.035$ ) and self-efficacy ( $P=.011$ ), but not for improved quality of life ( $P=.112$ ) and perceived stress ( $P=.931$ ) (Kato *et al.*, 2008).

In conclusion, this study has used both objective and self-report methods to measure their results, which supported the efficacy of serious games in improving behavioural outcomes. There was a large sample size and the duration of the study was 3 months, which is sufficient to observe behavioural change (Lazem *et al.*, 2016). The game was based on psychological theories, however no frameworks for the design or the development of the game were mentioned, which makes it difficult to compare the results of this study to other studies' results. This is a common limitation in the



evaluation of serious games as pointed out by (Derksen *et al.*, 2020). Additionally, this study was carried out for cancer treatment, therefore it is unknown whether the results can be interpolated for smoking cessation.

### 2.2 Case 2: Tobbstop

Tobbstop is a game developed by a multidisciplinary team specially for smoking cessation. It is built around Lazarus and Folkman's model, which is a psychological theory concerning coping with stress (Richard S. Lazarus and Susan Folkman, 1984). The aim of the game is to provide a distraction for stress-induced cravings, educate players on the risks of smoking and the benefits of smoking cessation, as well as helping them keep track of their progress. These aims are fulfilled through the game's features, including minigames to educate and eliminate anxiety and withdrawal symptoms, access to a data source for education on smoking, access to a social network and in-game access to expert advice through messages.

In a controlled, randomised study carried out by (Marin-Gomez *et al.*, 2019), the efficacy of Tobbstop in helping pregnant women quit smoking was tested. The trial involved an intervention and a control group, each consisting of 21 participants. The participants in the intervention group were to play Tobbstop for 90 days and their total number of days without smoking were to be tracked and validated through measuring the concentration of Carbon Monoxide (CO) in the participant's blood.

Results showed the number of participants who remained quit until the end of the trial was significantly higher in the intervention group (57.1% compared to 14.3% for control group), with ( $P < .001$ ). This shows that Tobbstop, a serious game for smoking cessation, was able to help pregnant women quit smoking by 42.8% more than the control group during the first 90 days of cessation.

Strengths of this study include the use of CO concentrations which is a reliable and objective measure (Marin-Gomez *et al.*, 2019). In addition to that, the study was carried out for the first 90 days of the quitting process, which is the standard testing period (Marin-Gomez *et al.*, 2019). However, relapse is still possible after the 90 days period; a study carried out by (Chaiton *et al.*, 2016) showed that the likelihood of relapse for some is high even after one year of successful cessation. Other limitation to this study, include small sample size ( $n=42$ ), and the lack of a design framework.

Nevertheless, the results showed that over a short period of time, serious games can result in positive smoking cessation behaviour. Further research would be needed to ensure the validity of these results in the long-term and their applicability for the general population of smokers.

### 2.3 Case 3: Crave-out

Crave-out is an endless multilevel memory game that increases in difficulty as players level up. The game uses goals and rewards that represents benefits of quitting smoking to motivate players.

The multi-centre study carried out by (DeLaughter *et al.*, 2016) involved 30 smokers aged 19 years old and above. The participants could play the game for as long as they wanted, and their smoke cravings were assessed using QSU-brief, which is a 32-item questionnaire to quantify the magnitude of a person's urge to smoke (Tiffany and Drobes, 1991).

The results showed a reduction in postgame cravings in comparison to pregame cravings. The reduction, however, was not statistically significant ( $P=.25$ ). In a subset analysis of the results, statistically significant reduction in cravings was observed in

participants who were abstinent for more than 48 hours prior to the trial ( $P=.03$ ).

In addition to testing for reduction in cravings, the study involved usability testing. 73% of the participants reported that the game was fun, 57% said that it distracted them from their cravings, 53% found it motivating, and 73% were willing to play the game outside of the study environment. These results show that the game had the potential to successfully distract the players from their cravings and to motivate them to play the game.

However, limitations of this study include small sample size, the lack of design framework or theory-based design, or used it was not mentioned. The short duration of the study is also a major limitation for the results regarding reduction in cravings, as the results were collected during the testing session only. Furthermore, the study was not controlled.

