TU WIEN Informatics

Analysis, Design and Prototypical Implementation of a Serious Game to Reduce Smoking

DIPLOMARBEIT

zur Erlangung des akademischen Grades

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im Rahmen des Studiums

Software Engineering & Internet Computing

eingereicht von

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an der Fakultät für Informatik
der Technischen Universität Wien
Betreuung: Thomas Grechenig

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ausgeführt am
Institut für Information Systems Engineering
Forschungsbereich Business Informatics
Forschungsgruppe Industrielle Software
der Fakultät für Informatik der Technischen Universität Wien

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Sylvia Winkler, Bsc

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Wien, 14. April 2021

Sylvia Winkler

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Kurzfassung

Nach Angaben der Weltgesundheitsorganisation (WHO) zählt Tabak zu den häufigsten Auslösern von vermeidbaren Krankheiten und Todesursachen weltweit. Jedes Jahr sterben über 8 Millionen Menschen an den Folgen von Tabakkonsum. Rauchen, eine der häufigsten Konsumvarianten von Tabak, erhöht die Wahrscheinlichkeit an kardiovaskulären oder respiratorischen Krankheiten sowie einer Vielzahl von Krebsleiden zu erkranken. Die Entwöhnung vom Rauchen wird allerdings durch die entstandene psychische und physische Abhängigkeit erschwert. Daher ist es das Ziel dieser Diplomarbeit, eine Anwendung zu entwickeln, die Raucher unterstützt, ihren Konsum zu reduzieren. Es sollte jedoch immer bevorzugt werden, den Tabak-Konsum komplett einzustellen. Die Anwendung wird für jene entwickelt, die die Anzahl an täglich gerauchten Zigaretten reduzieren möchten, es aber ohne Hilfe nicht schaffen.

Um die Anwendung an die Anforderungen der Zielgruppe anzupassen, wurde ein User-Centred Design umgesetzt. Dabei nahmen insgesamt 35 Teilnehmer in 4 Iterationen teil. In der Anforderungs-Analyse kamen unterschiedliche Methoden zur Anwendung, wie etwa Interviews, Brainstorming, Thinking-Aloud, Log-Daten Analyse und Fragebögen. Die gesammelten Ideen der Teilnehmer wurden in einem Prototypen umgesetzt wurden. Die iterative Entwicklung des Prototyps gab den Benutzern die Möglichkeit, unterschiedliche Entwicklungsschritte aktiv zu beeinflussen und mit ihren Ideen zu prägen. Durch die Nutzung von Gamification wurde die Motivation und das Engagement der Benutzer erhöht. Eine 6-köpfige Teilnehmergruppe testete den resultierenden Prototypen für eine einwöchige Testphase. Um die Auswirkung von spielerischen Elementen messen zu können, wurden die Nutzer in 2 Gruppen eingeteilt. Während einer Gruppe der volle Funktionsumfang zur Verfügung stand, konnte die andere Gruppe keine Gamification nutzen.

Das zentrale Element des finalen Prototypen war die Dokumentation der gerauchten Zigaretten. Die Testphase zeigte, dass dies von beiden Gruppen regelmäßig genutzt wurde. Außerdem empfanden die Benutzer die Möglichkeit, mit dem Rauchen assoziierte Emotionen zu protokollieren, als sehr nützlich. Die Nutzung von Gamification wurde ebenfalls positiv bewertet, besonders jene Elemente, die Fortschritt visualisieren, wie etwa Level, Erfolge und Punkte-System.

Keywords: *Rauch Reduktion, User-Centred Design, Serious Game, Plattform-übergreifende Entwicklung, Gamification*

Abstract

According to the World Health Organisation (WHO) tobacco is one of the leading causes of preventable illness and death worldwide. Each year 8 million people die from tobacco abuse. Tobacco smoke is associated with increased risk of serious cardiovascular, respiratory, and heart diseases. Different types of cancer are also associated with tobacco consumption. One way to reduce the risk to develop tobacco-related diseases is smoking cessation. But the psychological and physical withdrawal symptoms caused by tobacco consumption are creating an urge to smoke that is difficult to resist. Therefore the aim of this thesis is to develop an application that supports people who are willing to *reduce* their cigarette consumption. While smoking cessation should always be favoured, reducing is still better than continuing smoking as before. A void of support for these people was found. The target group for this thesis are therefore people who are willing to reduce their daily amount of smoked cigarettes but are unable to, without support.

