Using interactive interfaces to assist with smoking cessation

Creative Technology
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Abstract

Smoking is the main cause of noncommunicable diseases worldwide. Smoking causes a lot of irreversible damage in all age groups. Therefore it is essential to reduce the current smoking population. Luckily, the development of innovative interactive user interfaces has opened new possibilities to assist in the future cessation for tobacco users. By using interactive interfaces, users can be more actively engaged with their cessation method. Integrating cognitive behavioural change techniques within interactive interfaces has resulted in a new method to assist smokers with cessation. In the context of this graduation project, an interactive and tangible solution was developed to assist with behaviour change targeted at smoking cessation. The challenge lies in making a product that challenges smokers in terms of engagement, so that the user does not feel the urge to relapse. The graduation project focuses on the development of a possible solution. A user centred design approach was used to develop a game that uses behavioural techniques to assist the user to stop smoking.

The results of this graduation project take the things that work from existing cessation methods and combine them into a final tangible product. This field was not previously explored as a tangible design and therefore showed potential as a new method of smoking cessation. The user evaluated design was well received by the participants.

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Acknowledgements

I would like to take the start of this report to include a section of gratitude towards the people that assisted with the project. This mainly concerns my supervisor, Champika Epa Ranasinghe. Her guidance has steered this project towards completion.

I would additionally like to thank all of the participants that helped me conclude the user studies. All of the participants have contributed in their own way, helping me to create a finalised version of the product and the report.

Chapter 1 – Introduction

Currently, non-communicable diseases (NCDs), which are diseases that are not spread through other people, cause 41 million deaths every year according to the World Health Organization (WHO). [28] This makes NCDs the leading cause of death for most of the earth's population. NCDs like cancer, asthma or cardiovascular diseases are hard to cure, but can often be prevented.
The main causes of NCDs can usually be led back to the lifestyle of the affected person. Various cancers are more often found with regular smokers, and cardiovascular diseases can be linked to a consistent unhealthy diet.
The WHO estimates that tobacco use results in over 8 million deaths yearly. [29] Whilst some efforts to reduce smoking habits have shown to be effective, like the implementation of vile images on tobacco packaging, they are also prone to issues like banner blindness. [30] Other methods of assisting smoking cessation have also shown variable success. Pharmaceutical solutions are prone to side effects and users often relapse after stopping treatment. Smoking alternatives like vaporizers and e-cigarettes expose the user to toxic chemicals and there is no evidence that supports that they can be used as long-term replacements. [2]
Government practices are actively trying to reduce the amount of people that start smoking, specifically targeting the younger audience. For instance, The United Kingdom has implemented a ban on tobacco products for people born after 2009. [31] Supermarkets across the European Union have stopped selling tobacco products as well, making them inaccessible for a larger audience. Whilst these methods are effective for newer generations, they ignore the current smoking population. There is clearly a need for new ideas within this field, as only 1 in 10 smoking cessation attempts are actually successful.[1] The first part of this research explores why current methods are ineffective, and what factors should be taken into account when developing a new cessation method.
A relatively unexplored field of tackling the topic of smoking cessation coincides within Human Computer Interaction (HCI) Research. Cognitive behavioural therapy can help to successfully quit smoking. By altering the habits of the user, rather than completely removing existing habits, the user is trained in self efficacy and is less likely to relapse.
By providing behavioural change techniques with interactive interfaces, this graduation project explores the potential of emerging Interactive User Interfaces in smoking cessation, by producing a prototype. This helps to answer the research question: "How can interactive user interface technologies be implemented to assist smoking cessation among adults?"

Utilising user centred design and behavioural change techniques, a prototype was constructed specifically targeted at assisting smoking cessation. Combining techniques such as goal-setting, contingency management and stimulus control into one easy to access device was done via gamification.
Gamification combines factors that are engaging for users, as well as effective in triggering reflective moments for smokers. The user can use the device as a substitute for smoking, whilst keeping track of their set goals. The device helps with self efficacy and rewards the user for reducing their current toxic habits. Gamification allowed the product to become adaptive for different users, whilst keeping a high engagement and immersion factor. The device was user evaluated using the User Experience Questionnaire and generally well received. Further development of the product could lead to a new aid for smokers in cessation. A user evaluation where the product would be used over a prolonged

timespan would have to be conducted to test the effectiveness of the design, but this was not feasible within the scope of the project.

Chapter 2 - Background Research

The background research of this graduation project has several purposes. The first part of the literary research was conducted to discover what makes existing cessation methods effective or ineffective. Researching why certain methods, such as vaporisers, appeal to smokers can provide insight into making an engaging device targeted at smokers. Additionally, the techniques that result in a successful cessation should be adopted into a final prototype. The other parts of the background research are related to the design process for an interactive interface. Main aspects defined to produce a successful interactive interface for smoking cessation are user engagement and user reflection. A literature review was made about these topics to assist the production for the concept designs. Lastly, behavioural change techniques were analysed that could be used in the development of a prototype.

2.1 Existing smoking cessation methods

The research on existing smoking cessation methods is relevant for two different reasons. Firstly, it is state-of-the-art research into smoking cessation. It acknowledges the benefits and flaws of current cessation methods, which can be implemented into the future design process. Secondly, it provides an answer for the first research question, discovering why current methods are often not successful.

Defining current cessation methods

By analysing several papers, 4 main methods of tobacco cessation were found. The most attempted cessation method is based on will power and self-efficacy. This shall be referred to as an unassisted cessation method, also known as stopping cold-turkey. As it is the most predominant method of smoking cessation, it is also the most successful (most successful cessations come from this method). However, the effectiveness of unassisted smoking cessation is found to be rather low. This nation-wide study in Germany concluded that 95% of unassisted cessation methods are unsuccessful within the scope of 12 months within Germany. [1]

The paper continues to mention other cessation methods. In their user study they concluded that the usage of pharmacological solutions, namely Nicotine Replacement Therapy (NRT) can function as a potential intervention strategy.

Pharmacotherapy

Daniel Kotz mentions that NRT was the relatively most commonly used single, evidence-based, method for smoking cessation. NRT is mentioned in other systematic reviews of smoking cessation. [2] NRT works by administering nicotine to the user in a delayed timeframe. The desired effects of NRT assist the body by fighting withdrawal symptoms. Additionally, NRT stops cravings amongst smokers as the user is no longer in need of nicotine. NRTs come in different variants, appealing to a wider audience. This includes nicotine patches, chewing gum, tablets and pills, gums. [3] Some other methods can be used to administer nicotine, which operate in a similar manner. NRTs increase the rate of quitting by 50 to 70%, regardless of setting. [4]
There are some health-related risks to the usage of NRTs, namely skin irritation from nicotine patches and irritation near the mouth from gum usage.

Other forms of pharmacotherapy include prescription medicine like varenicline and bupropion. These methods also aim to fight withdrawal symptoms and nicotine cravings by altering dopamine, serotonin, and adrenaline levels. [2]

It is noteworthy that researchers have suggested that conclusions about the effectiveness of cessation medications may be the result of systematic biases. [5]

Furthermore, when users are incorrectly informed about the usage or dosage of pharmacological solutions, they are more likely to relapse into smoking behaviours.

Electronic cigarettes

Since 2013, the usage of electronic cigarettes has seen a large increase. [6] Electronic cigarettes such as vaporisers and JUULs have been gaining popularity, especially among young adults. The usage of electronic cigarettes is relatively new as a means of tobacco cessation. Similar to NRT, electronic cigarettes use nicotine to assist in coping with withdrawal symptoms. Furthermore, using an electronic cigarette simulates the same movement as smoking. Therefore, users that attempt to quit smoking using electronic cigarettes can retain their smoking habits, whilst inducing fewer toxic chemicals associated with tobacco. Over time, nicotine levels can be phased out. However, research is unsure on the effectiveness of the method. Some researchers suggest that there is serious potential in the usage of electronic cigarettes for smoking cessation, one claiming over a 100% increased chance of successful cessation. [7]. Other researchers are more sceptical, as the adverse effect from using vaporisers is not well researched. [2, 4] As the behaviour of a smoker is not altered by the cessation method, users are likely to return to smoking if they quit using electronic cigarettes. Other research also suggests that smokers are likely to retain their smoking habits, alongside the usage of electronic cigarettes. [8]

An unintended repercussion of electronic cigarette usage is the appeal to a younger audience. Research is indecisive but suggests that users exposed to electronic cigarettes are more likely to pick up smoking in the future. [2] Nevertheless, the usage of electronic cigarettes remains one of the most common approaches to smoking cessation. The German study [1] even indicated it to be the most used non-evidence based smoking cessation strategy, with over 10 percent of the research population using it.

Behaviour Therapy

The aim of behaviour therapy is to achieve a cognitive change amongst smokers which helps them quit indefinitely. There is no one method that works for all, as the cognitive therapy methods used alters per user. Some instances of behaviour therapy include talking groups, 1 on 1 sessions with physicians, or staged based interventions. Furthermore, behaviour therapy can focus on different aspect to assist smoking cessation. [2]

Changing modality, which refers to mood-related behaviour patterns, can be done by a multitude of aspects. For some, goal setting might be effective, whilst for others it is important to alter existing routines. Some of the goals of behaviour therapy for smoking cessation include: learning coping skills, managing cravings, how to deal with relapses and how to promote self-efficacy. The intensity of the therapy is in direct reflection with the population that is willing to use it. Whilst intense feedback sessions and smoking regulation is shown to be most effective, it also scares people. ‘It is too hard to quit’

This has led to self-therapy sessions, or programs. These programs don’t involve professional counselling but do give feedback to the user, whilst being proactive. [9]

Some research done on behaviour therapy does suggest that there is an increased success rate. This English study found over a 34% success quitting rate with certain approaches using behaviour therapy. [10] However, the lack of a control group due to a loss in cases in the long term research leads to insignificant evidence as a long term solution. Researchers agree that more research needs to be done on cognitive behaviour therapy, and efficacious smoking cessation interventions are needed. [11]

Whilst there is evidence that altering cognitive behaviour therapy contributes to smoking cessation, reaching this point is a lengthy and hard progress. The methods are often too intense, and emotionally draining. These skills learned in behaviour therapy are often hard to acquire, off-putting and challenging for a smoker that wants to stop. Having an active approach towards quitting and failing to do so due to cravings is one of the main reasons that people relapse.
Either behaviour therapy is not direct enough and causes people to relapse or it is too intense, causing users to quit the therapy.

Alternative methods

There are other methods of smoking cessation which are worth mentioning but have not seen significant evidence of an increased success rate. Most commonly, exercise is mentioned. An example of this is the act of breathing exercises. When performed instead of smoking, the user gets their moment of relaxation without inhaling toxic chemicals. It is considered an alternative method, but it contains aspects of behaviour therapy, by breaking regular smoking habits and training the brain to perform a different action.
Other methods also include acupuncture and hypnotherapy. These methods have no significant evidence of assisting with smoking cessation.

Conclusions

Nicotine replacement therapy is the most researched method of smoking cessation, which increases success rates by around 60 percent. Note that this is an increase from 5 out of 100 study participants to 8 out of 100 over a period of 12 months. Success rates are still extremely low, due to the high chance of relapse and a lack of cognitive change amongst users of NRT. Electronic cigarettes have similar results to NRT, but research is indecisive about the adverse effects of them. Cognitive behaviour therapy is more effective but hard to achieve and unappealing to the general smoker audience. It is hard to determine the exact effects of behaviour therapy. Unassisted smoking cessation by means of self-efficacy remains the most appealing method.

Below you will find a table based on German research.

Method	Appeal	Success rate over 12 months
Will power	59.7 %	5 %
Pharmacotherapy	8.2 %	8 %
e-cigarettes	10.2 %	5-10%
Behaviour therapy	6.9 %	5-34 %

Fig 1. A table that represents the appeal and success rate of different smoking cessation methods

Do note that a short intervention/ advice from a physician is already considered as behaviour therapy within this study. Success rate in talk groups or assisted smoking remission can go up to 34%, but the effective success rate cannot be determined. E-cigarettes are a relatively new invention and have not yet been fully observed in terms of the effectiveness for smoking cessation. Behavioural change is required in order to prevent the user from relapsing.

2.2 Designing a new interactive interface for smoking cessation

Following the analysation of the existing smoking cessation methods, it can be concluded that there is a need for new inventions in the field. The challenge lies in inventing a method that both appeals to the population that wants to stop smoking and has a high success rate. There is some potential in the field of HCI for mental health using cognitive behaviour therapy. [12]
However, research specifically altered to smoking cessation in the field of HCI mainly focuses on mobile app development. [13]
In this study, a user study of 1271 participants was conducted over a period of 6 months where they found that optimising accessibility is beneficial for the usage of web-based smoking interventions. Other explorations in the HCI field include virtual reality to assist with smoking cessation. [14] Whilst some early research is done, few can be said about the effectiveness.

From the literature research on behaviour therapy, it can be concluded that new inventions in efficacious smoking cessation by means of assisting cognitive behaviour change is needed. Effective existing HCI research on the topic focuses on mobile and web-based interventions. These interventions are prone to banner blindness, as digital environments become unappealing or non-immersive. In order to successfully design an interactive user interface for smokers that want to attempt smoking cessation, the installation must be engaging. Additionally, to assist a successful cessation attempt, the user needs to be provoked to reflect on their smoking behaviour.
To accurately develop an interactive interface for smoking cessation, the key factors of engagement and reflection were analysed. This is done as the user needs to want to interact with the device on a level that is compatible with smoking, whilst being motivated to reflect on their smoking behaviour.

Engagement is defined as the maintained perceived connection of the user between the device. High engagement factors relate to the urge of the user to interact with the device, and to when the user chooses to stop interacting with the device. [26]
In order to keep the user engaged with the device, usability must be ensured. The product must be reliable and dependable. If the device is non-consistent in its interactions or malfunctions, users are less engaged. Another important factor on engagement relates to the adaptability of the device. While unintended changes to the device can worsen the engagement, there needs to be some change in the interaction in order to prevent boredom and repetitiveness. The device should create a desirable user experience for different users. One way in which this can be achieved is by inspiring fun. Creating visually appealing experiences for the user by interacting with the device is a great way to maintain attention and engagement. Aesthetics play an important role in the willingness to interact with the device. [27] Most of these factors wish to immerse the user into the environment of the device. By making the user less aware of current surroundings or issues in their life, specifically targeting smoking, the user becomes more engaged with the device. It is important that the user does not run out of interactions with the device. This can be achieved by enabling progression and exploration in the device. If the user has a goal to work towards, that furthers the interactivity of the device, the user

is likely more engaged and motivated to interact more commonly with the device. The last factor of engagement relies on social connectedness. If a user has the ability to share their progress with others, they have more motivation to outperform and compare themselves with others. Social connectedness can increase engagement by achieving certain goals in order to receive pride.
Reflecting on smoking behaviour is a critical aspect of cessation efforts, as it enables users to understand their habits, motivations, and the consequences of their actions. Various factors can facilitate this reflective process, encouraging individuals to gain insights and make positive changes. The most important factor in triggering cognitive behavioural change in users is reflection. Four main factors were identified that can cause reflective moments for the user.