## 2.4 *Limitations in the Evaluation of Serious Games*

The previous section discussed three serious games that were geared towards achieving a behavioural change. Some of the limitation of those studies were briefly mentioned. This section will go into more detail about the limitations commonly found in serious games for behavioural change. This is important as unaddressed limitations could result in the production of a game that is not theoretically grounded and therefore may not be fit for purpose. In later sections the design of a game for smoking cessation will be created, which will consider findings from this section.

### 2.4.1 *Standard Framework*

Despite some games basing their design on theories such as the self-efficacy theory or the social cognitive theory, there is no standard framework for the design of serious games for behavioural change. This would make it difficult to compare results from different studies (Derksen *et al.*, 2020). Going forward, the establishment of a standard framework would enable more accurate comparisons between games, which could help better identify the most important components of serious games.

This project will contribute to serious games that use frameworks, and could be used in the future to make comparisons

### 2.4.2 *Follow-up Duration*

There is an issue with serious games studies not being long-term or involving no follow-up (Kelley *et al.*, 2017), which is especially important in the case of smoking cessation as relapses are still likely within the first year of cessation (Chaiton *et al.*, 2016).

### 2.4.3 *Misalignment of Goals*

This refers to the issue of in-game goals not being clearly linked to real-life goals (Kelley *et al.*, 2017), which according to (Starks, 2014) and (Derksen *et al.*, 2020), is an important element of behavioural change in serious games.

All in all, there are major gaps in the evaluation of serious games.

More research is required, for instance (Thompson, 2016) points out questions that have yet to be answered, such as whether serious games are more effective for specific types of health behaviours compared to others, or if certain genres are more fit at addressing particular issues. Additionally, there is a handful of design and evaluation frameworks for serious games that have yet to be validated and there is no standard for serious games design.

Likewise, there is no standard method of evaluation for serious games. In a study carried out by (Calderón and Ruiz, 2015) questionnaires were the most common, which are suitable for usability but not effective method of assessing behavioural change due to their limitations which will be mentioned in chapter 3.

## 2.5 Design Framework

As mentioned in the section before, majority of serious games that have been included in literature reviews and journal articles either did not mention or use a design framework for their games. This section will discuss a design framework that was created based on psychological theories and game design principles tailored specifically towards health-related behavioural change in serious games.

As mentioned in chapter 1, (Starks, 2014)'s Cognitive Behavioural Game Design (CBGD) model is a theory-based model combining two psychological theories; Social Cognitive Theory (SCT) which focuses on achieving behavioural change (Bandura, 2006), and the Theory of Multiple Intelligences (MI) for the improvement of the learning experience within the game (Gardner, 1983). These theories are incorporated with game design principles to produce CBGD. This framework has been tested in the original study and has since been used in other studies that were not closely related to the topic of this project.

The model operates through the expression of social cognitive elements: knowledge, goals, outcome expectations, encouragement and barriers, via multiple intelligence elements, while facilitating the enjoyment aspect of the game as shown in Figure 1.