A user-centred design approach was chosen, with a total of 35 participants. During the course of the initial design phase and four iterations, a variation of methods were used, such as: literature research, state of the art research, interviews, brainstorming, thinking-aloud, log-data analysis, user session, and questionnaires. The iterative development enabled the users to influence the design throughout the development with their ideas. The use of gamification and game elements was considered to increase the motivation and engagement. The implemented prototype was tested by smokers for a test period of one week. In order to evaluate the effects of the added game elements, the participants were split into two groups. One group had the full range of functionality, while the other group had only access to features without any gamification.

Requirements found to be crucial in order to reduce smoking, were the documentation of smoked cigarettes and associated emotions. The addition of game elements was received well, especially elements like levels, achievements, and points. These elements can be used to monitor, compare, and visualise progress. The use of gaming elements was integrated to keep users interested in the long term. It could be shown, that users are interested to document smoked cigarettes, and they are also interested to document emotions, associated with smoking.

Keywords: *Smoking reduction, User-Centred Design, Serious Game, Cross-platform Application, Gamification*

Contents

Kurzfassung **xi**

Abstract **xiii**

Contents **xv**

1 Introduction **1**
1.1 Problem Description 1
1.2 Motivation 3
1.3 Methodology 4
1.4 Research Design 5

2 Fundamentals **7**
2.1 Smoking Reduction and Cessation 7
2.2 Serious Games 15
2.3 Game Elements 21
2.4 User-Centred Design 27

3 State of the Art **41**
3.1 Crave-Out 41
3.2 QuitIT 42
3.3 Inspired 43
3.4 Quittr 44
3.5 Summary 46

4 Results **49**
4.1 Application and Adjustment of User Centred Design 49
4.2 Initial Design Phase 55
4.3 Iterative Development Phase 63

5 Discussion **99**
5.1 Research Question 1 100
5.2 Research Question 2 102
5.3 Research Question 3 103

6 Conclusion and Future Work **105**

Bibliography **109**

List of Figures **117**

List of Tables **119**

Appendix **122**
Pretest Questionnaire: Iteration 1 and 2 122
Data Collection Sheet: Iteration 1 124
Posttest Questionnaire: Iteration 1 and 2 125
Data Collection Sheet: Iteration 2 126
Questionnaire: Iteration 3 127
Use Case Diagram 133
Questionnaire: Final Prototype 135

CHAPTER 1

Introduction

This chapter provides an insight of the topic discussed in this thesis. The profound effects of smoking include health and social issues on a personal as well as on a public level. Therefore it is often discussed politically. This thesis provides an attempt to improve the situation, with the objective to provide an aid for smokers, to reduce their cigarette consumption. The introduction also gives an overview of the selected methodological approach as well as the structure of the thesis.

1.1 Problem Description

Tobacco kills more than 8 million people each year and is therefore one of the leading causes of preventable illness and death worldwide. Tobacco smoke is associated with increased risk of serious cardiovascular and respiratory diseases as well as heart disease and a variation of different types of cancer. Burning tobacco products release more than 4000 chemicals, 250 of which are known to be harmful and 50 to be carcinogenic. [1]

Especially respiratory organs such as the lung are affected from tobacco smoke. The risk to develop lung cancer is highly increased among smokers, with 9 out of 10 lung cancer patients being smokers. The World Health Organisation (WHO) [2] also states that tobacco increases the risk to six out of eight leading causes of death worldwide. Therefore tobacco consumption is a major health problem worldwide. The caused health issues are leading to increased health-care costs and lost productivity. Therefore is tobacco consumption also responsible for economic damage that affects individuals, families and countries worldwide. The damage is estimated to over half a trillion dollars each year. [3]