The concept of temporal perspective involves using time-related elements to facilitate reflection. By considering past, present, and future contexts, users can gain a comprehensive understanding of their smoking behaviour. Utilising the data entered into the device allows users to reflect on long-term patterns and issues related to their smoking habits. By tracking personal data over time, users can have revelations about their behaviour, leading to more effective reflections on the past.
Reminding users of past events related to their smoking can also trigger reflective moments, helping them to recognize patterns and the impact of smoking on their lives, by remembering the past .
Alternatively, messages for the future self or predictions based on current behaviour can motivate users to consider the long-term consequences of their smoking, encouraging proactive steps toward cessation. Lastly, the action of smoking can be delayed in order to create a moment of reflection rather than immediate gratification from smoking a cigarette. Forcing a short pause can result in the user thinking about their actions,making them more aware of their smoking behaviour.
Conversations with others can significantly enhance reflective thinking about smoking. Having a conversation about current smoking habits allows the user to form new perspectives, find encouragement, and share experiences with others.
Simulated conversations with technology can achieve the same goal as normal conversation, by helping the users to reflect on their current behaviours by prompting them to consider appropriate actions and the implications of their smoking.
Similarly to conversation, comparison can place the user's smoking behaviour in a broader context. A social comparison allows the user to reflect on themself with others.This shows the users how they measure up against their peers in their cessation attempt. This can be motivating, as users can see how long-term adjustments have positively impacted others, encouraging them to continue their efforts. An absolute Comparison can be made by comparing their current situation with an ideal scenario. Users can see how far they need to go to achieve their goals using an interactive interface. Feedback and visualisations, such as status bars, can inform users of their progress, highlighting areas for improvement and celebrating achievements.
Finally, elements of discovery can stimulate curiosity and provoke thought, leading to deeper reflection of the user. Most importantly, the ambiguity of an interactive interface can result in a meaningful reflection. Data represented in unique or ambiguous ways can prompt users to think more deeply about their smoking habits. This ambiguity can lead to a more personal and meaningful interpretation of the data. Art and technology also provoke a reaction that can disrupt habitual thinking patterns, encouraging users to consider their smoking behaviour from a new perspective. Lastly, physicalizing data in novel ways can reframe how users see their smoking habits. By presenting information differently, users can gain new insights and open up to reflective thinking.

By integrating these factors into a tangible device for smoking cessation, users can be encouraged to reflect deeply on their smoking behaviour. This reflection is crucial for understanding the underlying motivations and consequences of smoking, ultimately supporting more effective cessation efforts.

2.3 Cognitive behavioural therapy and behavioural change techniques

As was mentioned in the behavioural change section of this chapter, therapeutic sessions are not very popular amongst current smokers. There is a large commitment attached to starting a therapeutic approach towards smoking cessation. However, if the user successfully completes a cessation attempt based on behavioural change, they are less likely to relapse, as their behaviour has changed. The main benefits of cognitive behavioural change are unfortunately also its biggest downfall. A personalised approach requires a deeper understanding of the individual that is attempting to quit, to adapt and create realistic goals for the user.

However, within gamification it is possible to hide elements of behavioural change techniques. Here, some of the most important behavioural change techniques for smoking cessation are discussed.

Goal setting

Goal setting is the most obvious method of behavioural change. Setting a goal for the user to achieve provides a motivation to continue working towards the goal. Goal setting in relation to smoking usually relates to setting a date where the user completely stops consuming tobacco products. Goals can be user specific, as some users wish to reduce particular habits. Goals could also relate to self efficacy, control over cravings or social environments. This method can be implemented within gamification. User specific goals can have a linear progression with the game. Doing this provides an additional motivation for the user to complete their goal. Achieving their goal would also complete the digital environment. As goal setting is easily implemented and effective for smoking cessation, it is an essential behavioural change technique for this project.

Contingency management

Contingency management refers to a type of behavioural therapy in which individuals are ‘reinforced’, or rewarded, for evidence of positive behavioural change. [25] Rewarding the user for performing well is a technique that is already used to treat substance abuse. Punishing the user by resetting current progress made within a gamified context can be an effective method for the user to be motivated towards not smoking. In turn the user would be rewarded for having good self control. Rewards in a game can be achievements for reaching certain landmarks and goals, or other resources that can be exchanged in game. Alternatively, physical rewards could be provided to the user, or gift cards could be distributed on completing the cessation attempt. Another benefit of contingency management relates to regulation. If the user is regulated by means of rewards, it is easier to regulate smoking behaviour.

Stimulus control

Stimulus control refers to the effect of objects on the behaviour of the user. For example, a red light at a traffic intersection does not force the user to stop, but does encourage the user to do so. Similarly, the presence of a tracker or a game can influence the decision of the user to smoke. The presence of

the tangible device can cause reflective moments for the user, which is a key part in the successful cessation of the user. This is of huge importance on why the user of the device should be tangible, and not be app-based on a mobile device.

Substitution

Lastly, the device should function as a substitution for smoking. Typical behaviour in terms of substitution can be found in eating or chewing gum. It is a common practice to replace smoking with some other habit. When the user is tempted to consume a tobacco product, they should be prompted to reach out for the device. This promotes a positive lifestyle and slowly eases the user into replacing and reducing their nicotine intake.

Chapter 3 – Methods and Techniques

For the development of an interactive interface for smoking cessation, this graduation project uses the Creative Technology design method [15]. This method developed by Angelika Mader and Wouter Eggink uses a combination of divergence, convergence models and spiral models. By defining a clear design space accessing them correctly, reiterations of products become effective at their desired use case. By using a clear design process, a coherent structure can be followed leading to the production of a functioning prototype. The creative design method can be found in appendix D.

There is an emphasis on the design process for CreaTe, where the method is divided into four different phases. By converging and diverging in these different phases, one final solution was reached. The first phase is defined as the *ideation* phase. The most important part of this phase is the definition of the selected problem and doing research on it. This can be literary research or by means of observation of user needs. When relevant knowledge is collected on the topic, rough ideation can begin in the form of sketches, mock-ups, storyboards or prototypes. Using technology as a starting point, the ideation phase aims to come up with creative solutions for stakeholders. When a preferred prototype is selected the ideation phase shifts into the next phase.
For this graduation project, brainstorming was utilised after conducting a literature research. The project used a user centred design approach. After the brainstorm was completed, a user study was conducted to discover what methods needed to be implemented in the final design. This allowed a list of requirements to be made.
In the second *specification* phase, prototypes of the selected idea are produced and reiterated. By using an evaluated feedback loop, prototypes are tested and perfected. At the start of this phase bigger alterations can be made, and as feedback is implemented, small changes are made. At the end of this phase, there is a clear specification of the desired prototype and product development can begin. In this graduation project, the specification phase starts by gathering a list of materials needed for the product. Having an overview of hardware and software that needed to be developed created a strong start for the third phase.
In the third phase, *realisation,* the product specification is used to create a working product. Electrical components, 3D-prints and other design elements are implemented and engineered. The product should work correctly, and the specification requirements should be met. In the final phase of *evaluation,* the product will be tested and reviewed. Making sure that all requirements are met and implementing user feedback wrap up the CreaTe design method.

This graduation project needs a strong design method in order to be completed successfully. The ideation aspects needed to be scientifically sound to lead to a successful specification phase. Without proper research, a prototype would not appeal to smokers or would not be successful as a cessation aid. To furthermore aid the ideation process, a user study was conducted to eliminate bias and validate the specifications. In the specification phase, the most important data from the ideation phase was processed. Using feedback is useful in the production of a first prototype, after which user testing and evaluation can begin. It is likely that the prototype will be reiterated multiple times before a final product can be produced. This report however focuses on the potential of a tangible interactive interface for smoking cessation and does not require the final product to be completely foolproof . A second user test was conducted using a Likert scale, in order to reflect on the usability and requirements of the produced prototype. The UEQ method was used to create a final overview on the

topics of efficiency, attractiveness, perspicuity, dependability and stimulation. The long term effectivity cannot be tested in the length of the research.

Additionally, some methods and techniques from existing HCI research can be applied to the graduation project. Some research has been done on the use of co-design in health data representation. [16-17] Elements of this co-design were used in the specification and realisation phase, specifically in the form of a co-design session, where advice from experts was implemented into the design.

Lastly, as the design is aiming to achieve behaviour change, methods from this paper on behaviour change methods in HCI [18] were used. The paper suggests that existing HCI methods aimed at behaviour change specifically target the present, while behaviour is commonly more intertwined with personal values and existential models. In the specification phase these techniques will be analysed and implemented into the product design.

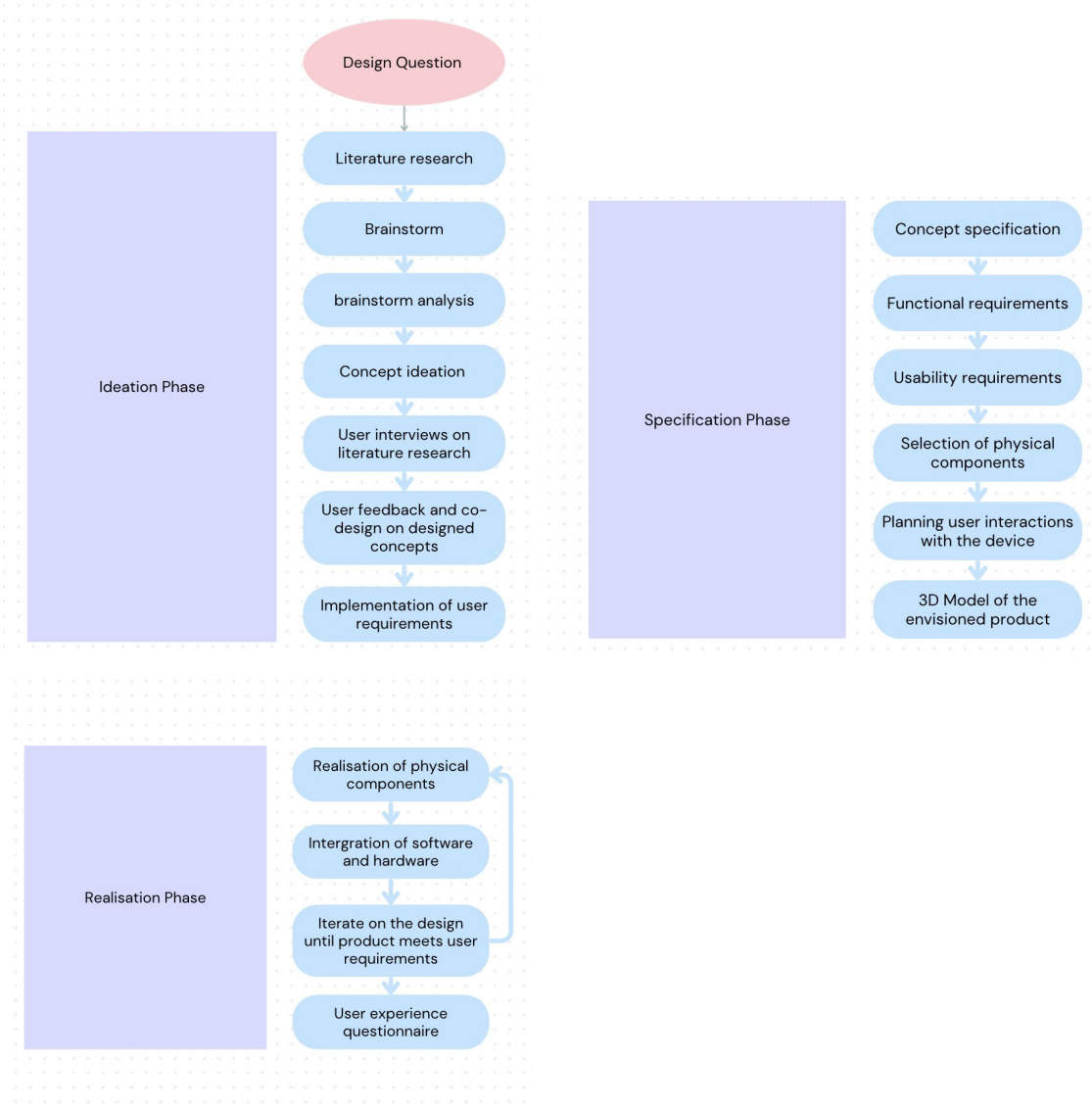


Fig 2. The adapted Creative Technology Design Process for this graduation project

Chapter 4 – Ideation

In the ideation chapter, several steps are taken to start the development of a product that assists with smoking cessation. By reiterating, designing and brainstorming ideas, based on literature research, a blueprint is made for a successful product. This chapter provides a problem statement, which the developed product is trying to tackle. The process of developing a product is described, as well as the involvement of stakeholders in the development process. All the collected information from this chapter is used in the specification of the product.

Problem statement

A clearly defined problem statement is necessary in order to develop a product that is effective in tackling the problem at hand. Furthermore, it has helped to set a realistic outcome of the product and answer the research question. The problem statement takes into account the feedback that was given by the users and the literature review.

Firstly, it is important to note that the product has to be designed to assist smoking cessation, and thus is aimed at users that are actively trying to quit their tobacco usage. The product does not have to be an incentive to motivate users to start their cessation. From a design perspective, this means that the product's priority is not to attract users to start engaging with the product, but to maintain the user's engagement level whilst using it. Because the engagement with the current cessation methods is relatively low, designing in a way to immerse the user is more important.

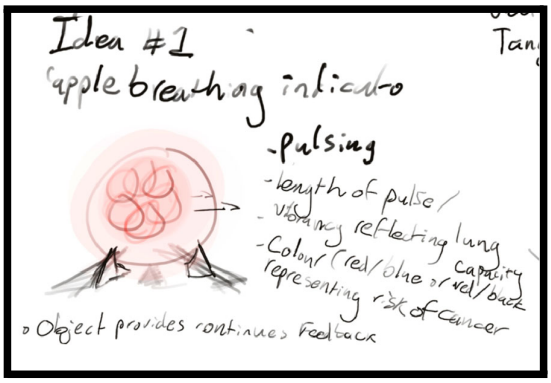
Secondly, out of the studied cessation methods, behavioural change techniques have shown the highest potential. Therefore, it is important to implement them into the product design. The product must have a long lasting impact on the user. Re-usabilty also plays a role in the design, as the user should be tempted to use the product over potentially relapsing to smoking. The device should be intriguing to use while trying to quit smoking, and easy to pick up when the user is relapsing.

Lastly, the device must be tangible in order to appeal to users. The user study indicates that there is little interest in a digital solution, as digital environments are prone to banner blindness and heavily impact the engagement of the user on the product. One of the participants mentioned: "I would probably be smoking a cigarette while updating my digital smoking profile". It is thus important that the interaction with the device must replace the action of smoking. A physical representation of data is more impactful.

The goal is to create a tangible device that assists smokers in their attempt to quit smoking, by using behaviour techniques in an immersive environment.

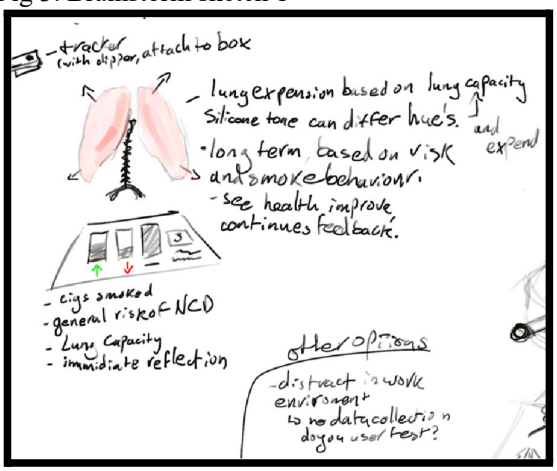
Brainstorm

The second step of the ideation phase is described as the initial concept design. Based on the literature research, several concepts were designed. These concepts try to combine existing behaviour change techniques, whilst being engaging for current tobacco users. The initial ideas were based on a brainstorming session, where no ideas were immediately rejected. The end goal of this brainstorming session was not to come up with a final concept, but to discover why certain ideas would be rejected. This would help to create a list of requirements. From there on, new ideas could be developed.



Idea 1 represents an orb which would be stationed at an office environment. The orb would pulse, reflective of the user's smoking behaviour. This idea was later on revised and used in the concept development.

Fig 3. Brainstorm sketch 1



Idea 2 is an interactive interface that represents the user's lungs. It would track the user's current lung health and represent it by colouring them in darker tones. The display would be interactive to view how the user's lungs would develop if they were to keep using tobacco products. The idea was later rejected as the installation would be too vile for users. Whilst the idea showed some potential, users were not interested in long term interaction of such a device.