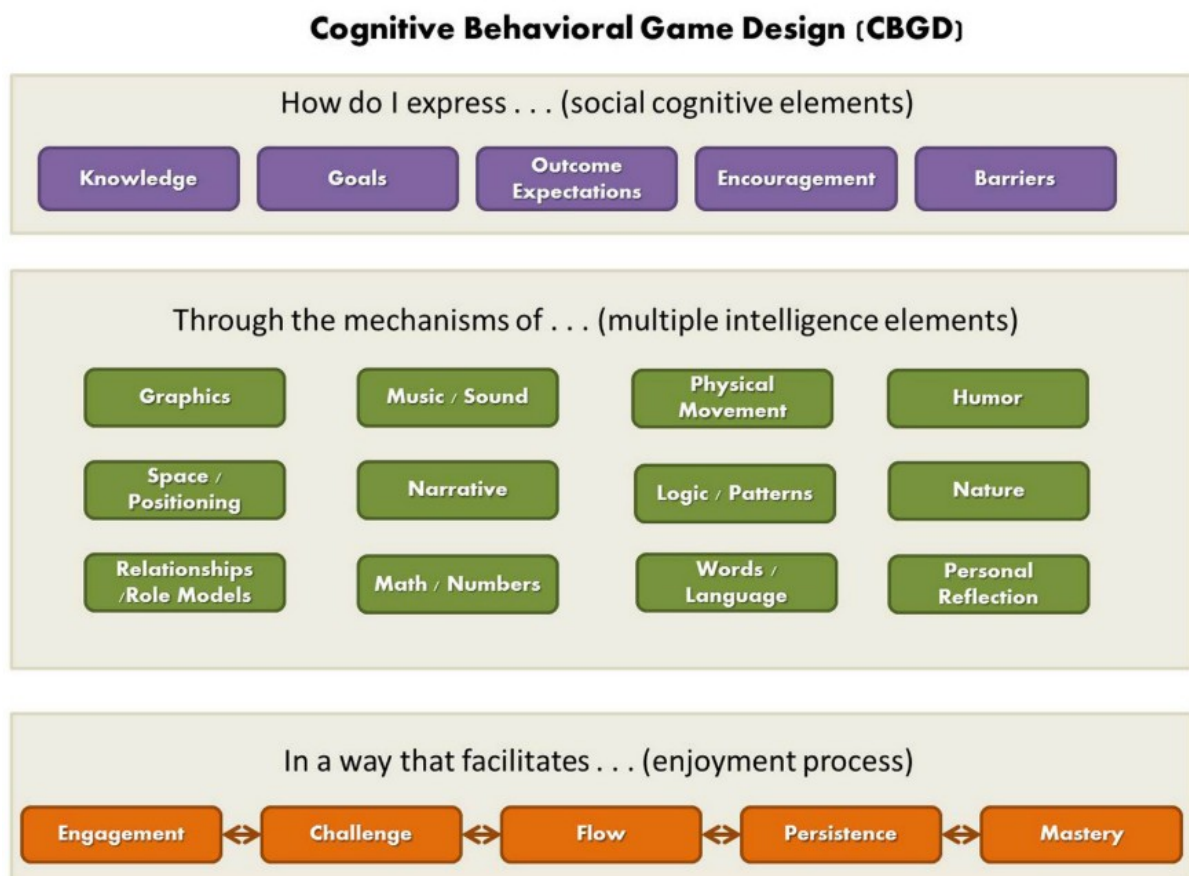


Figure 1 Elements that form the CBGD model (Starks, 2014)

The following section will provide a brief description of what each of the social cognitive elements are and how they will be applied into the game.

### 2.5.1 *Knowledge*

This refers to the knowledge the game will convey. It contributes to the overall purpose of the game (Starks, 2014). Since the goal of the proposed game is to help smokers quit smoking, this element will focus on teaching players about treatment options used to manage cravings.

### 2.5.2 *Goals*

Goals in CBGD refers to both in-game goals as well as the real-life outcome goals of the game. It is important for both these types of goals to be in alignments with each other (Starks, 2014). Misalignment of these goals is a common criticism in the design of serious games as it makes it difficult for in-game changes to be mirrored in real life behaviour, as pointed out by (Kelley *et al.*, 2017).

The real-life outcome goal of the propose game is smoking cessation, this will be achieved in-game through the player obtaining treatment packages and delivering them to smokers to reduce their cravings. A progress bar will also be used to show the player's progress in reducing cravings, to mimic their progress towards goal attainment in real life (Starks, 2014).

### 2.5.3 *Outcome Expectations*

This refers to the player's outcome expectations upon carrying out a specific in-game behaviour. Outcome expectations are intended to be parallel to real-life outcomes for a similar in-game behaviour. If the cravings bar for the smokers the player is delivering treatment to gets too high, the smokers will get relapse. The player's avatar will then get engulfed in smoke and they will lose, representing an in-real life relapse. If the player prevents that from happening, they win and can progress to the next level.

### 2.5.4 *Encouragement*

This element refers to both environmental and social support factors within the game, and how they can contribute to goal attainment; also referred to as facilitators (Starks, 2014). facilitators could be implemented through audio feedback to encourage or give approval for positive behaviour. The proposed game will implement audio feedback as well as multiplayer features to facilitate social encouragement in the game. This will be discussed in further detail in chapter 3. This element is extremely important for smoking cessation games as quitting is a long process (U.S. Department of Health and Human Services, 2019), and players need to be motivated to play the game throughout that period of time.

### 2.5.5 *Barriers*

Barriers are game elements that hinder the player from reaching their goal. It is important that these barriers do not discourage game play, but rather their aim is to develop the player's coping skills. They can be designed to mimics real-life situations as with the other elements (Starks, 2014). For instance, in the game there will be smoke clouds that can harm the player, the player would have to have to avoid these clouds otherwise their health bar would decrease.