Smoking cessation is a solution to these problems. The positive impacts are proven and have been verified by multiple studies. Quitting decreases the stroke risk continuously, such that a former smoker can reach the stroke risk of a non-smoker within 5 to 15 years. Also the risk of developing lung cancer is halved within 10 years. [4, 5]

Smokers know about the risks and health issues they are exposing themselves to, they are also well aware of the costs of smoking, but still keep on smoking. The reason behind this, is that smoking tobacco is highly addictive and overcoming the urge to smoke is not easy. A strong psychological and physical dependence on smoking is built and the caused withdrawal symptoms make it that regular smokers keep smoking. [6, 7]

Overcoming the addiction created by nicotine is difficult and many smokers fail at suppressing their cravings. Only 3% of are able to stay abstinence within the first 6 month after quitting. The probability of relapse is especially high in the first days after quitting. The longer the period of abstinence, the lower the probability of relapse. [8] Success rate can be increased, when smokers use some form of further assistance. A variation of different approaches are offered to support smoking cessation. Popular methods are behavioural therapy, nicotine replacement therapy or usage of medication. [9]

Despite the addictive nature, smokers still want to change their smoking behaviour. In Austria more than half of all smokers are unsatisfied with their current smoking behaviour and are willing to quit or reduce their consumption. [7]

Smoking cessation should always be favoured compared to smoking reduction, but reduction is still better than continuing the consumption unmodified. Smokers with the will to reduce their tobacco consumption are faced with a lack of support. Therefore this thesis targets smokers who are willing to reduce smoking. Reduction is therefore defined as a decrease in the number of cigarettes smoked per day. The following research questions were defined:

> *Which requirements can be identified for a gamified smoking diary to increase motivation on reducing cigarette consumption?*

To answer this question it is essential to identify requirements. The main source for requirements was user feedback, another source was literature research. To gather requirements from users, a user centred design was implemented with an initial design phase and four subsequently implemented iterations. A total of 35 participants were involved throughout the process. The methods to gather feedback and evaluate interim results were varied to get the best results for the respective phase. Methods used were: literature research, brainstorming, questionnaires, user sessions, thinking aloud, log data analysis, and user testing.

> *Which elements of Serious Games and Gamification can be identified to support smokers in reduce smoking?*

This question can be answered by using the defined requirements. These were prioritised, selected and combined to design an application that supports the user in reducing the amount of smoked cigarettes. Gamification elements were chosen according to the users

liking and to create meaningful play. During the user centred design, users evaluated the application within four iterations. The feedback was used to improve the usability and usefulness of the application and resulted in a cross-platform prototype.

> *In what way can the consumption of cigarettes be reduced within the evaluation period by using a Serious Game?*

This question was answered by separating a test group into two groups and let them use the final prototype for one week. The first group had full access to all features, including the Serious Game, while the second group, had only a reduced set of features, without any gaming elements. The differences between the two groups were analysed and evaluated. This revealed the effect of the Serious Game and information about how users of both groups used the application.

1.2 Motivation

WHO started publishing reports of the global tobacco epidemic back in 2008. The goals were to monitor and track measures to improve global tobacco control. WHO established MPOWER as a policy package of effective interventions to reduce the demand of tobacco. MPOWER is an abbreviation where each letter stands for an evidence-based tobacco control measure that helps countries to implement effective actions. The measures of MPOWER are defined by the WHO as follows [10]:

- **M**onitor tobacco use and prevention policies
- **P**rotect people from tobacco smoke
- **O**ffer help to quit tobacco use
- **W**arn about the dangers of tobacco
- **E**nforce bans on tobacco advertising, promotion and sponsorship
- **R**aise taxes on tobacco

Smoking laws and the protection of non-smokers has been the subject for heated debates for years all over the world. In Austria the debate around the protection of non-smokers hit a peak when the federal government decided to cancel the complete ban on smoking in catering. The cancelled amendment would have been targeting the P of MPOWER - *protect people from tobacco smoke*. The law included the protection of non-smokers in places where food and drinks are processed or consumed as well as an expansion of youth protection. The reasoning to abandon the amendment was to protect the freedom of entrepreneurs. [11]