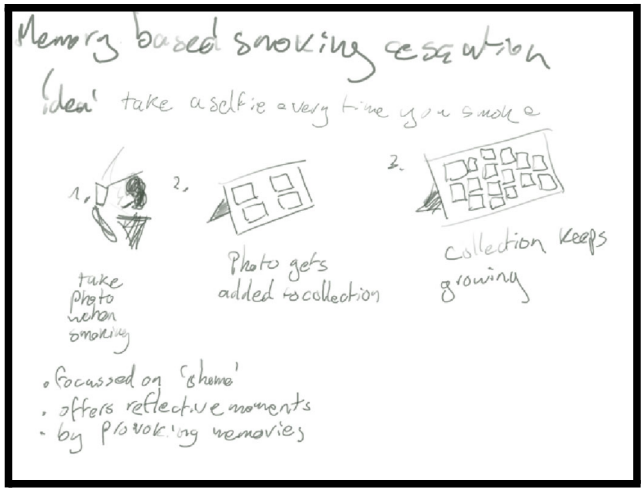
Fig 4. Brainstorm sketch 2

Idea 3 is an interactive ashtray that would display negative facts about your smoking behaviour if it saw the ashtray being used. The idea was rejected as users would be discouraged to use the ashtray and data could easily be skewed. The user would also need to be smoking in order for the product to function, contradicting its main goal.

Fig 5. Brainstorm sketch 3

Idea 4 was a clip-on device that would be attached to cigarette packages. It functioned as a tracker and would display lung health and smoking patterns to the user. It was rejected as it was perceived as a chore, whether then being an effective aid. It was too impractical and inefficient.

Fig 6. Brainstorm sketch 4



Idea 5 was an interactive display connected to a mobile device. Whenever the user would smoke, they would have to take a picture. The picture would be displayed at home. The display would cause the user to reflect on their smoking behaviour.
It was rejected on the potential for misuse and human error.

Fig 7. Brainstorm sketch 5

Reiteration of initial concepts

Out of the first concept designs, only idea 1 was developed further. After analysing what factors are important to smokers when trying to quit tobacco usage, a list of requirements was made. Three final concepts were developed from the list of requirements. In order to validate the interest in these concepts, a user study was conducted. This user study had multiple purposes. The users had to select their favourite concept in order to eliminate bias, and find an idea that works for the largest audience. The users were also asked to provide new ideas and variations, based on the concepts presented. This method takes elements from a co-design session, as feedback was later implemented into the final reiteration of the product.

Concept 1

As a continuation of the first developed idea, concept 1 builds on negative reinforcement learning in order to reflect on smoking behaviour. The installation would build up tar around the edges as a representation of the state of the user's health. As the user would smoke more, they would be met with a negative representation within the statue. This would help to trigger reflective change..

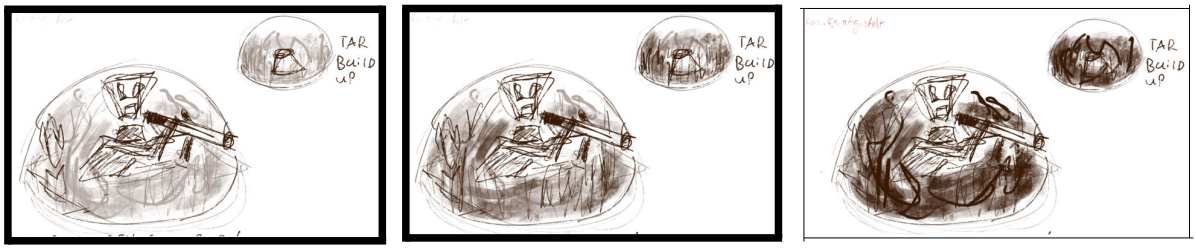


Fig 8. Drawings of concept 1

The installation would use a tracker to inform the device on the user's smoking habits. If the user was doing better, the system would reflect that. It uses adaptability and immersion as methods of engagement. It is adaptable as the user can see the environment of the device change, in direct correlation with the user's own usage. It uses temporal perspective as a method of reflection. Data collected about the user's smoking habits would impact the device on a daily basis, which allows for a daily overview and reflection for the user.

The idea was brought into user evaluation, where participants mentioned that they would be discouraged in using a tracker when applied to negative reinforcement learning. 8 out of 14 participants indicated that they would be prone to either forgetting or tampering with the tracker, as they would actively be punished for smoking. This ultimately led to the conclusion that a tracker is not attractive to smokers. Users also indicated that this design would be extremely confrontational. Confrontation is effective in motivating a tobacco user to start cessation, but that is not the goal of the design. Some users mentioned that they would not know where to put such a device, as they would be ashamed of it. On the one hand, putting the device in a personal space makes it prone to banner blindness and it can be easily ignored. On the other hand, putting the device near a smoking spot would be ineffective, as the device would then primarily be used whilst smoking.

From the user study this concept seems to have potential for users. If the users benefits from constant confrontation and could utilise the concept by getting a reflection on their temporal perspective, the concept shows potential.

Two out of fourteen participants choose this option as their favourite.

Concept 2

The second concept was developed based on the potential of social connectedness as a means of engagement. By implementing a social aspect into the smoking cessation process, it motivates users to open up and talk about their smoking habits. This method would assist users to share their cessation progress and potentially encourage others.

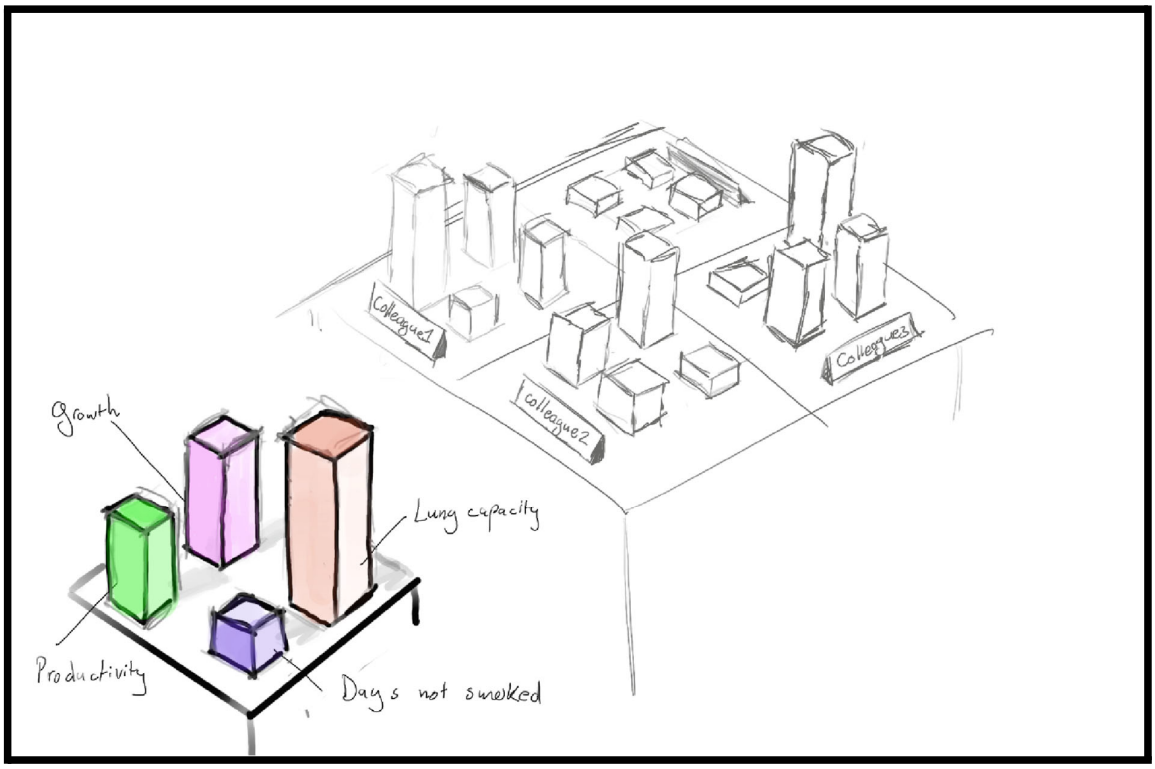


Fig 9. Drawing of concept 2

Concept 2 is an installation that would be put into an existing smoking area. The device would track the user's smoking habits by accessing the area. This could be done in an office-like environment by connecting the accessibility to a company card. The installation itself is a large elevated space, which is divided into several quadrants. The buildings on the installation represent the user's smoking statistics. For example, one pillar could represent money saved by not smoking, whilst another could track how many days the user has been successful in cessation. The concept compares the user's progress with that of colleagues, encouraging people to start cessation, talk about their progress and compete. The user reflects using comparison, conversation and temporal perspective. The latter is done by reflecting data on the pillars, which changes from day to day basis. The installation is engaging in the aspects of social connectedness and ensuring usability. It would mainly be effective within the premises of the office, as in order to access the smoking area, the user would be forced to partake in the concept. However, the installation does encounter several bottlenecks.

The first issue addressed with this concept would regard anonymity and enforcement. By providing the installation in a work environment and limiting access to the smoking area, you enforce the users to interact with the installation.

Ethically, there are a few problems with this concept. In the presented scenario, users have to choose between getting their personal data gathered or to not smoke on the premises. This is not something that would be highly praised by employees. Moreover, if the data is collected, how can it be anonymised? One of the main goals of this installation is to start conversation and compare the user's progress to others. User's should have the right to not share this information with others. As the installation would only track habits on the premises, the data is also not necessarily an accurate representation of the user's smoking habits. As an example, some users might smoke more while on the premises to cope with stress, whilst others smoke more in a non professional environment. This could lead to misleading data represented in the installation. The installation is also rather prone to bad actors, as the nature of the installation is competitive. If the data is shared among all peers, user's

would also be tempted to exploit and skew the statistics, in order to have better results. In the user study, one participant mentioned that they might try to get ‘the highest tower’ by smoking as much as possible. While the target audience, users that are explicitly trying to stop smoking, could benefit from this installation, other parties might misuse it.

In the first user study, there was a discussion on this design with an expert in the field that saw much potential in the concept in the catering industry. If co workers collectively decide to reduce smoking on the premises and are actively competing with each other, the concept would work in theory, by achieving the goals in terms of engagement and reflection.

The idea was liked among the user tests, but not the preferred method. Participants noted that it could be effective if implemented by a company, but all users must actively work on their smoking cessation. Data cannot be tracked outside of the work environment. Three out of fourteen participants preferred this method over the others.

Concept 3

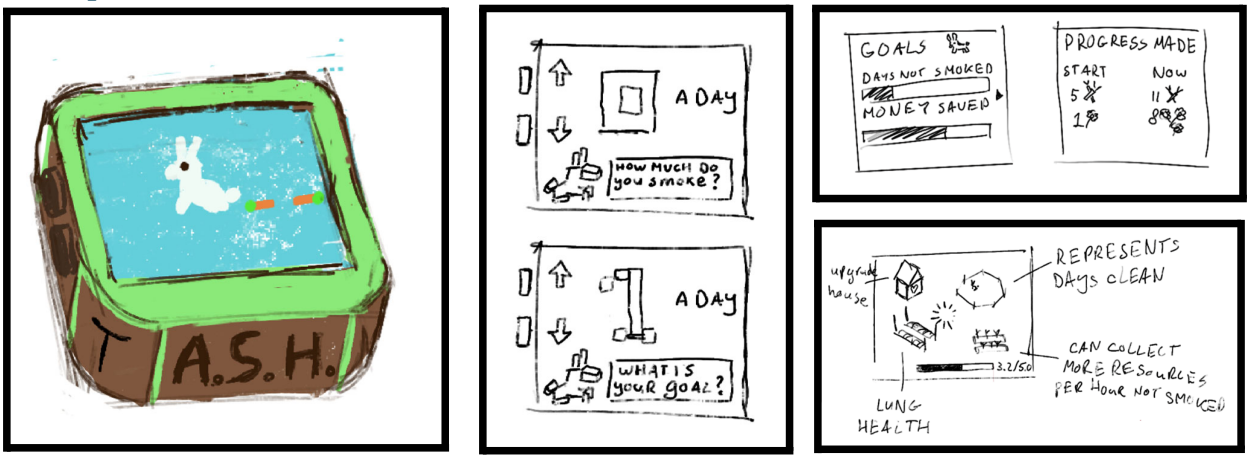


Fig 10. Initial drawings of the final concept

Concept 3 implements gamification into tobacco cessation. It is a device that would be used when the user intends to smoke. The main benefit of this device is the replacement of the action of smoking with another activity. It functions by implementing behaviour change methods such as goal setting into a gamified setting. The high engagement factor of video games provokes users to interact with the device. This, alongside its portable design, ensures usability and creates immersion. A great benefit of a digital environment is the adaptability to the user and the software. Software updates could easily be implemented so that the user is entertained and keeps returning to the device. It is adaptable as the user determines its own goals, and gameplay changes accordingly. By completing these goals, the user would improve its digital environment, with the end goal being a complete tobacco usage stop. The concept tries to alter the behaviour of the user by inspiring fun. Exploring the digital environment and watching it grow and evolve alongside the users smoking habits causes the concept to be extremely immersive.

To avoid the problem of the user potentially smoking alongside using the product, the gameplay must directly intertwine with the user's smoking habits. The initial naming of this concept, (T.A.S.H. - To Assist Smoking Habits) is to target smokers specifically.[1]

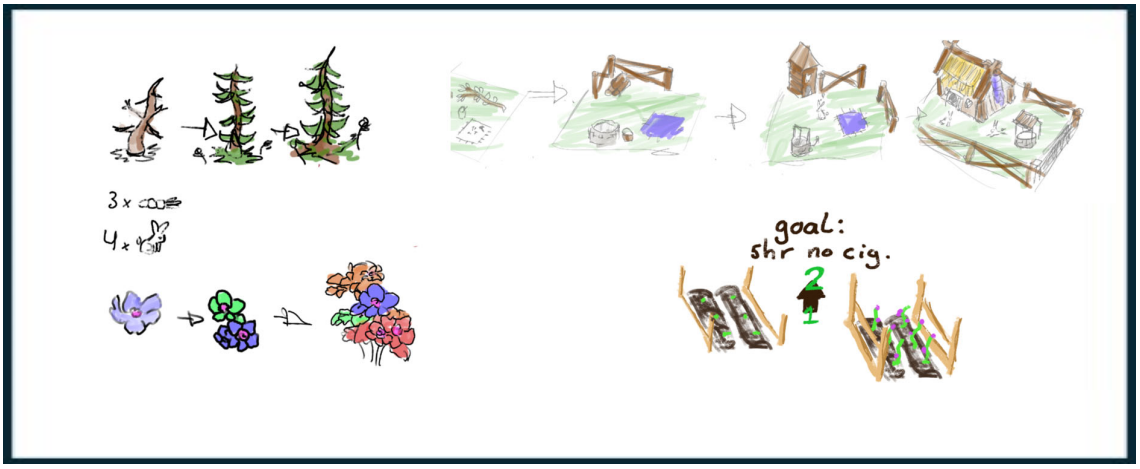


Fig 11. Initial design ideas for the upgrading and resource system of the device

[1] The naming was later changed as it could be wrongly interpreted.

In the initial concept, the user would receive quests and goals based on their current smoking habits. Completing these goals would reward the user with different resources. The goals consist of daily challenges - such as not smoking at work, or long term commitments - restrict access to tobacco products for a certain amount of time. These resources collected by completing these challenges could be spent to improve the digital environment. Ultimately, the user would have a fully developed digital environment when they have successfully quit smoking.In terms of reflection and behaviour change, the concept would provide an element of discovery and provide progress updates. The concept would provide statistics and facts about smoking, further informing the user of the importance of quitting their smoking habits. The progress section of the digital environment would showcase the progression of the user, alongside other statistics. For example, it would showcase the amount of money saved, how the condition of the user has improved over the time of using the product and the amount of tobacco products consumed.

The concept was well received by participants of the first user study. The most important finding of the user study was the lack of interest in a phone application. Implementation of the concept into an application would be easier to develop but would significantly reduce the immersion of the application. Participants noted that an application on your phone could easily be ignored and the user is easily distracted by other tasks on a mobile device. The benefit of a dedicated separate device is the immersion factor. From a design perspective it makes sense to direct the focus directly at a separate device, as the user would do if they were to smoke. The user would be excited about taking the product with them and interacting with it, whilst a phone is primarily used for a different purpose. Another benefit of a tangible device would be that the user could take this with them instead of tobacco products when they leave their house.
Some participants were sceptical of the device. Three participants mentioned that they would see little use in the product as they would like to immediately quit using all tobacco products when they attempt cessation. Other participants mentioned that the gameplay elements are not impactful enough as an intermission method. As the concept is aimed at behaviour change and does not include NRT, they would not be interested in using the device.