It is important to note that in-game barrier should be challenging, but not to the point of inducing frustration and stress within the player (Schlam and Baker, 2020).

### 2.5.6 *Self-Efficacy – A Hidden Factor*

Despite not being a social cognitive element, self-efficacy is a factor that has been found to have a significant effect on behavioural outcomes, and therefore is part of CBGD. Self-efficacy is a person's belief in their ability to achieve a goal (Bandura, 2006), and is affected by and has an effect on elements such as mastery, engagement, challenge and flow, which are all parts of the Enjoyment process in CBGD (Figure 1). The higher a person's self-efficacy is, the more likely they are to take up more challenging goals and increase their mastery, and vice versa.

For this reason, Self-efficacy is not included in the CBGD model as a separate element, instead it is incorporated in aspects found in both the mechanisms and enjoyment process elements, which will be discussed in chapter 3.

### 2.6 **Summary**

In this chapter, the traditional approach to smoking cessation and why it is not the most effective approach to the problem was addressed. Cases that demonstrate serious games' ability to achieve behavioural change and usability outcomes have been introduced, discussed, and evaluated. One of the major limitations found in previous studies is the lack of use of a design framework, therefore CBGD, a theory-based behavioural change game design model, was introduced as the design framework to be used for the proposed game.

Ways to implement CBGD elements into the proposed game have been briefly explored in this chapter. The following chapter will look further into the design and development of a serious game for smoking cessation using the CBGD model.

## CHAPTER 3: DEVELOPMENT AND EVALUATION

This section will discuss the design, development, testing and evaluation of a mobile game for smoking cessation. The design decisions taken are informed by the research carried out in chapters 1 and 2.

### 3.1 *Design*

#### 3.1.1 *CBGD Elements*

As mentioned in chapter 2, the CBGD model forms the basis for the design decisions of this game. The implementation of the model's criteria was briefly discussed in section 2.6. This section will go into more details about how knowledge, goals, barriers, outcome expectations, encouragement, and enjoyment elements including engagement, challenge, flow, persistence, and mastery are fulfilled in the design of the game.

Squeaky Ways is a Fast-paced, 2D, multiplayer, role-playing game designed in alignment with the CBGD model's design criteria. The game is set in a city where the player's friend is a smoker who is stressed and is about to relapse.

When joining the game, the player can interact with a non-player character (NPC) who gives the player instructions on how to win the game. NPCs contribute to encouragement factor of the game, and therefore would motivate the player to continue playing. Additionally, it facilitates engagement through the use of a narrative (Starks, 2014).

The player's aim is to team up with other players to collect nicotine-replacement medication from around the map and deliver them to the smoker friend to help with their cravings and prevent them from relapsing. This is the game's main goal, it is clear and is aligned with (Starks, 2014)'s criteria mentioned in section 2 regarding goal setting.

Upon collecting the packages, the player is shown a message containing the details about the item they had just picked, such as whether they are over-the-counter or prescription items, or if there is statistical data regarding their effectiveness. For instance, nicotine replacement therapy such as nicotine lozenges were shown to double the likelihood of a person successfully quitting (Lindson et al., 2019). This element is aimed at educating the player about nicotine replacement therapy that they can use, and how they can be obtained. This was only applied for three of the treatments. In the future, more options could be added in when the game is scaled up.

Information regarding the treatments was obtained from the Smokefree.gov website (U.S. Department of Health and Human Services, 2019) and (Lindson et al., 2019)'s study providing statistical information about the effectiveness of combining treatments and varying dosage.

Another feature in the game is players having to avoid smoke clouds found around the city, which are caused by smokers inhabiting the city. This is an implementation of the barrier element of CBGD. It also facilitates the MI element: challenge (Starks, 2014), and could potentially represent players avoiding smoke in real life, or protecting themselves from second-hand smoking.

The players are about monitor their progress in-game through bar metres. They are also able to see the amount of time they have left before their friend relapses and they lose the level. The time limit is added to the game to facilitate challenge, which could have positive impact on the player's feelings of motivation, engagement and mastery,

as well as the flow of the game (Starks, 2014).