Afterwards a referendum was held in Austria in October 2018 where 881.692 (13.82% voter participation) people voted to maintain the previously determined amendment for the protection of non-smokers. The high participation made it the sixth most successful referendum in Austria. [12]

The aim of this thesis cannot be classified into MPOWER but is mostly related to the O measure - *offer help to quit tobacco smoke*. Currently smokers who want to reduce have a hard time to find support, because all the support is aiming to get smokers to quit. The motivation of this thesis is to reach a target group that has been neglected so far: smokers that are willing to reduce their daily cigarette consumption. Therefore a state-of-the-art cross-platform application was developed. The application aims to support smokers in reducing their consumption by documentation and rewarding mechanisms. The digital diary helps the user to keep track of the current tobacco use and emotions related to smoking are also documented. The tracking of smoked cigarettes and emotions is easily integrable into everyday life. The application aims to motivate the user to stick to the custom limit by including a game, where success is coupled with sticking to the self-imposed goals. By supporting the user in reaching the goal the application aims to have a positive influence on the users life.

1.3 Methodology

The aim of this thesis was to develop, implement, and evaluate a prototypical application in order to support people in reducing their daily cigarette consumption. To enhance availability it was developed with state-of-the-art technology for mobile platforms. Therefore cross-platform ability was emphasised to include as many users as possible. The implemented solution was tested by a total of 6 smokers to verify if they are willing to use such an application and if the application fullfils the desired goal of smoking reduction. A long-term evaluation of the application is not part of this thesis but can be pursued in the future.

The aim was to identify if motivation towards smoking reduction can be increased with the developed application. The inclusion of a serious game into the application was evaluated as well. The playful fundamentals of a serious game, aimed to increase the motivation of the user towards the application and encouraged them to reach the self-imposed goal. The idea was to increase the users interest in using the application, which in turn constantly remembered them of the self-imposed goal. The documentation of smoked cigarettes and related emotions could also help to make the user more self aware of behavioural pattern related to smoking and identify trigger situations. This could help the user to develop counter-measures in order to cope with cravings. The collected data was analysed in order to answer the research question of this thesis.

Figure 1.1 shows an overview of conducted iterations, methods used, number of participants per iteration, as well as the number of gathered requirements.

An integral part of the research phase was requirements engineering, which started with

Iteration ID	IT-0		IT-1	IT-2	IT-3	IT-4
Method	Literature Research	Brainstorming	User Session	User Session	Questionnaire	User Testing
Number of Participants	0	2	1	5	23	6
Determined Requirements	9	16	-	6	13	-

Figure 1.1: Overview of iterations

the initial design phase, also referred to as IT-0. This helped to gather an overview of the topic in general. The two main sources were literature and user feedback. A literature review was conducted to collect general information on the topic as well as an overview of comparable state-of-the-art applications. Consulting smokers provided a better understanding of smoking behavior, problems with smoking cessation and motivation to stop or reduce smoking.

The gained knowledge from IT-0 was combined and built the fundamental for the user centred design. The user centred design gave users a unique chance to influence the development of the application in order to fit their needs. Through critical analysis, a total of 44 requirements for a serious game were determined.

A total of 4 iterations, IT-1 to IT-4, helped to improve and refine the requirements and functionality. Incorporating users continuously during development gave them the possibility to influence the development with their ideas and requirements. In the end high-fidelity prototype developed as a cross-platform application for Android and iOS, was evaluated during a one week long test phase. To evaluate if the serious game is able to help smokers reduce their cigarette consumption and to see if gaming increases the users' motivation, users were divided into two group, each consisting of 3 participants. One group was using the application with its' full range of functionality, while the comparison group had only access to the diary without gaming functionality. Subsequently collected data was compared and the documentation of cigarettes was analysed. Besides the health and financial benefits for the user, the acceptance to use the application was of interest as well. A qualitative questionnaire after the test phase revealed the subjective perception of users in regard of usability and gameplay.