This concept was selected by the majority of the user test group as their favourite. It implements usability, adaptability, immersion, inspiring fun and exploration as factors of engagement. It implements Temporal perspective and discovery as methods of reflection. Nine out of fourteen participants selected this concept as their favourite. Alongside the popularity of participants, the concepts shows a lot of potential and was thus developed in order to answer the research question: How can interactive user interface technologies be implemented to assist smoking cessation among adults?

Explorative user study

Conducting a user study on smoking cessation was highly beneficial for several reasons. There are practical insights which could confirm findings from the literature research. Additionally, having a behavioural understanding of smokers gives insight into why findings are not relevant. Defining why cessation methods are ineffective for certain users is important to take into consideration when designing a new cessation method. By fixing the problem that was encountered or by designing around it, a future design can be improved. This allows the design to be more user friendly.

To confirm the findings from the literature review, a user questionnaire was presented to an audience of 15 regular smokers. This audience was recruited through connections of the user within the University of Twente. The participants were all aged between 19 and 26, except for two participants which would be categorised as seniors.
The explorative user study was held with smokers above the age of 18 that claim to be addicted to smoking. A questionnaire was first held with users to confirm the findings of the literature review. Other questions were asked in order to find possible correlations between their preferred cessation method, and their current smoking habits. In order to make sure that the questionnaire was ethical, the ethical board of the University of Twente checked the research on potential risks. As no risks were identified, the questionnaire could be given to the participants. The user study had a standard procedure, where the participants were first given an information brochure about the project and then given a copy of the informed consent form. When the information about the project was clearly conveyed, the consent form could be signed and the questionnaire could begin. One participant was determined to be an outlier, as they did not consider themselves to be addicted.

Alongside the benefits to the literature research, the user study also helped to design the prototype. Tailoring the existing concepts to specific user needs allows for an enhanced design, ensuring interventions are aligned with the needs and preferences of the users. At the end of the questionnaire, the participants were presented with 3 concepts that are elaborated in chapter 4. A description of the concept was given to the participant and they were asked to provide information on the effectiveness of the concepts. This gave insights by finding out why current smokers are appealed to certain methods of smoking cessation.

Results

To protect the anonymity of the participants, the results of the test will not be shared, as participants could be identified by their age, gender and answers provided. Each user was asked about information on their current smoking habits. Firstly, the users were asked where they smoke the most. Most participants indicated that they smoked mainly at social gatherings.

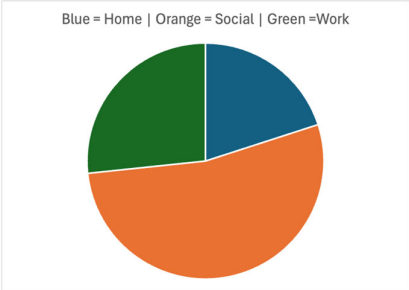
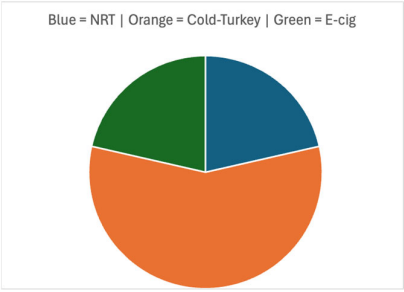


Fig 12. A chart showcasing the usual location of smokers
All participants indicated that they smoke because of the calming effect; in order to relieve stress. Participants were also asked about their previous cessation attempts, if they had any. Most participants had attempted a cessation attempt at least once. Withdrawal symptoms observed by the participants were irritation, mental and health related. Participants were then asked on their method of cessation, and if they had a preferred method in the future.



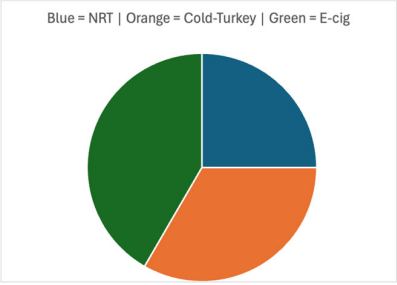


Fig 13A. Past cessation method Fig 13B. Future cessation method

It was observed that most of the participants tried to quit smoking unassisted. Note that none of the participants were successful in their method, as the participant needs to be an active smoker in order to participate in the research. A small number of participants had tried using nicotine replacement therapy or using vaporisers. Most participants argued that they returned to smoking due to peer pressure and stress. When asked about future cessation methods, most participants argued to use vaporisers as a substitute to nicotine. The users that have used vaporisers in their previous cessation attempts did not select this as a future option. This indicates that the smokers that are familiar with vaporisers as a cessation method do not classify it as effective. When questioned about this, one participant mentioned that they would just increase their nicotine intake by smoking alongside the product. Unfortunately, no other correlations could be found from the results of the questionnaire.

As mentioned in chapter 4, the concept that was preferred by the participants was concept 3. Participants were asked on how to possibly improve the concept. Multiple participants mentioned that interactivity between recourse gathering within the game and the visualisation of the farm had to inspire fun. The concept did not receive a lot of criticism, except from the senior participants. They preferred other methods as the gamification element could not be taken seriously in regards to smoking. A large preference for the third concept was provided, and this concept was thus selected to be developed further.

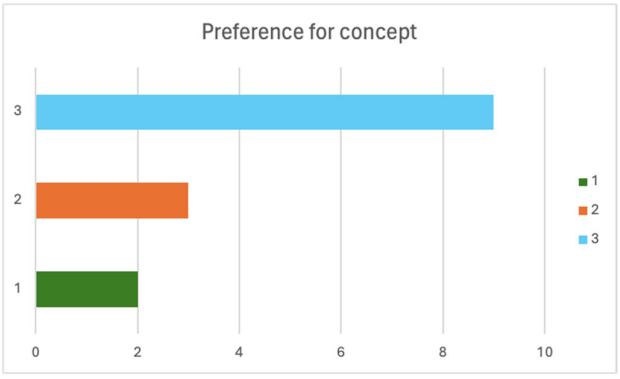


Fig 14. The preference for concept 3 in bar charts

Chapter 5 – Specification

In the specification phase of the Creative Technology Design Process, the final concept created during the ideation phase will be refined and developed into a functional prototype. Feedback that was given during the user study will be implemented into the design, causing the design to be reiterated. The final version should fulfil the preliminary requirements and shall be evaluated for the stakeholders. This helps to answer the research question.

Creating a tangible user interface (TUI) to assist with smoking cessation involves several requirements to ensure it is user-friendly, and effective. As mentioned in the literature research, in order to assist with smoking cessation, the product must be engaging, and must trigger reflective moments.

The following chapter is divided into three sections. The first section of this chapter are the functional requirements. The second section is about usability and technical requirements, and the last section is on psychological and behavioural requirements.

Functional Requirements

Monitoring and tracking

In order for the product to trigger reflective moments, it must be able to put the users smoking habits into statistics. Being able to see the progression of the user within their cessation attempts is one of the main functional requirements of the product. This must be done by gathering information on the frequency of smoking. Therefore the product must have a built in tracker. Other statistics are useful to gather, but not necessarily. General health conditions, such as the heart rate or lung capacity are useful to determine the potential risk of NCDs. As the product is aimed at behavioural change, these statistics will not be gathered. They could be estimated, just like more potential useful information for the user, such as how much money they have saved over the span of their cessation attempt. Additionally, it would be useful to track the location of the user to determine potential hotspots. Based on common patterns of the user, the player could receive challenges to not smoke in a certain area or when they are at home. Functionally the product must have a way to track their smoking habits, and extra features could be implemented in order to improve the user experience.

Gamified feedback and notifications

In order to implement the behavioural change techniques, the product must provide some sort of feedback system. The user must receive rewards for doing well, or be punished when doing badly. Within gamification, this is feasible by implementing achievements in the form of badges, points or resources. There must be at least two possible rewards, one aimed at achieving long term goals, with the goal of reaching a complete tobacco usage stop, or preventing relapse. The other must represent their current smoking behaviour. This must be done by having an immediate response to the behaviour of the user. This has to correlate with the smoking tracker of the device, to define the behaviour of the user with their smoking addiction. The device must alert the user that they are doing well or badly.

This can be done in several ways, such as implementing a buzzer, sound or other methods. Conceptually, the device could also use non-conventional methods to alert the user, like changing the temperature to indicate if they are doing well. For the scope of the project, the device must have some sort of feedback mechanism, which can be explored further in later reiterations.

Challenges and goals

Gamification allows for an easy way to visualise long and short term goals. In order to help the user engage with the product, there has to be an implementation of goals. The goals must be realistic to achieve for the user. Thus, the goals must be adaptable based on the user's smoking habits. The goals must be varied, in order to keep the user engaged over a prolonged period of time. The minimal requirement for the goal-settings aspect is to have different challenges that the user can focus on, aimed at either long term goals or short term goals. The reward obtained from achieving these goals must be represented visually. This can be done by implementing progress bars, statistics of health improvement or other visual clues. To build on the concept presented, the rewards should include virtual items which can be exchanged in order to improve the virtual environment. The difficulty of the challenges must vary according to the user's progress. If the user is doing badly, the challenges should become easier to overcome. The rewards must be aesthetically pleasing for the user, and consistent in theme.

Usability Requirements

User friendly design

The product must be easy to operate. This interaction should be smooth and reliable. There should be no frequent errors, and no game breaking errors. An interaction with the device should aim to be of similar length as smoking a cigarette. This is done in order to replace the action of smoking. If the device has helped to stop the urge to smoke for the user, it has been effective. Furthermore, the device shouldn't take away from the user experience of a smoker. The user should still be able to go outside and use the device where they want. The device must thus be portable. In order to achieve this, the device has to contain a battery and must be chargeable. It also must be compact in order for the user to take it with them. Ideally, it must have a similar size to a package of cigarettes, so that the user is tempted to take this device instead of their tobacco products. The device should be easy to understand and easy to learn. The user interface should be logical and attractive, especially for current smokers. Clear instructions in the form of a virtual tutorial have to be implemented. Ideally, the product should provide a seamless user experience that integrates gamification elements naturally into the users daily life. In order to quickly adapt and integrate these features, the device must be able to update regularly.

Design requirements

In order to create a positive user experience, the design should include some basic features. There must be a screen, in order to visualise everything. As mentioned before, a battery must be included for the portability of the project. In order to preserve the battery life, an off-on button also needs to be installed. A way to alert the user should also be available. As gamification is often intertwined with

sound design, it is logical to implement an audio driver and speaker. Other actuators could be implemented like buzzers or bright LED's. A gps system could be implemented to create more personalised challenges. The device could also have the ability to share data and progress to a mobile device, but this has a low priority as the user study concluded that this is not popular among smokers. Potentially there could be some integration with wearables, by enabling synchronisation across devices and updating the users progress digitally using - for example - a smartwatch. All data collected should be anonymous, as it is the experience of the user, and it should be their choice to share or withhold information to others.
Physically, the product must be compact. The device should also look attractive to the user, so it is more likely to engage with it. The device mustn't be too fragile, so it doesn't brake during normal use. The product could be customisable for the user. Additionally, the device mustn't be too heavy, as a product with too much weight would take away from the usability.

Psychological and Behavioral Requirements

The device must incorporate principles from behavioural psychology to effectively influence user habits within the gamified context. This is done by providing elements of discovery into the game. The user should learn more about the consequences of smoking; or their cessation thereof. Game interactions should include information and push the user to improve themselves. The product must help the user to stop cravings and the product should provide encouragement. Ultimately, the design must have gamified features that help users form new, healthier habits to replace smoking, and reminders and prompts to reinforce these new behaviours.

Chapter 6 - Realisation

In the realisation chapter of the adapted creative technology design progress, the concept was developed from a concept into a final product. Before this was possible, the design that was presented in chapter four had to be adapted to abide by the specification chapter. In the first subsection of this chapter, the concept is adjusted to include the requirements set. After an analysis of the requirements, a decomposition of the product was made. In the later subsections, it is described how the final product was developed. This includes both physical and technical components, as well as some design decisions. Lastly, all elements were combined and fine tuned into one coherent prototype which will then be carried into the next step of user testing and evaluation. Ultimately, some sacrifices to the product had to be made in order to conduct an evaluation of the product.

The product was named T.A.S.C. - To Assist with Smoking Cessation. It represents the task at hand when starting the journey of fighting an addiction.
A 3D model was developed as a visual representation of the desired product. In the initial design, several tactical buttons located around the device were placed. The buttons would be used to control the game. Later on the device was altered to contain a capacitive screen, and the buttons were not implemented. For some of the upcoming design sketches, this model was used.

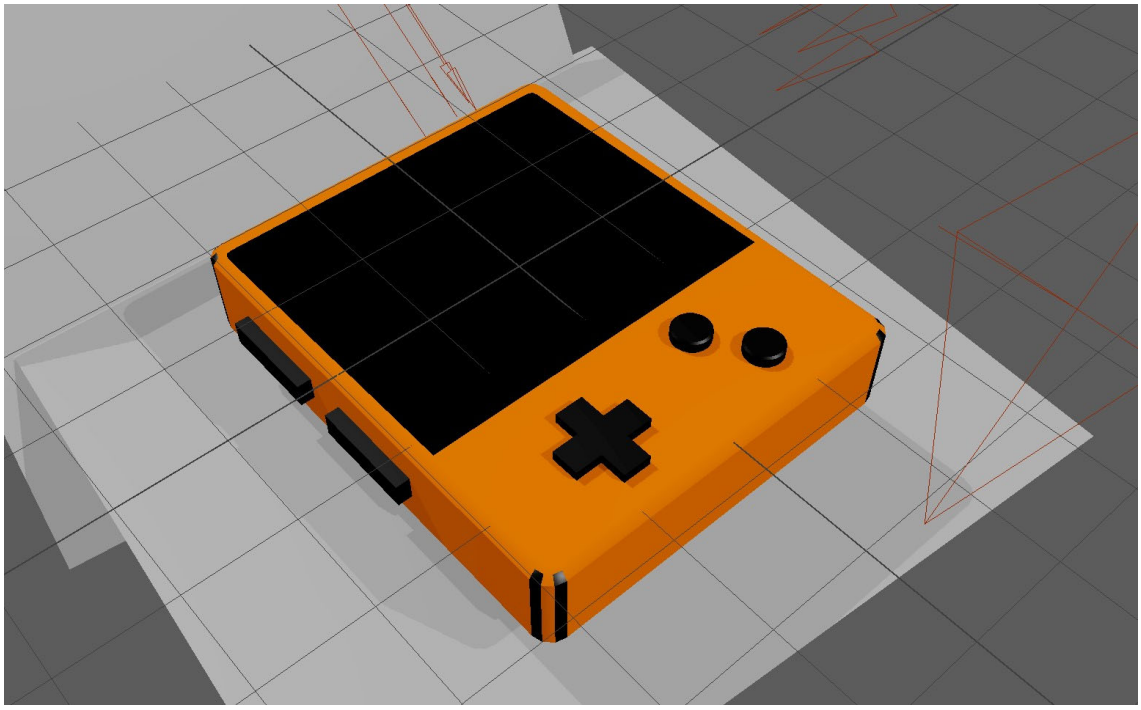


Fig 15. A 3D model of the envisioned final product

6.1 Decomposition of the product

When designing a product that includes gamification to assist with smoking cessation for this graduation project, multiple components are necessary. Hardware in order to interact with the product is required, as well as software in order to implement the several gameplay aspects. Combining the hardware components with the software provides the finished prototype. Before development on the software of the product can start, a working physical device had to be completed. It was thus important to create a listing of physical components as the first stage of the realisation chapter.

As the specifications require the finished product to be fairly small, it was logical to use a microcontroller for the project. Because the project relied on quick prototyping and adjustments to the code, as well as physical hardware that had to be controlled by the microcontroller, python was selected as the programming language. Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development [19]

Based on previous experience and the adaptability of python, a Raspberry Pi was chosen as the designated controller for this project. Initially, the Raspberry Pi Zero 2 W was chosen, because of the small size whilst remaining versatile. However, during the development several connection issues with the screen were led back to the microcontroller being incompatible. After switching to a larger Raspberry Pi 4b, these issues were resolved.