Persistence is seen in the game where if the player walks into enough smoke clouds to lose all of their health and lose the game, they are able to try the level again. This is the game's ability to allow players to recover from their mistakes without the burden that could be present when making real-life mistakes (Starks, 2014).

### *3.1.2 Other Design Decisions*

For this game, a city was chosen as the theme due to cities being the most diverse living environments (Clements, 2015), and therefore would be relatable to the majority of players.

Additionally, the game was designed to be a mobile game due to the size and growth of the mobile games market. In 2019, mobile games alone accounted for 45% of the games' market revenue, and had seen a 9.6% year on-year increase in revenue (Newzoo, 2019). Furthermore, the portability of smartphones means that smokers would be able to play the game at any time to distract them from cravings when other devices may not be readily available.

### *3.2 Development*

This game was developed using Unity3D engine, in addition to Photon engine to implement the multiplayer element. The graphics used for this game were obtained from the Unity Asset Store and from Itchi.io. The licenses for the assets used were appropriate for the purposes of this project, and they were credited inside the game where appropriate.

The development process followed the Personal Extreme Programming development methodology process outlined in section 1.3. The programming aspect of the game utilised Object-Oriented Programming principles to ensure that the code produced was efficient and scalable. Testing the efficacy of this game in the future would require more levels and content to produce a sufficient amount of gameplay that the player can go through during their quitting journey, therefore scalability was taken into account.

Figure 1 shows a screenshot of the final product (Appendix A).

#### *3.2.1 Evaluating the Implementation of the Game*

This game was originally designed to be a multiplayer game. However, due to technical difficulties and faulty equipment, it was not possible to run the produced game using the Photon Engine. Therefore, the game had to be built as a single player game to be tested.

Although the multiplayer aspect of the game was important to the engagement of the player, there were other elements such as the NPC that also contribute to engagement and therefore could compensate and maintain engagement.



### 3.3 *Testing*

The original plan for testing included a testing session where recruited players would be briefed on the purpose of the study, fill out the consent form (see Appendix A) if they agree to being involved, and then allowed to play the game. Players would then be encouraged to think aloud as they play; their thoughts would be taken note of and used to produce qualitative data about their impression of the game and any difficulties that they might have faced. Subsequently, they would be given a questionnaire to answer about the game (see Appendix A), which would be used to produce quantitative data specific to the criteria of CBGD elements in the game.

However, due to circumstances surrounding COVID-19, the interview section in testing had to be cancelled, and only the unsupervised questionnaire was used to test the usability of the game.

#### 3.3.1 *Evaluating Testing Methods*

No qualitative data will be collected from the players, meaning that there could be information that will be missed that could have been brought up by the player but not originally included in the questionnaire. In the future, Unity Analytics could be integrated into the game to compensate for that limitation, as well as assist in identifying players' behaviours and trends to identify what features are desirable.

The participants included in the study were students from the University of Greenwich. The sample size was (N = 12) which was a small sample size and not representative of the whole population. Despite that, it provides initial testing information that could be improved upon in a subsequent study.

The questionnaire utilised a 7-point Likert scale instead of the standard 5-point scale. This is due to the 7-point Likert scales being found more likely to produce results that accurately represent the participant's true evaluation (Finstad, 2010). A limitation to using the questionnaire mentioned is the presence of questions that rely on the player's impression alone. This issue could have been solved using Unity Analytics. For instance, instead of asking the player if they felt they wanted to play the game again, there would be data on the number of minutes or hours they spent playing to verify that.

### 3.4 *Improvements*

There are features that were not implemented into the game but could potentially have positive effects if they were. For instance, allowing the player to choose their avatar is a form of tailoring that could make the avatar more relatable to the player and increase their engagement in the game (Derksen *et al.*, 2020).

### 3.5 *Results*

The results of the questionnaire are displayed in Appendix A as a percentage of responses for each of the questions.

Despite the compromises made on the quality of the testing methods, the results mostly show respondents rated the answers to the questions between 5-7 (agree to strongly agree). This shows that the game implemented the majority of CBGD elements successfully.

However, for the question regarding the strength of the rewards in the game, 25% responded between 1-3 (strongly disagree to disagree). This suggests that the strength of the in-game rewards was not strong enough, and that they could be improved to more appropriately award and motivate positive behaviour.