1.4 Research Design

This thesis is structured into 5 chapters, in which the main stages of this research are explained in more detail. An overview of chapters is given in the following.

Chapter 2: This chapter discusses fundamenalts relevant for this thesis. This includes medical information about smoking, addiction, smoking cessation and reduction. Theoretical fundamentals about serious games such as their intention, classification and related concepts are presented. Basics of game design are discussed and a theoretical description of the user centred design approach is given.

Chapter 3: In this chapter the state-of-the-art is discussed. This means applications, which are designed to support smokers. The emphasise is on applications which use gamification and have a scientific background. All applications are compared in a variation of criteria. Also the prototype developed within this thesis is compared with existing solutions.

Chapter 4: This chapter presents the results of this thesis. The adaptions of the user centred design are explained, as well as the implementation and its various iterations. This includes the development from the initial concept to a final high-fideltiy prototype, and its evaluation by participants for a one week test phase. An in-detail overview of participants is also given. This chapter summarises the data and results collected throughout.

Chapter 5: The results presented in the chapter 4 are discussed and evaluated in this chapter. With the gained knowledge the questions presented in section 1.1 are answered.

Chapter 6: This chapter assesses the completeness of this thesis, potential extensions as well as shortcomings.

CHAPTER 2

Fundamentals

This chapter describes the fundamentals for this thesis. First, health issues related to smoking and difficulties with reduction and cessation are explained. Then a definition and general information about serious games are given. Approaches to categorise serious games and related concepts are presented. The fundamentals of gamification are discussed and game elements are categorised and described. In addition this chapter includes a theoretical description of the methodical approach of a user-centred study.

2.1 Smoking Reduction and Cessation

Data published by Statistik Austria [13], the Austrian statistical office, shows that the total number of daily smokers in Austria older than 16, increased slightly from 48,5% in 1972 to 48,9% in 2014, as seen in figure 2.1. The figure also shows the development of daily smokers separated by gender. While the number of men smoking dropped from 38,7% to 26,7% (-11,8%), the corresponding number for women has more than doubled from 9,8% to 22,2% (+ 12,4%).

Also the amount of cigarettes smoked per day varies between the genders. Of all men who are smoking the average of cigarettes per day is 17, and women who are smoking consume an average of 14 cigarettes a day. [14]

2.1.1 Health risks

Smoking is a preventable risk factor for a variety of diseases that can be classified in cardiovascular diseases, respiratory diseases, cancer, and other influences like skin ageing and dental diseases. The risk to get cancer is increased among smokers. Smoking increases the risk for lung cancer, as well as other cancer types like: esophageal, liver, kidneys, pancreas, and many more. Cardiovascular diseases caused by smoking are for example arteriosclerosis. Smoking is also responsible for harmful deposit in vessels, which prevents

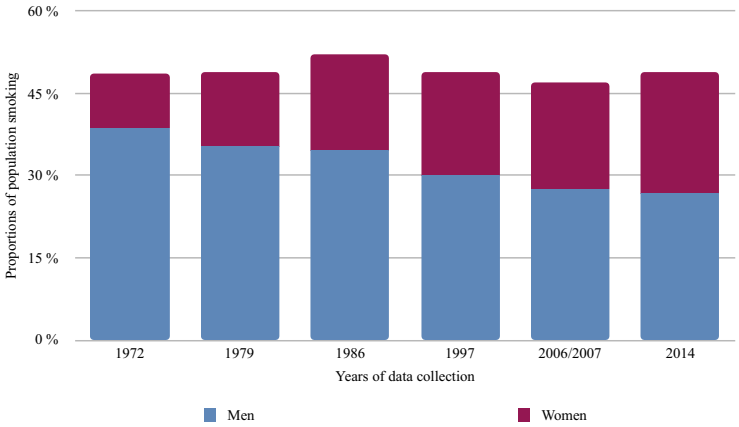

Figure 2.1: Daily smokers in Austria older than 16 years, separated by gender and in total [13]

sufficient blood flow. This leads to the constriction of blood vessels, with the result of a higher pulse, decreased skin temperature, caused by poor circulation and increased metabolism. More harmful effects are heart attack, stroke, or peripheral arterial occlusive disease. [7]