It was important to select a functional screen for the project. The screen needs to be small enough, mustn't consume too much power and must be bright enough. Additionally, the screen needs to be easy to work with and also intuitive for users. To improve the user experience, a touchscreen device was selected. [20] The main benefit of a capacitive device is that the controls from the game can be bound to the screen, allowing buttons to be anywhere on the screen and disregarding their need elsewhere on the device. This saves space within the device. The screen selected included several physical buttons that were initially planned to be used to control the device. These buttons did not prove to be necessary for the gameplay of the device. However, they were utilised during the development of the product, to quickly allocate resources to the user or reset progress. This significantly sped up the rapid prototyping of the device.

In order to achieve portability, the device must contain a battery; and ideally a way to charge this battery. Because of their long lasting juvenility, a 2500 mAh LiPo battery was used. To correct the voltage for use in the device, a small power supply had to be implemented. [21] This unit was directly connected to the battery and soldered onto the Raspberry Pi. It also contains a micro-USB charger, allowing the device to be rechargeable. A power switch was also connected to the power supply, in order to turn the device on or off. The device is able to achieve an active on-time of four and a half hours before needing to be recharged.

Lastly, the device must be able to alert the user. Because of the relatively simple implementation, two vibration motors were connected to the Raspberry Pi. These could be used in specific in-game events. To further alert the user and implement sound design into the game, an amplifier and speaker were installed.

Below you can find a full layout of the device. The GPIO pins of the Raspberry Pi were directly connected to the screen, which was specifically selected to be able to pass the unused GPIO pins through it.

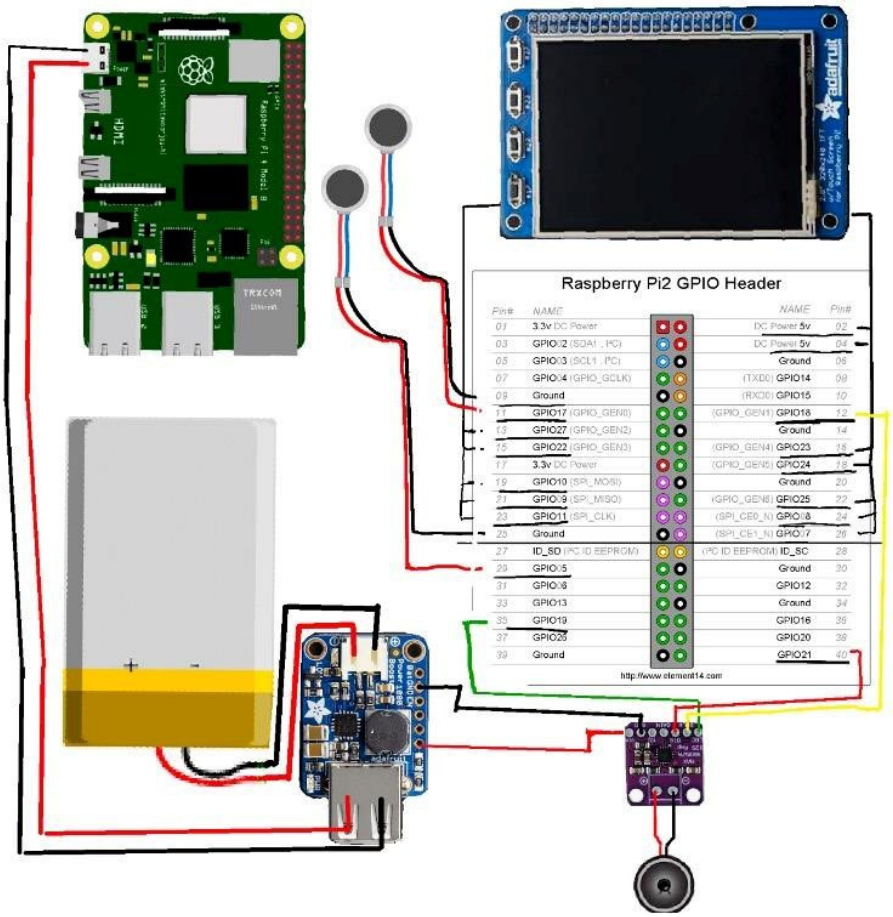


Fig 16. An overview of the electronic products used in the prototype.

Component Realisation

For the protection and presentation of the device, a casing had to be designed. The casing had to be rigid enough to support the electronics inside. It also had to be compact, as the outer shell of the product determines the sizing. It also should be attractive to the user, easy to hold and comfortable. In order to achieve stability in rapid development, 3D-printing was utilised. To accurately accomplish a tight fitting around the electronics, a 3D physicalization was first digitally modelled.

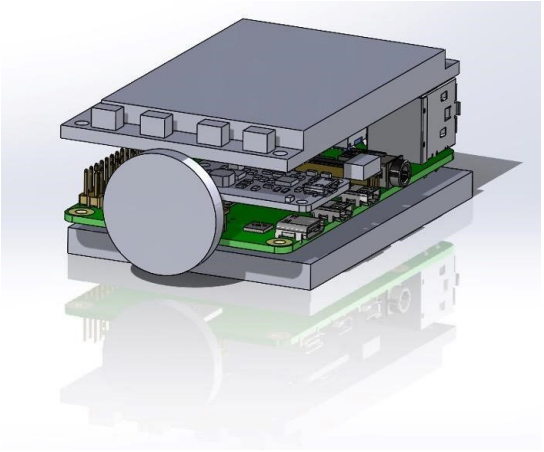


Fig 17. A digital representation of the assembled electronic devices

This model contained all electronic components as well as the corresponding places for the cutouts for the design. These cutouts were for the on and off switch, 4 buttons at the top for debugging purposes, the charger hole and the speaker. The battery was included into a separate compartment, in order to be easily accessible and replaceable. This also prevented possible overheating issues and prevented the battery from being damaged.

The 3D casing could now be designed around the device. The casing was designed to come apart easily, so the electronics could still be accessed during development. Screw holes were also implemented to secure the 3D print around the electronics. The casing was divided into 3 parts. The first part covers the top part of the device and includes the previously mentioned cutouts. The second part covers the bottom part of the device, storing the battery and also has a cutout for the speaker and wiring. A third part was placed within the device, storing the power supply, vibration sensors and power switch. This provided stability, making sure that the different parts inside the device do not interfere with each other.

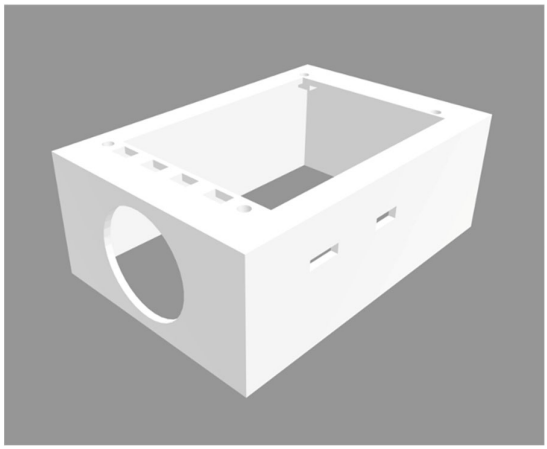


Fig 18A. The top side of the 3D encasing

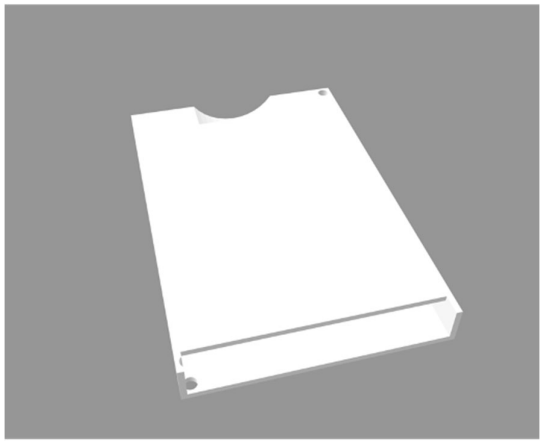


Fig 18B. The bottom side of the 3D encasing After 3D printing, the parts could now be assembled into the finished prototype.

Fig 19A A front view of the device

Fig 19B. A ¾ view of the device

6.2 Integration the software and hardware

With the physical assembly of the device completed, it was now possible to create a digital environment for the game. One of the core elements of the game is the element of adaptability. The game needs to be usable for different kinds of users. The user experience should differ depending on the user's previous cessation attempts and their current tobacco usage. For most users, the product would have to calculate challenges to reduce current consumption patterns. These challenges would scale in increments, based on current tobacco usage. A user that consumes over 20 cigarettes a day likely needs a longer adjustment period then a user that smokes 1 cigarette a day. Additionally, from the user study, it was concluded that some users might prefer to immediately quit all tobacco products; stopping cold-turkey. To implement these different use case scenarios, a timeline was made where users would be placed, based on the answers they give in a questionnaire when first given the product.

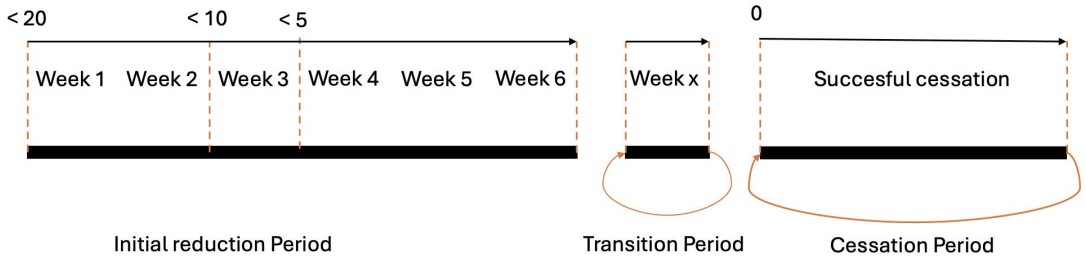


Fig 20. The different periods within the game development

When users first start using the product, they are divided into one of four different categories. These categories divide the user in terms of their current smoking behaviour. When the user smokes more than 20 cigarettes per day, they are categorised as a heavy user. If the user consumes between 10 and 20 cigarettes per day, they are categorised as a strong user. Between 5 and 10 cigarettes they are classified as a regular user, and below 5 cigarettes per day represents a light user.

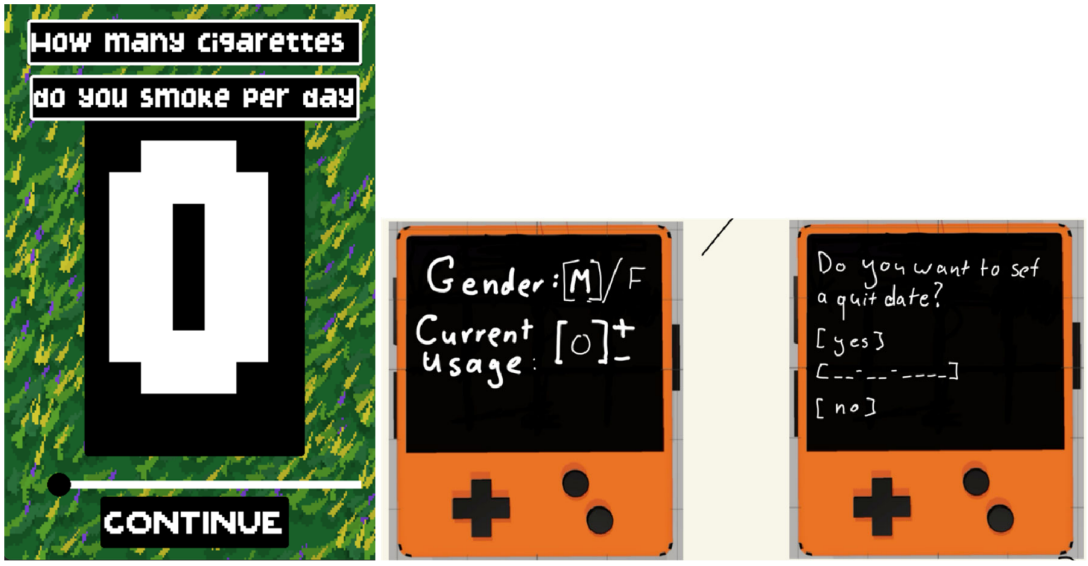


Fig 21 A and B. The digital questionnaire to alter the user experience

The user could select their current day to day tobacco intake when first using the product, which determines where they would be placed along the timeline. The user could also manually set a quit date and adjust their gender.

Additionally, the user can indicate their preferred method of cessation. This is a choice between the regular cessation method of slowly reducing their tobacco usage, alongside the usage of behavioural change techniques, or an immediate cessation. Correspondingly to their classification and preferred cessation method, the user is placed somewhere in the timeline. Heavy and strong users will start from week 1, while regular users will start from week 2 and light users will start from week 3. This is done to compensate for the nicotine dependence of the user. In the initial reduction period, the user cuts down from their current usage to a set quit date. At the set quit date, which is within 6 weeks for heavy and strong smokers, but earlier for lighter smokers, the program determines whether the user is ready to transfer to the cessation period. If the user determines that they are not ready to quit yet, they are placed in a transition period. This period is meant for users that particularly struggle with reducing their smoking habits. The periods will be further described later in the chapter.
Alternatively, if the user chooses to quit cold-turkey, has finished their initial reduction period, or decides to place the quit date to an earlier date, the cessation period starts. Gathering other statistics could be useful to alter the gameplay experience, such as gender, previous cessation attempts and age. These factors were not added to the game due to the complex integration of the research in these fields. For example, in order to see if the effectiveness of the device is gender-specific, the device needs to be finished and tested with a large group. The only feature that was integrated for the first version of the product, is the current usage of tobacco products.

After the user has finished the questionnaire, they are met with the home screen. The home screen represents a garden, which virtually mimics the success of the user's cessation attempt. Depending on the current period of the user the environment will look different. However, the layout of the essential features of the game will remain the same. Below, you can find the initially designed layout.

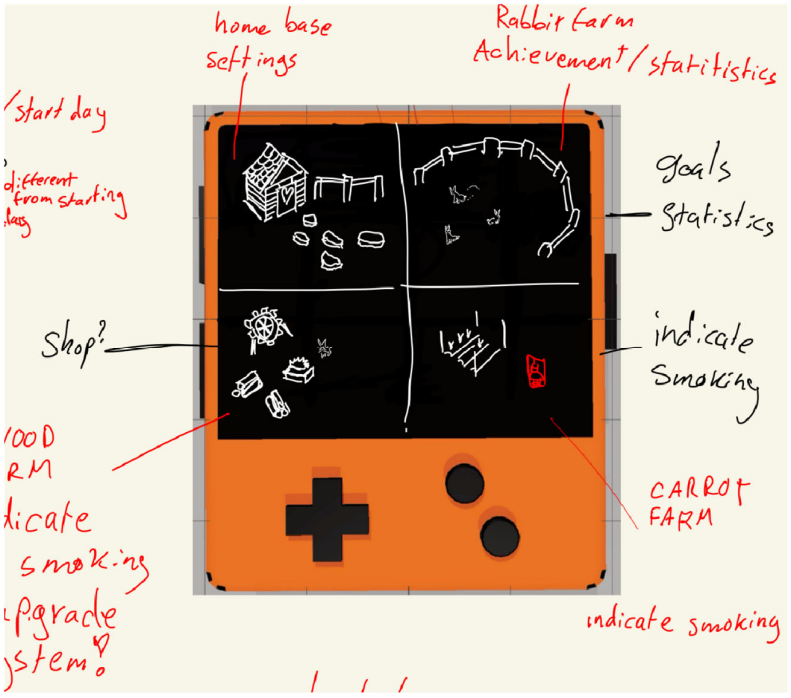


Fig 22. The initial layout of the digital environment of the product
The 4 quadrants represent different elements of a virtual farm. A wooden hut, found on the top left, would be representing the settings. This is where adjustments could be made to the quit date, current usage or other basic settings. The top right corner would be occupied by a bunny den. This

represented the user's progress whilst using the device. Selecting this den would provide statistics for the user. It would give an overview of completed goals, challenges, as well as money saved and long health. A countdown to the user's set quit date could also be found here. On the bottom right, a small carrot farm can be found which is used as a tracker for smoking habits. The tracker would provide resources based on set goals, challenges and by smoking less. These resources could then be spent over in the bottom left. This space represents a lumberjack that will improve the farm with the resources given to it.