## CHAPTER 4: CONCLUDING DISCUSSION

This chapter gives a summary of the main points of the dissertation, presents the research contributions made and discusses possible future research and development that evolves from the dissertation.

### **4.1 *Summary of the dissertation***

This dissertation investigated the efficacy of serious games in assisting with smoking cessation. This was achieved through analysing previous and recent literature about behavioural change in serious games.

Chapter 1 of this piece discussed the prevalence of smoking in recent years. It explored some of the psychological theories that are involved in the process of smoking cessation, which is a form of behavioural change.

In chapter 2, research was carried out to investigate how psychological theories had been previously used in serious games, and how effective they were. Results of the research showed that serious games have potential in causing behavioural change. Some of the gaps in previous studies were identified, one of which was the lack of use of a design framework. To address that, a serious game design framework, CBGD, was studied and used to design and develop a game for smoking cessation that can be tested further in future studies.

Chapter 3 discussed the development, testing and evaluation methods used for the creation of Squeaky Ways. Usability testing suggested that the game successfully produced the desired effects of the CBGD elements mentioned, there were, however, some improvements to be made to enhance the quality of the game and the effect it has.

### **4.2 *Research contributions***

The result of this project is a smoking cessation game designed using the CBGD model. Literature found covering serious games for smoking cessation are theory based but do not follow a design framework. This game addresses that gap, which means that in future studies it can be used to assess the efficacy of serious games in this field in relation to the elements of the design model used. Furthermore, if more games were to start using the same design model, the model could become the standard; making it easier to compare results from different studies. This could result in better identification of the factors that have the greatest effect on behavioural change in serious games.

Additionally, if a larger study was carried out to evaluate this game and prove its efficacy, the game could be used as part of smoking cessation plans that are organised by national smoking cessation services or added to health care plans.

### **4.3 *Future research and development***

The game produced for this project was tested for usability. Going forward, the results obtained from the testing can be used to improve the current state of the game. Due to the code being object-oriented, it will be easy for another person besides the original developer to make amendments to the game and scale it up.

This research can be taken further by carrying out a larger study that would test the efficacy of the game, rather than just its usability. Measures such as the QSU-brief mentioned previously, or carbon monoxide readings can also be utilised to produce

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objective results. Outcomes of such a study would be ultimately used to establish or reinforce standards for serious games' production and would largely support the serious games industry.

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## APPENDIX A: PRIMARY DATA COLLECTION METHODS

### A.1 Consent Form

I agree to participate in the study conducted by Fadwa Hasanin

I understand that participation in this usability study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study administrator.

Please sign below to indicate that you have read and you understand the information on this form and that any questions you might have about the session have been answered.

Date: \_\_\_\_\_

Please print your name: \_\_\_\_\_

Please sign your name: \_\_\_\_\_

Thank you!

We appreciate your participation.

*Table 2 The consent form that would be used before the testing session begins (U.S. Dept. of Health and Human Services, 2006)*



**A.2 Questionnaire**

	Questions	Rating (1-7)
<b>SCT</b>		
Goals	1. The goal of the game was clear.	
	2. I could extrapolate my actions in the game into my actions in real life.	
Outcome Expectations	3. My positive actions in the game were rewards accordingly.	
	4. My negative actions in the game brought about negative consequences.	
	5. The consequences for in-game actions are similar to real life consequences.	
Encouragement	6. If there were more levels of this game, I would play them.	
Barriers	7. The smoke clouds made this game challenging and not discouraging.	
	8. The time limit was challenging but not impossible.	
Self-efficacy	9. I felt confident I could win the game.	
	10. Playing this game was enjoyable.	
	11. The non-player character (NPC) in this game made it more relatable.	
<b>Enjoyment</b>		
Engagement	12. I felt immersed when playing this game.	
Challenge	13. The challenge in this game made me want to play more of it.	
Flow	14. Time passed by quickly when I was playing this game.	
Persistence	15. When I made a mistake in game, the feedback I received helped me advance in the game.	
Mastery	16. Winning this game gave me confidence that I can win a more difficult version of it.	