The designed interface could now be digitalised. During the development, a decision was made to create a bigger space for the farm element, allowing for animals to roam the screen, rather than being stuck in the top right corner. The smoking indicator was automatically implemented into a timer, running in the background of the program. This allowed for a bigger free space, where the user's progress is represented. Below you can see the virtual environment designed for the main screen of the program.

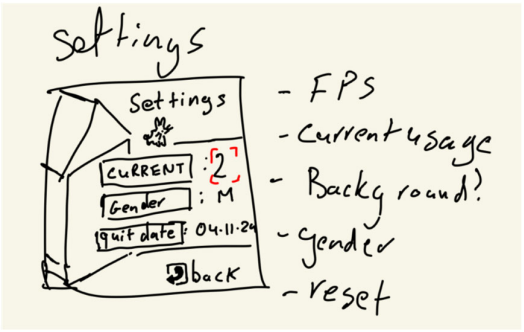


Fig 23. The basic layout in the finalised digital environment

Fig 24. A sketch of the settings menu

Settings

The settings within the main menu provide access to the essential functions. Technical functionalities include: changing the volume of the sound, turning on and off vibration and changing the brightness of the screen. The frame rate could also be adjusted here. Apart from the technical functionality, the settings also provide a way to reset current progress made within the game. The user can use the settings to adjust their quit date. This changes the challenges and goals, to compensate for the change. Moreover, the progress of the device could also be completely reset within the settings menu. This allows the user to retake the initial questionnaire. This feature was useful for prototyping, but serves an additional purpose. In the event that the user would relapse during the cessation period, the progress could be reset, so that the device remains useful to the user. Alternatively, the device could be reset and given to another user, to assist with their smoking cessation.

Goals and challenges

Different goals and challenges could be given to the user. All of these challenges relate behavioural change techniques to the user's smoking habits. Using these techniques is key to providing a successful user experience. Challenges are daily objectives that the user tries to complete, while goals are long term objectives. A challenge could be to put a tobacco product on top of a shelf, so that extra effort is required if the user does decide to smoke, in turn discouraging the user from smoking. The main goal of the device in the initial reduction period is to achieve a daily average of zero tobacco products consumed by the set quit date. Goals can be worked on over the timespan of using the device, whilst challenges try to provoke the user into helping themselves. Both challenges and goals are also meant to help the user discover the consequences of smoking, by implementing aspects of discovery.

Fig 25. A sketch of the goals and challenges menu

The goals and challenges given to the user depend on several factors.

In the first week of the initial reduction period, the user would receive relatively simple goals such as: smoke less than your daily average the upcoming week. As weeks progress the goals and challenges will become harder to accommodate for the fact that the user should be smoking less. This change is more gradual for heavy and strong smokers, as they are given a longer initial reduction period to compensate for their larger nicotine intake. If the challenges and goals still prove to be too hard, the system will adjust the difficulty. If the user is not ready to commit to the quit date by the time it arrives, they can go into a transitional period where the challenges and goals strongly encourage the user to quit smoking, or seek medical help.

Once the user has reached the cessation period, most of the current goals and challenges become reductant. The main goal from this point forwards becomes to not relapse into old smoking behaviour. The device is used as a way to distract the user from wanting to smoke. Interactions with the device are mainly to represent progress. Goals now relate to the amount of time not smoked, or achieving a certain amount of money saved from quitting. The device will also provide facts about the recovery of the patient, as well as statistics on the reduced chances of getting a NCD. Challenges and goals at this stage will become repetitive, as the need of the device correlates with the user's smoking habits.

Rewards and progress

In order to keep the user engaged with the device, the user must be rewarded for doing well. The user needs to want to come back to the device, and be able to use it when they have the urge to smoke. However, use of the product will differ significantly between users. It is expected that the user uses the device primarily in the first 3 weeks of obtaining the product. This is an important period, as most

smokers relapse within this period of having quit.To maintain the users engagement and immersion, more challenges and goals are given in the initial period of using the device (first 3 weeks). Rewards from completing challenges and goals are representative of the progress of the user. Completing every task correctly will provide the exact resources to complete the digital environment at the determined quit date of the user.

Initially, different rewards were planned to be implemented and assigned by the difficulty of the challenges and goals completed. This system would be adaptable based on the category of the smoker and their success rate of previous challenges. However, this system was not implemented as the long term effectiveness of this adjustment could not be tested in the evaluation of the project. Instead, a system was set in place that allocated resources to the user based on a timer. The device would vibrate and make a sound when the timer was reached, prompting the user to check the device.

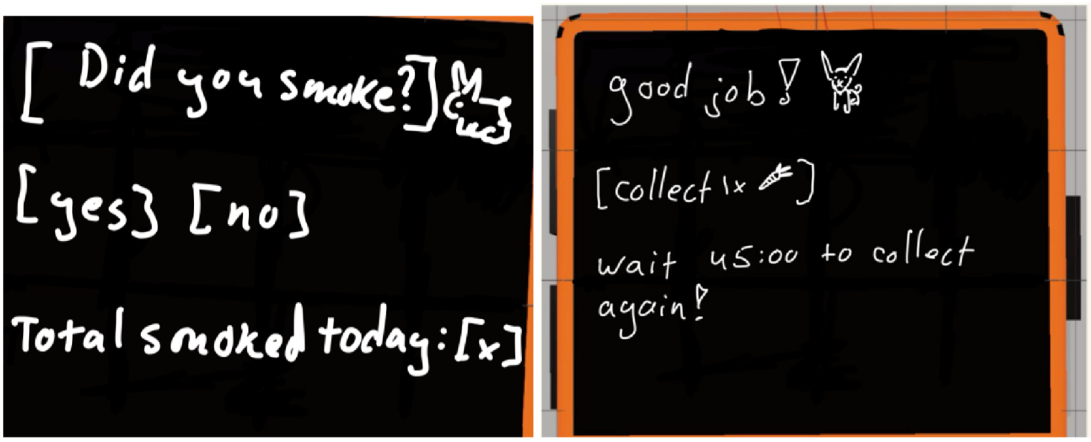


Fig 26. The prompt shown when indicating whether the user has smoked

If the user did not smoke in the period between checking the device, resources were allocated to the user. If the user did smoke within this time period, the device would register this data and provide a fact about the importance of smoking cessation. This data can later be viewed within the progress section. The timer correlates with the users current smoking behaviour, so heavy users would be granted resources more commonly than light users. In the later weeks, when the user was nearing the cessation period, these resources were no longer provided as the user approaches an average of 0 cigarettes smoked per day. Near the end of the initial reduction period, the user would have to complete challenges and goals to complete the digital environment.

Improving the digital environment is done by exchanging the resources of the user in the shop. Here, different things could be upgraded or added to the game. Most upgrades are cosmetic. It was planned that the user would be able to upgrade the shop, allowing for more purchases, unlocking access to more achievements and adding more life to the digital environment. The latter was implemented into the game for the user evaluation.

Fig. 27 The improvement of the digital environment based on the user interactions

By improving the user's smoking habits, they could improve the digital visualisation of their farm. Apart from adding animals such as cats, birds, butterflies and bunnies, the user could adjust the season of the farm, add trees, toys for the animals to play with and more. These features were not added as they do not add too much value to the user evaluation, but they showcase the possibility for further expansion within the game. This way, the user keeps getting content and stays engaged. Additionally, apart from improving the digital environment, the user tries to complete challenges and goals. This progress is tracked. By the end of every week, the user is shown an overview of their completed challenges and goals, and a showcase of their progress made so far. This data is represented in the amount of money saved, the daily average of their smoking behaviour, and their physical health improvements. Other statistics could also be added. This menu is automatically provided to the user by the end of each week, but could also be accessed by pressing anywhere on the farm; if it doesn't interact with animals currently placed in the digital environment.

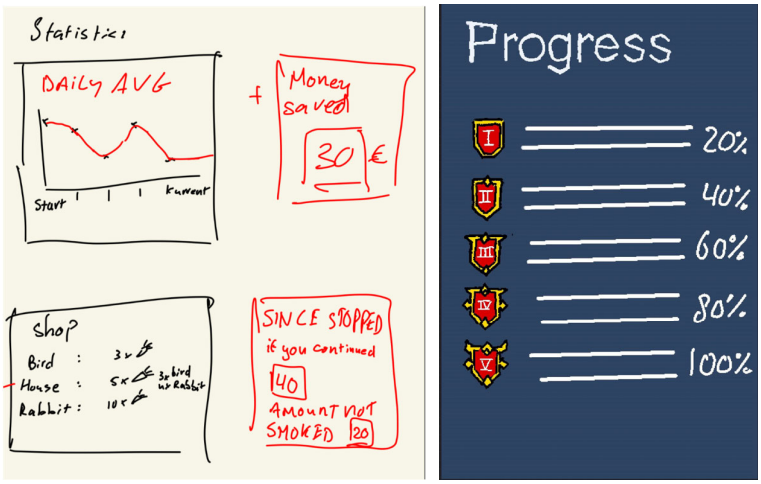


Fig 28. The data gathered from the user represented in statistics

Fig 29: The progression of achievements that the user could achieve

Achievements that are achieved represent by obtained badges, which are improved by reaching certain goals. For example, in the cessation period, a badge is given for reaching an amount of days without smoking. Other achievements would be related to the statistics, like saving a certain amount

of money, or reducing the chance of getting a NCD to a lower percentage. Here, the user is also informed of the importance of their cessation attempt.
Lastly, within the progress section, a flower is grown from the start of the user's cessation journey. This flower will grow towards the quit date set for the user. If the user does badly or is delayed, the flower will not grow. This flower represents the user's progress and shows the user a visual representation of how far they have come. Inspiring the user is one of the core methods of keeping the user engaged and motivated to continue their cessation.

Fig 30. The progress of the user represented in a growing flower

When the quit date is reached, the user can go to this screen to start the cessation period. Here, the user is prompted to take good care of the flower, as well as growing other flowers. Resources could be collected from the flower to further upgrade the digital environment. If the user does relapse, the flower would shrink in size.
To further implement this flower theme into the game, a login screen was added. This screen was used as a screensaver as well as the login page for the game.
The full code of the project can be found on github. Github was used to edit and save the code written in python. [22]

Fig 31. The home screen of the device

Chapter 7 - Evaluation

This chapter describes the evaluation of the prototype that was developed in chapter 6. As the evaluation could not be done over a period that covers the initial reduction period, the product could not be evaluated on the effectiveness of this smoking cessation method. Instead the prototype was altered to include gameplay aspects in a short timespan. The gameplay was still adaptable and required a questionnaire to be filled out at the start. User testers were given the resources to explore the prototype and experience the product to the fullest within a 15 minute time period.

This chapter is divided into two separate chapters. One describes the setup and interaction with the prototype. The other focuses on the results gathered from the test that was conducted.

7.1 User testing

The device had to be tested in different categories in order to be properly analysed. To reliably measure the user experience, the User Experience Questionnaire was used.[23] This questionnaire consists of 26 questions relating to the attractiveness, perspicuity, efficiency, dependability, stimulation and novelty of the device. To estimate these factors, the questionnaire provides a Likkert scale test where users have to determine the user experience of the device.

In order to ethically approach the user test of the device, the ethics committee of the University of Twente checked for possible risks. No notable risks were identified with the interaction of the device deeming the prototype ready for use.

Users were selected from the previous user study. Three experts on the field of user experience that are also current smokers performed the UEQ on the product. Before their interaction with the device, the device was cleaned and fully charged. The current progress on the device was also reset. The participants had to read the information brochure and sign an informed consent form, which both can be found in the appendix.

In order to fully experience all the mechanics that are implemented into the software, that are supposed to be experienced over a prolonged period of time, the participants were given resources on a much quicker scale. This meant that the user would have to wait between 10 and 30 seconds to obtain new resources, based on the categorization of smokers they classified as. The participants were

asked to envision the product as it would be used over a longer period of time. If the participants struggled to interact with the device, the researcher was present to assist them.

After the participants were done with interacting with the device, they had to fill out the UEQ. This data was later processed by the researcher to evaluate the product. Lastly, the researcher asked if the participants would use the product and what adjustments they would like to see to the device.

7.2 Results

The finalisation of the user tests meant that there was now enough data to be processed to draw conclusions on the user experience of the device. The data was first anonymised and stored. As the UEQ covers a wide variety of questions, the results provide a range of valuable insights on several topics. The UEQ automatically processes the data obtained from the questionnaire.

This data is not processed as one singular score on the overall user experience. Rather, the UEQ categorises the questions into different fields. For example, in the first question, the user has to rate the user experience on a scale from annoying to enjoyable. This impacts the overall score on attractiveness of the device, alongside 5 other questions in the questionnaire. A mean score can now be calculated on the different categories.
The scores given scale from -3 (horribly bad) till +3 (extremely good). Generally, a score between -0.8 and 0.8 represents a neutral evaluation. Scores higher than 0.8 represent a positive evaluation, and scores below -0.8 represent a negative evaluation. According to the UEQ, it is extremely unlikely to receive scores above +2 or below -2. This is because the score is calculated as the mean of many different factors, amongst multiple people. Answer tendencies of the participants also affect the score - some participants are reluctant to give a maximum or minimum score on a Likert scale. This is why scores ranging between +1 and +2 are already considered very positive results. Below you can find a chart representing the mean score on the different categories. This includes the deviation between the results. You can also find a scale that just represents the mean values, scaling from -2 till 2, as values above +2 or below -2 are unlikely to be found.

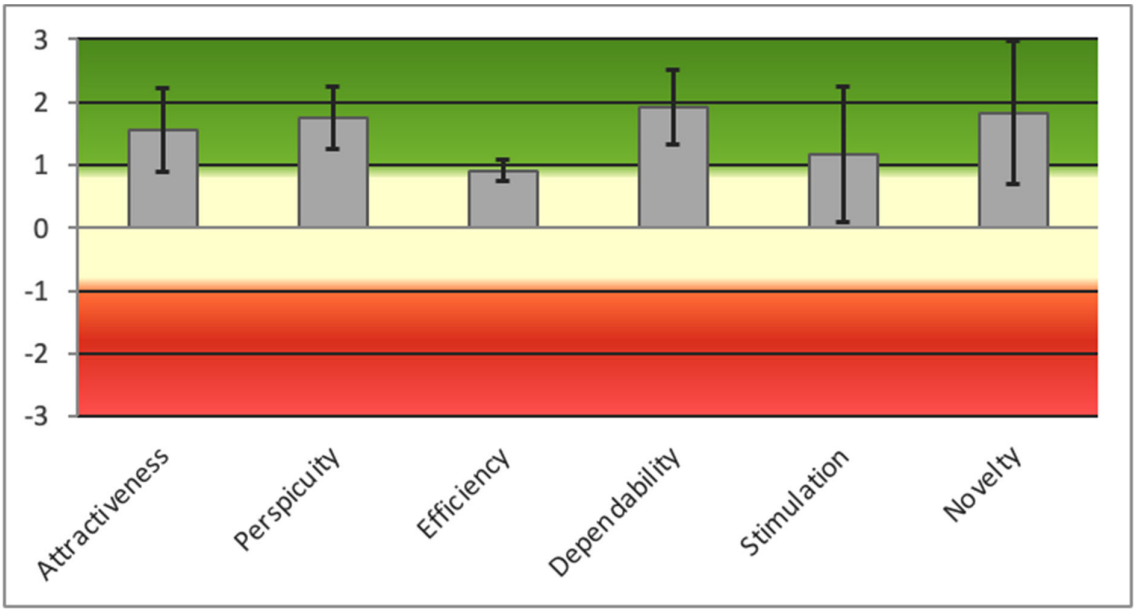


Fig 32. The mean results of the UEQ, with variance indicators

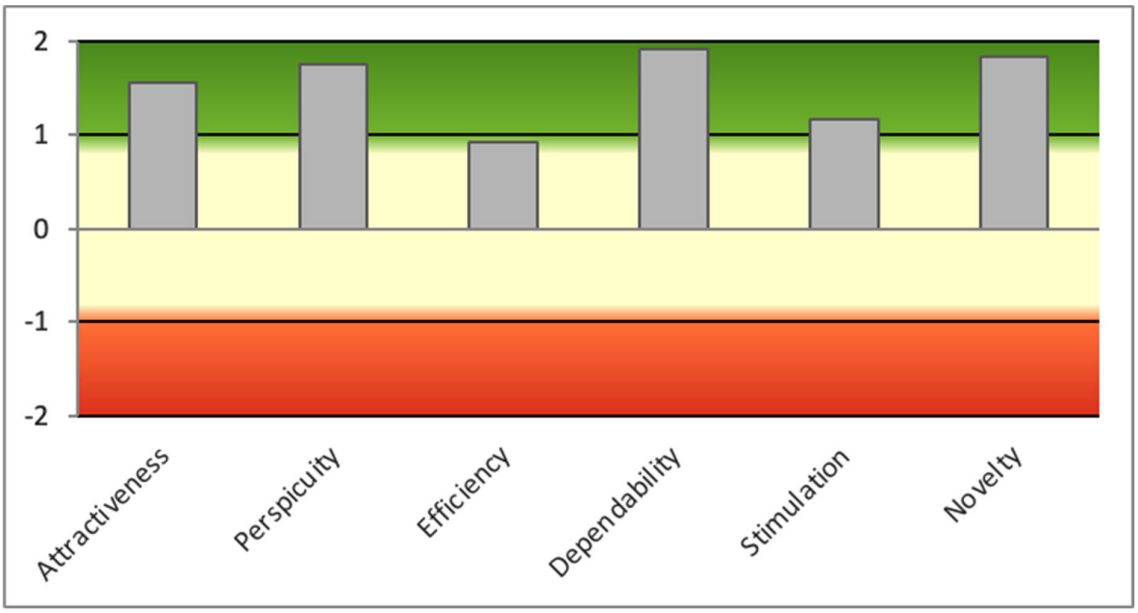


Fig 33. The scale is limited to values of +2 and -2.

From an immediate observation, the results are very positive. To further analyse each category, the mean values of each question are found below.The exact answers are provided in the appendix.

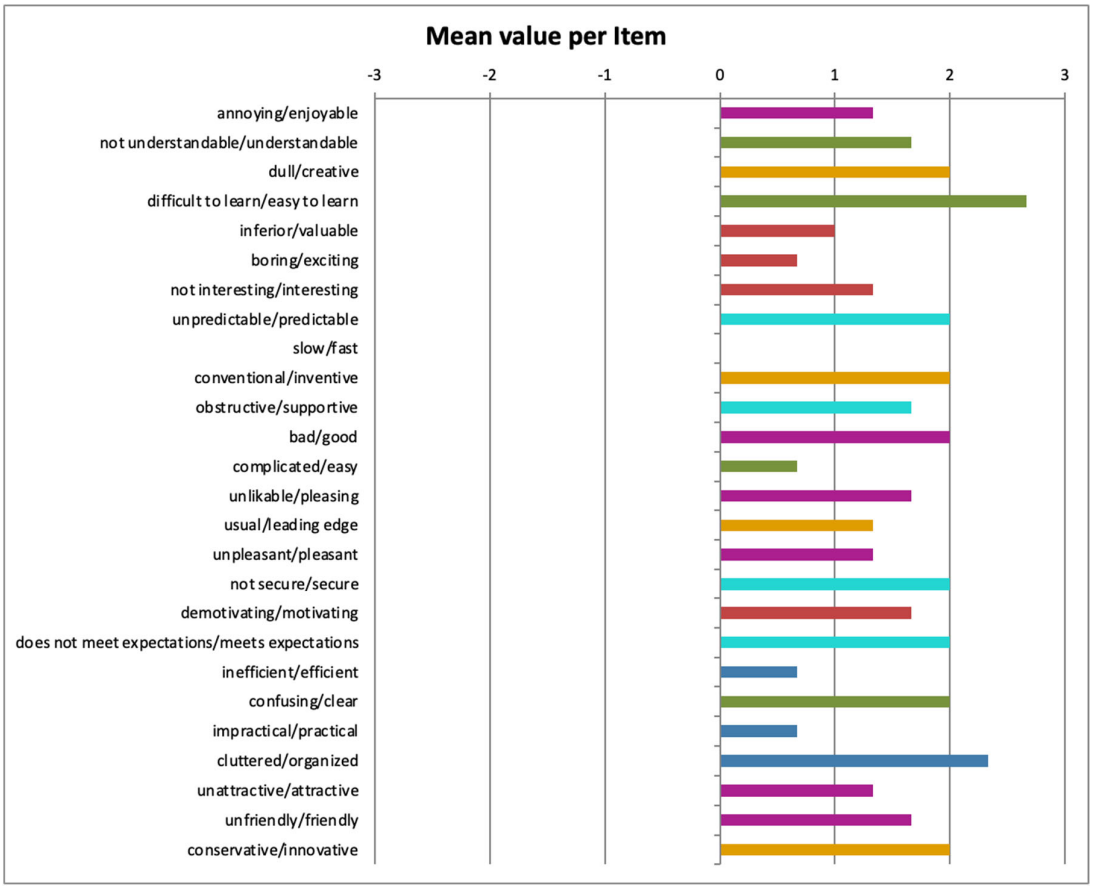


Fig 34. An overview of the mean values per category.

Attractiveness

The product scored a mean average of +1.556 on attractiveness. The idea of a game that assists current tobacco users appealed to the participants. Gameplay was considered enjoyable and pleasing. A score above +1.5 means that the product is extremely well received. This was one of the main goals, in order to obtain more engagement from the participants. One of the participants noted that they would have given higher scores if the animations and outer shell were worked out further. In general, this score indicates that the product appeals to the users.

Perspicuity

One of the other main goals of the product relates to its perspicuity. The device has to be easy to grasp and learn, to create more investment for the user. If the user is able to intuitively operate the device, with a small learning curve for the mechanics of the gameplay aspects, the perspicuity of the device is significant. During the user study, all participants were able to operate the device intuitively. This was also represented in the scoring of the UEQ. The product scored a mean average score of +1.75. This is a very high score, taking into account that the variance is relatively low (0.19). The questionnaire revealed that every participant found the product easy to learn, this particular question scoring a mean average score of +2.7.

The main reason why the score isn't higher relates to question 13, where the participant is asked to score the device between complicated and easy. The points distributed here valued greatly between participants; this question received a mean average of +0.7, with a variance of 2.3. This is likely due to an outlier, as the device could be interpreted as complicated in design, while being easy to operate. Removing this outlier would result in the mean average of the perspicuity score rising to +2.0. Regardless of this, the perspicuity of the device is represented positively, achieving one of the main goals of the design.

Efficiency

The efficiency of the device has received the lowest scoring in the UEQ, with a mean average of +0.917. This is still an observed positive change. To further analyse why the scoring isn't higher, the questions were observed. Observing the answers of the questions can explain the score provided by the UEQ. The first question that is related to efficiency is whether the device is fast or slow. A neutral score was given by all participants, as the device was neither slow nor fast. Another question that was prompted is on whether the device is efficient or inefficient. The question could be interpreted as the efficiency of smoking cessation whilst using the device, but this could not be tested within one user study. As there is no direct goal other than this associated with the device, it is hard to provide a score on this question. This resulted in another neutral score. The next question on efficiency was about practicability. One of the main goals of the prototype was that the device has to be portable. While this is achieved in the wireless device, the participants found that the sharp corners and height of the device represented negatively on the practicability. The device was not easily stored in the pockets of the participants; but was portable nonetheless. This resulted in a third neutral score for the efficiency of the device. The last question on efficiency was related to clutterness in comparison to organisation. This question received a positive response, at a mean average of +2.3, meaning that the device is very organised. This relates back to perspicuity, as a device that is well organised is also easier to learn. In further reiterations of the design, the product should focus on being more practical, which would result in a higher evaluation in regards to efficiency.

Dependability

Dependability refers to the safety and reliability of the device. An interactive interface that would not reliably provide its service would score low on dependability. However, in a gamified environment, dependability is mostly reliant on software. During playtesting, no bugs or hardware issues were observed. This resulted in a mean value of +1.917 for dependability on the device. This score is extremely positive, and is reflected in the answers. The device was considered predictable, supportive, secure and it meets the expectations of the user. Whilst reliability is one of the most important factors when using the device, it is often only noticeable when things go wrong with the interaction. In user testing, the device worked reliably, but when more features and interactions are implemented into the device, the risk of potential bugs increases. It is hard to determine the exact dependability based on around 15 minutes of playtime by each of the participants. However, the high dependability of a digital game was expected and received a positive response from the UEQ.

Stimulation

Stimulation is one of the most important factors of the evaluation. Stimulation relates closely with the engagement and immersion of the participants. It is to tell whether the device is stimulating enough over a long period of time, as the participants could not anticipate if using the device becomes repetitive. On average, the participants gave the stimulation of the device a score of +1.167. This is considered a positive score. Analysing the questionnaire reveals that the positive score is related to being interesting and motivating to the user. This was one of the goals that the product was trying to achieve. However, the product scored neutrally on a scale from boring to exciting. It is expected that the product was not exciting in terms of the user experience, as resources were given to the user at the start rather than being earned. This takes away from the progress and rewards given upon the player in a normal usage scenario. The product still scored highly on stimulation and thus achieved its goal in terms of engagement.

Novelty

Novelty has the highest degree of variance among the gathered results. This is likely because the device itself is not very innovative, nor is the gameplay. The concept of collecting resources to improve digital environments is known in build-a-base type games. The novelty of this project comes from the combination of hardware, software and smoking cessation. Smoking cessation is a new field within interactive interfaces and gamification in a tangible device has not yet been explored. This is why novelty scored highly on the UEQ, with a score of +1.833. The high variance was likely explained by the answer tendencies. Whilst the product is innovative in the appliance of existing technology, it is not necessarily leading edge technology. The user experience benefits from familiarity with existing technology, and sacrifices some opportunity to be novel.

Combining different scores can provide an overview of some of the most important qualities of the device. The pragmatic quality refers to the dependability, efficiency and perspicuity of the device. Hedonic quality represents the stimulation and originality of the user experience.
On all of the above mentioned qualities, the prototype scored really well. Overall, the participants enjoyed interacting with the device.

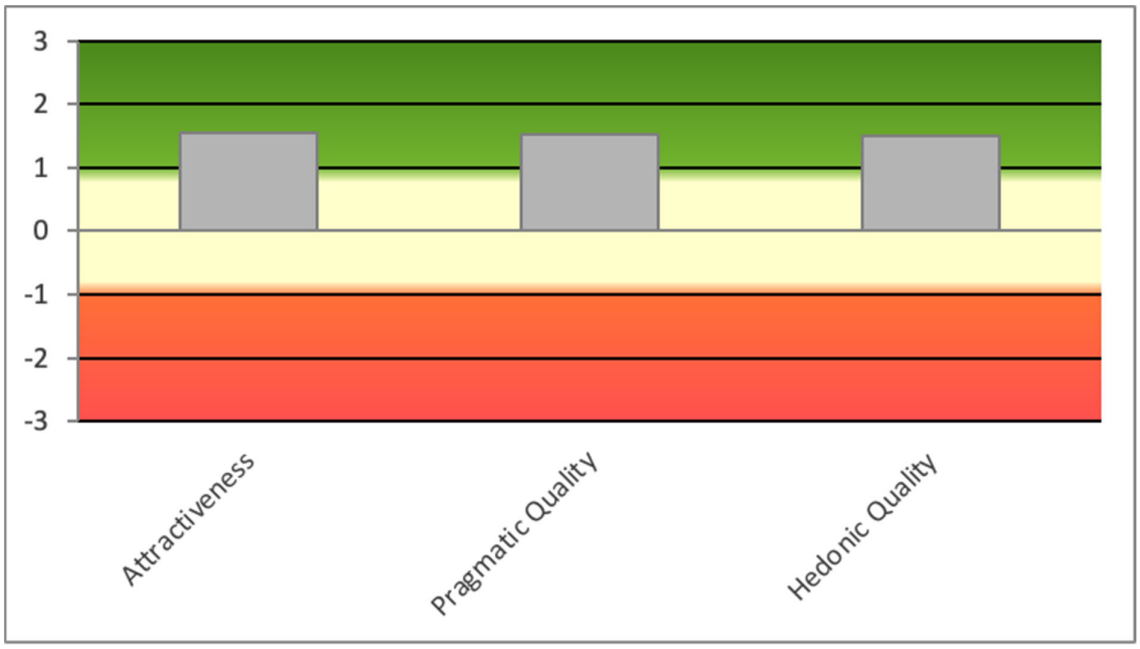


Fig 35. A bar chart showing the different qualities of the prototype

Usability

Whilst not being part of the UEQ, it was important to determine if the participants were open to utilising the product for a long period of time. Knowing what aspects of the design particularly relate to smokers is important for making further developments.

The participants were asked if they would likely use the device when they would quit smoking. Participant 1 and 3 were excited about the idea, if the content was fully worked out they would be eager to discover new elements while using the device. However, they would not go out of their way to purchase such a device, as a high cost would possibly not justify the price-content relation. Participant 1 mentioned that if the product was given to them, perhaps via work or a medical clinic, they would definitely use it. Participant 3 would buy the device in order to discover the efficiency, claiming that the device would be worth the investment if it ends up working.Participant 2 was more hesitant in using the device. As the second participant preferred to stop cold-turkey, they were afraid to forget to use the device. While the gameplay and interaction with the device did seem interesting to them, they were not open to using the device as their preferred smoking cessation method.

Chapter 8 - Discussion

The discussion chapter analyses the quality of the conducted research. Discussing the research findings is important to determine their significance. If the research is significant enough, future work can be done on the project. The discussion provides information on the improvements that can be done to both the literature review and future iterations of the product.

The design

The design of the product has certain goals that it was trying to achieve. These goals were described in chapter 5 of this report. All of the functional requirements were met for the development of the device. However, there are several fields that could be explored. The evaluation revealed that the device should be more portable and compact, in order to be more practical for the user. The original requirement of the device was to be functional as a replacement for the user to take with them instead of their tobacco products. This requirement is reached but could be improved in further versions.. This is easily done in newer iterations, as the device made for the evaluation was built for quick access to the electronics and rapid changes. The battery could be implemented with the other electronic devices. A custom pcb could be designed and installed to reduce space, implementing the power supply, sound drivers and cpu of the device. A different screen could be used that utilises more of the surface of the device.

The outer shelling of the device could also be adjusted in order to more accurately represent a cigarette package, or to be easier to hold. A smaller design of the electronics would translate into a different design of the product. In later iterations, sturdier and more luxurious materials should be used. This would significantly increase the attractiveness and dependability of the device. Other methods of alerting the user could be implemented into the design. This idea was briefly touched upon in the literature review, but quickly abandoned. Non-conventional outputs and inputs can potentially be utilised. Temperature could be used to alert the user, or a camera module could be installed for certain challenges. Most logically, a gps could be installed to give the user region based challenges and goals. Other implementations could relate to connectivity. Implementing internet on the device could help with the dependability of the device, by storing progress made in an online database. Internet access would also allow the user to share their progress with themselves on other devices, or to their friends and family. Ultimately, many electronics can be added to the device. These additions can be analysed and evaluated to determine their increased effectiveness on the device. However, these additional electronics are not necessary to determine if the device has potential to be used as a smoking cessation method. Improvement of the physical hardware is mainly aimed at marketability of the device.

Gamification allows for infinite design choices. The development of a build-a-base type of game can be infinite. More resources can be added to the game, and more achievements, goals and challenges can be added. The requirements related to the software of the design do focus on two parts. It first questions how behaviour change techniques are utilised within the game in order to fight smoking urges. Secondly, the design should engage and immerse users.