*Table 3 Questionnaire to assess CBGD elements in the game, with 1 representing strongly disagree, and 7 being strongly agree*

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	Questions	Percentage of Answers
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SCT		Rating (1-3) %	Rating (4) %	Rating (5-7) %
Goals	1. The goal of the game was clear.			100
	2. I could extrapolate my actions in the game into my actions in real life.		58.3	41.7
Outcome Expectations	3. My positive actions in the game were rewards accordingly.	25	8.3	83.3
	4. My negative actions in the game brought about negative consequences.		16.6	83.4
	5. The consequences for in-game actions are similar to real life consequences.		16.6	83.4
Encouragement	6. If there were more levels of this game, I would play them.	8.3		91.7
Barriers	7. The smoke clouds made this game challenging and not discouraging.		66.6	33.3
	8. The time limit was challenging but not impossible.			100
Self-efficacy	9. I felt confident I could win the game.			100
	10. Playing this game was enjoyable.		16.7	83.3
	11. The non-player character (NPC) in this game made it more relatable.		33.3	66.6
Enjoyment				
Engagement	12. I felt immersed when playing this game.		58.3	41.7
Challenge	13. The challenge in this game made me want to play more of it.		33.3	66.6
Flow	14. Time passed by quickly when I was playing this game.			100
Persistence	15. When I made a mistake in game, the feedback I received helped me advance in the game.			100
Mastery	16. Winning this game gave me confidence that I can win a more difficult version of it.		8.4	91.6

*Table 4 Results of questionnaire in percentages*

## APPENDIX B: IMAGES



Figure 2 Screenshot of Squeaky Ways where the player is interacting with an NPC, there is a dialogue screen visible, as well as the progress bar and the timer. UI assets obtained from Lynda Mc Donald

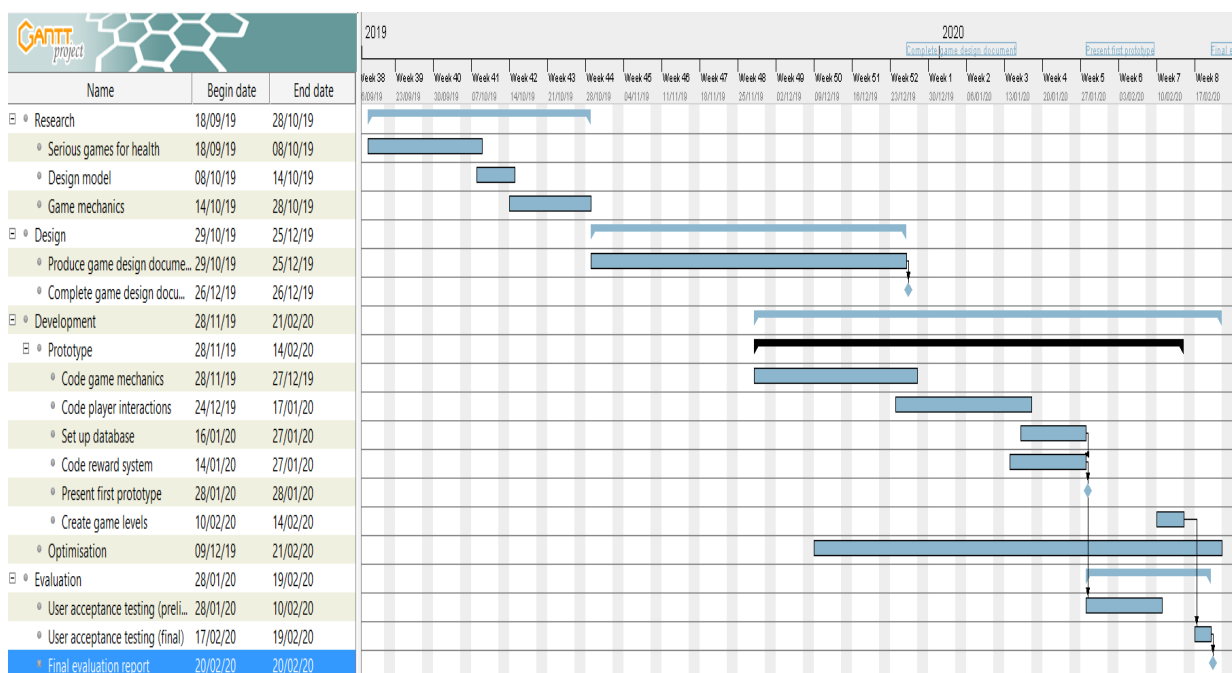


Figure 3 Gantt chart showing milestones in the development process that uses Personal Extreme Programming