Behaviour change techniques were analysed in the literature review. This research could be expanded in further research. Potentially there are more methods that can be implemented into the game that could assist the user with their cessation. Currently, the device itself functions as a substitution for smoking. By using repetition and goal settings, the game slowly rewards the user for working on their

self efficacy. Providing a way to reflect by representing the progress section allows the user to study their behaviour, acknowledge their situation and improvement whilst using the product.
The combination of all of these factors are all effective in changing the behaviour of the user, but could be improved. Challenges and goals can be more adaptable and specific to each user. There is also the possibility of using artificial intelligence in order to create content for the user. The prototype that was used for evaluation had a fairly basic algorithm to determine goals and challenges for the user, based on a questionnaire given to them. To fully adjust the device to the needs of the user, the device should be adjusted by a medical professional alongside the user. Improving the algorithm would increase the engagement of the user and the effectiveness of the device. The design of the game could also be adjusted to improve the engagement. More consistency and more content, like more rewards to be given to the player or interaction with the digital environment should be implemented.

Overall, the product was positively reviewed during the user evaluation. It seems to appeal to smokers and the literature research showcases the potential benefits of using this device as a method of smoking cessation. Further improvements to the design of the hard- and software of the device would increase the marketability, dependability and attractiveness of the design.

The evaluation

As a result of the timespan of the graduation project, there were some limitations in regards to the evaluation. The UEQ provided insights on the initial user experience, but the product could not be tested over a longer period of time with users that are explicitly trying to quit smoking. Evendough initial factors of engagement were very high, the repetitiveness and effectiveness of the design could not be tested. There is no way to confirm the findings of this research on the questions of the effectiveness of a tangible user interface that utilise gamification for smoking cessation. To conclude that there is a scientifically significant benefit of using this device to assist with smoking cessation, a large user study needs to be done. In this user study, many volunteers should interact with the device and be observed over a period of at least 2 months. Comparing the amount of users that relapsed while using the device to users that relapse while not using an assisted method of cessation provides evidence for the significance of the device.
This large scope of research is not feasible for a graduation project, as it is costly and time consuming.

Future research

There lies serious potential in the use of a tangible user interface using gamification for smoking cessation. According to the literature review and based on positive user testing, there is an ability to develop the product further. Further research can be conducted on the behaviour of smokers in relation to gamification. To further carry out the research, a large user study needs to be conducted. Before this can be done, the design needs to become fully operational. This includes all of the implementations mentioned above to the hardware and software. A compact and cheap, yet attractive product needs to be ready for a larger production and distribution between participants of the user study. The software needs to be stable, and include enough gameplay elements to ensure the user does not get bored whilst using the product.
Observing the effectiveness of the device based on age, gender and current tobacco usage would provide valuable information. The device could be changed and reiterated multiple times based on the results of the user study. A statistical analysis would confirm the hypothesis of this graduation project.

Lastly, the product can be targeted at consumers. If the product proves to be effective at assisting smoking cessation, it should be distributed among the public, to fight NCDs.
Furthermore, research could be done on the effectiveness of the device in regards to other addictions and substances. There is no evidence that the provided solution is ineffective for other addictions.

Chapter 9 - Conclusion

This graduation project was aimed at exploring the possibilities of reducing non communicable diseases. Analysing the main causes of NCDs has led to the observation of the high fail rate of current smoking cessation methods. The goal of this report was to figure out why current cessation methods are ineffective, and if there is a possibility to utilise behavioural change techniques in a tangible user interface to assist with smoking cessation.

The literature research found that it is generally hard to quit smoking. Most existing methods are aimed at replacing nicotine for the user, so they are not urged to smoke. When these methods are no longer used by the user, they tend to relapse to smoking. The most effective method of cessation comes from a slow build off of tobacco products, while actively changing the behaviour of the user. Cognitively changing the user's habit of smoking gives the highest chance of preventing a relapse.

The consequently developed product was aimed at exploring the possibility of implementing cognitive behavioural change techniques into a tangible user interface. Known methods of goal setting, contingency management and stimulus control were put in a gamified environment. The developed device was designed to appeal to smokers and adjust to their personal needs and challenges during their smoking cessation.

The personalised approach, in combination with the perspicuity of the device provided an engaging experience for the users. It was positively evaluated on the general user experience of the design. Future work needs to be done to statistically prove the effectiveness of the device. The research suggests that gamification can be an effective method for behavioural change amongst smokers.

Appendix

Literature list

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Appendix A: Information Brochure

Information brochure for Tangible user interface to assist smoking cessation

The purpose of this meeting is to assist in writing a bachelor thesis on the topic of smoking cessation. The researcher is interested in the possibilities of a tangible user interface as a means of smoking cessation. In a previous questionnaire, the interest in such a tangible device was researched.

A device was selected that showed promise in assisting smoking cessation. The device contains a game in which you grow an environment based on your smoking habits. It involves behaviour change techniques that have proven to be e>ective in smoking cessation, but in a fun and engaging way.

The interaction with the device takes between 10 and 15 minutes. The participant is prompted to experience and interact with the device, to potentially find bugs, and form an opinion on the prototype. If features go unnoticed, the researcher will assist with the interaction of the device.

The questionnaire will be used to investigate the interest in this device. The researcher wishes to know what things are good and bad about the device. How can it be improved? The participant will be asked to answer questions about their personal smoking experience, and in what way the prototype would be effective in their smoking cessation attempts. The questionnaire process will take approximately 15 minutes **and will be recorded.** This is solely for better reflection on the held questionnaire. Data will be deleted after it is processed into the Bachelor report.

It is possible that the participant might experience mental discomfort due to smoking being a sensitive emotional topic. It is important for the participant to know that they are free to refrain from any answer and can quit participating at any time. The research data corresponding with the participant will not be included in the research if the participant decides to withdraw from the research.

Participation in the research is anonymous. However, some personal information on the participants smoking behaviours will be collected. This data will be anonymized and used as a general indication for the research. Personal information will maintain confidentiality. The data collected will be stored in the Creative Technology Bachelor
Thesis Archive. Personal data collected will be deleted after it is processed into the
Bachelor report. (Maximum of 6 months after the interview is conducted.)

In case any questions arise from this information brochure, or the consent form, Please contact the researcher
Juno Marty Reuvers
J.m.Reuvers@student.utwente.nl

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

The research project has been reviewed by the Ethics Committee Information and Computer Science

Appendix B: Informed Consent Form for Tangible user interface to assist smoking cessation

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [__/__/____], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I understand that taking part in the study involves a survey. A questionnaire will be completed by the interviewee.	□	□
I understand that observational notes may be taken by the interviewer during the questionnaire.	□	□

Risks associated with participating in the study

I understand that taking part in the study involves the following risks: mental discomfort in relation to smoking cessation.	□	□

Use of the information in the study

I understand that information I provide will be used for the related bachelor thesis report and development of low/ high fidelity prototypes.	□	□
I understand that personal information collected about me that can identify me, such as smoking habits and gender, will not be shared beyond the researcher.	□	□

Future use and reuse of the information by others

I give permission for the survey questionnaire answers that I provide to be anonymised and are to be archived in the Creative Technology thesis repository, so it can be used for future research and learning.	□	□
I agree that my information may be shared with other researchers for future research studies that are similar to this study. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information.	□	□

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I give the researchers permission to keep my contact information and to contact me for future research projects.	□	□

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____ _____ _____ Researcher name [printed]
Signature Date

Study contact details for further information: [*Name, email address*]

Contact Information for Questions about Your Rights as a Research Participant

E-mail: J.m.Reuvers@student.utwente.nl

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

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Appendix C: Question guidelines for the smoking cessation interview

interviewee requirements:

- Above legal age of smoking (18+)
- Smokes at least an average of 1 cigarette a day
- Has smoked over 100 cigarettes in their lifetime

Personal data

- What is your age?

- What gender do you identify as?

What kind of smoker is the participant

- How much do you smoke?
- Would you view your smoking habits as an addiction?
- In what situations do you currently smoke the most?
- Do you have any usual smoking cues? Think of morning coffee or social gatherings.
- What are current personal triggers that make you smoke? Think of stress or social pressure.
- Are there any specific emotions or feelings that you associate with smoking, such as relaxation or a sense of belonging?
- How would you describe your relationship with smoking? Do you see it as a habit, a coping mechanism, or something else?

Previous efforts of smoking cessation

- Have you tried to quit smoking before?
- If so, how many times and have they been successful? What methods did you use?
- Why did you return to smoking?
- Do you experience withdrawal symptoms when you try to quit or cut down on smoking?
- What, if any, were the main factors of successfully cutting down on your smoking behaviour?

o Pharmacotherapy

o E-cigarettes o Behaviour therapy o Exercise o Alternative

- Did you experience any downsides whilst trying to stop smoking?
- When did you relapse?
- Have you ever used a tangible user interface in regards to smoking cessation?
- What did you do during your usual smoking cues

Social aspects

- What role does smoking play in your social life?
- Are your smoking habits different around non smokers or smoke free environments?

Are you affected by non-smoke areas

Future smoking cessation

- What areas are most influential to you to want to stop smoking?
  Health, societal, psychological,
- What support or resources do you think could be beneficial to help you stop smoking?

o Pharmacotherapy
o E-cigarettes o
  Behaviour therapy
o Exercise o
  Alternative

When do you find yourself reflecting on your smoking behaviour?

What are triggers to start reflecting on your smoking behaviour?

How often do you think of the consequences of smoking?

How often do you think about previous times that you have smoked?

How often do you talk about your smoking behaviour? Does

talking about smoking affect your smoking bevahiour?

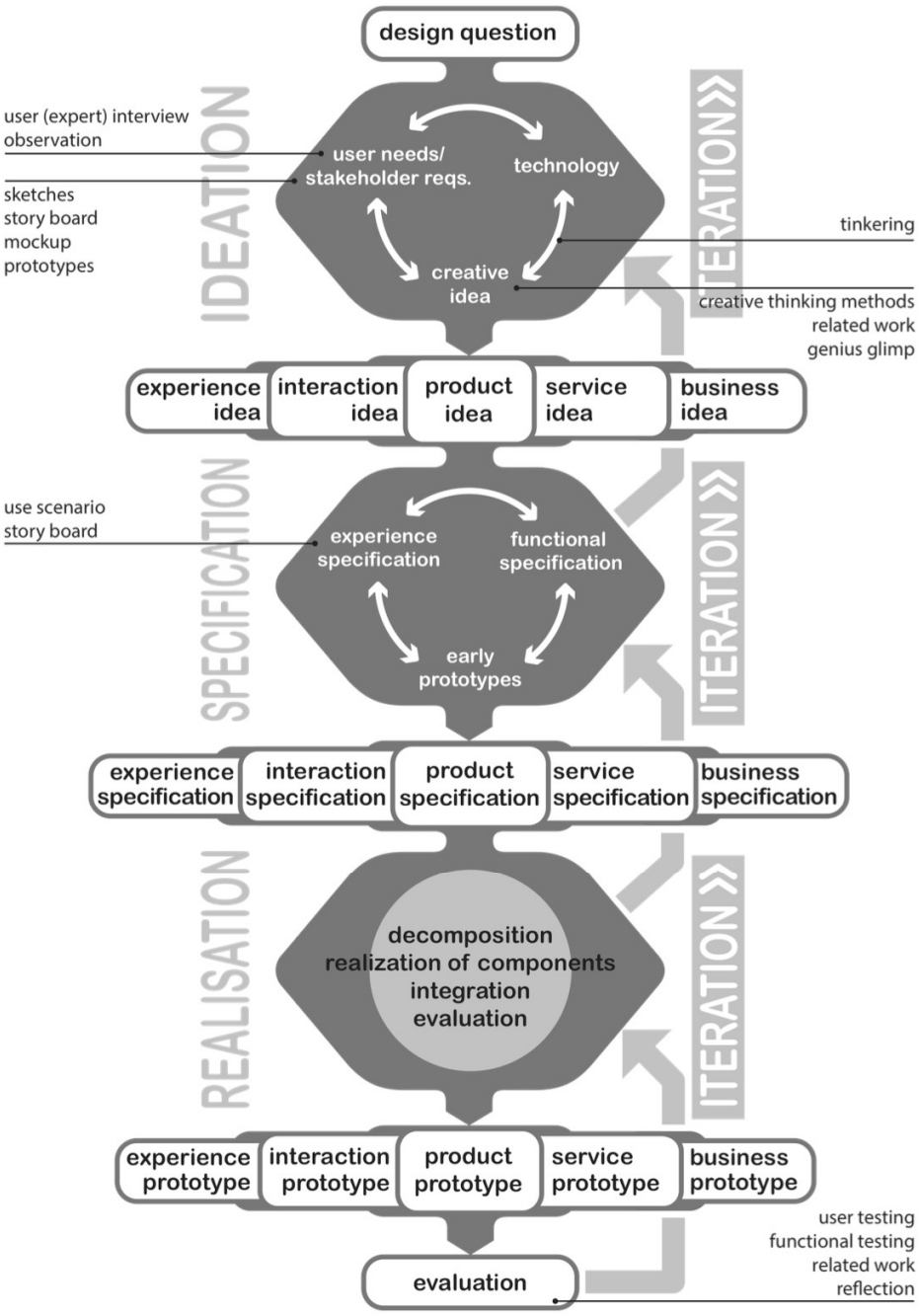
if you wanted to stop again, do you start the same way or try different route, what are you envisioning and what are your goals

explaining research

- what are your main problems when you try to stop smoking
- distraction
- negative reinforcement
- positive reinforcement
- do you see potential in my approach
- what would you want from it when you hear it

What aspects do they like about the design?
Would they use it themselves?
What is their preferred method?

Appendix D: The Creative Technology Design Process



Appendix E: The results of the UEQ

Item	Mean	Variance	Std. Dev.	No.	Left	Right	Scale	
1	1,3	0,3	0,6	3	annoying	enjoyable	Attractiveness	
2	1,7	0,3	0,6	3	not understandable	understandable	Perspicuity	
3	2,0	1,0	1,0	3	creative	dull	Novelty	

4	2,7	0,3	0,6	3	easy to learn	difficult to learn	Perspicuity
5	1,0	1,0	1,0	3	valuable	inferior	Stimulation
6	0,7	0,3	0,6	3	boring	exciting	Stimulation
7	1,3	2,3	1,5	3	not interesting	interesting	Stimulation
8	2,0	1,0	1,0	3	unpredictable	predictable	Dependability
9	0,0	1,0	1,0	3	fast	slow	Efficiency
10	2,0	1,0	1,0	3	inventive	conventional	Novelty
11	1,7	0,3	0,6	3	obstructive	supportive	Dependability
12	2,0	1,0	1,0	3	good	bad	Attractiveness
13	0,7	2,3	1,5	3	complicated	easy	Perspicuity
14	1,7	1,3	1,2	3	unlikable	pleasing	Attractiveness
15	1,3	1,3	1,2	3	usual	leading edge	Novelty
16	1,3	0,3	0,6	3	unpleasant	pleasant	Attractiveness
17	2,0	0,0	0,0	3	secure	not secure	Dependability
18	1,7	1,3	1,2	3	motivating	demotivating	Stimulation
19	2,0	1,0	1,0	3	meets expectations	does not meet expectations	Dependability
20	0,7	0,3	0,6	3	inefficient	efficient	Efficiency
21	2,0	1,0	1,0	3	clear	confusing	Perspicuity
22	0,7	0,3	0,6	3	impractical	practical	Efficiency
23	2,3	0,3	0,6	3	organised	cluttered	Efficiency
24	1,3	2,3	1,5	3	attractive	unattractive	Attractiveness
25	1,7	0,3	0,6	3	friendly	unfriendly	Attractiveness
26	2,0	1,0	1,0	3	conservative	innovative	Novelty

Items																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
6	6	2	1	4	5	5	6	3	2	5	2	6	7	6	6	2	3	2	4	3	5	2	1	3	6

5	6	3	2	3	4	4	5	5	3	6	3	5	5	4	5	2	3	3	5	1	5	2	4	2	5
5	5	1	1	2	5	7	7	4	1	6	1	3	5	6	5	2	1	1	5	2	4	1	3	2	7