One component of tobacco is nicotine, which is poisonous and lethal at a dose of 50mg. The nicotine dose contained in one cigarette is 13mg but only 1mg is absorbed during smoking. [7]
Apart from nicotine, burning tobacco releases more than 4000 chemicals, of which 250 are known to be harmful and 50 are known to be carcinogenic. [1]
These harmful substances in tobacco are released by burning tobacco products and enter the body trough inhalation. This leads to respiratory diseases, which are caused by smoking because the substances in tobacco smoke cause an inflammatory reaction in the respiratory tracts. Which then may lead to breathing difficulties, chronic cough, and the chronic obstructive pulmonary disease (COPD). Smoking is the most common cause of COPD, and 90% of the people suffering from COPD are smokers or former smokers. Harmful substances in tobacco smoke can damage skin cells and leads to premature skin ageing. [7]

These effects are not only affecting the smoker itself. Smoke released into the environment is also inhaled by people around. Second-hand smoke is classified to be exhaled by the smoker and emitted by the lit cigarette, also called sidestream smoke. [1]
Sidestream smoke is three times more toxic and was found to be up to six times more tumor-inducing. Second-hand smoke increases the risk to smoke related health issue, as listed in the following [15]:

- Lung cancer: 20% increase
- Asthma: 50% increase

- Stroke: 80% increase
- Coronary heard disease: 20% increase
- COPD: 30% increase

Worldwide tobacco is associated with the death of more than 8 million people each year, 1.2 million of those as a result of second-hand smoke. [1]
In Austria a total of 12.000 to 14.000 people die each year in Austria due to the consequences of smoking and about 1.000 due to second-hand smoke. [16, 17]

While the exposure to tobacco toxins affects people of all ages, it is especially harmful for children and babies. Children who are exposed to tobacco smoke develop weaker lungs which increases the risk for several health problems. Such as increased susceptibility to acute respiratory infections, ear problems and more severe asthma (more frequent attacks and attacks being more serious). [18]
Also the birth weight of newborns is reduced by 40% if the mother is exposed to second-hand smoke. [15]

2.1.2 Smoking Addiction

Smoking is classified by the International Statistical Classification of Diseases and Related Health Problems (ICD) [19] in the categories *F17 Mental and behavioural disorder due to use of tobacco* and in *F17.2 - Dependence syndrome* defined as: [19]

> *"A cluster of behavioural, cognitive, and physiological phenomena that develop after repeated substance use and that typically include a strong desire to take the drug, difficulties in controlling its use, persisting in its use despite harmful consequences, a higher priority given to drug use than to other activities and obligations, increased tolerance, and sometimes a physical withdrawal state."*

Smoking tobacco is highly addictive. Addiction is defined as a mental dependence on a substance. The addictive substance in tobacco is nicotine. Nicotine enters the lungs upon inhalation of cigarette smoke, is then absorbed by the bloodstream and distributed through the body. The brain and the nervous system reacts, pleasant feelings are induced and unpleasant feelings are diffused. [6]
The immediate effects of smoking a cigarette can be a brief relaxation, a calming effect, increase attention, enlighten mood and inhibit appetite. [7]
This means that the mood is positively affected by smoking and to regain the pleasant emotional state, a craving for the next cigarette arises. By regular smoking the body adapts to nicotine and the dose needs to be increased to achieve the same effect. [6]
A dependence on nicotine develops in a couple of weeks and can affect the life of affected person tremendously. [7]

Smokers suffer from their addiction but stopping is not easy, especially an abrupt end is uneasy because of the formed dependence. Quitting leads to withdrawal symptoms. The symptoms are both physical and mental. Most common withdrawal symptoms are irritability, nervousness, headaches, and trouble sleeping. But also dizziness, depression, feeling of frustration, impatience, anger, anxiety, trouble concentrating, restlessness, boredom, increased appetite, slower heart rate, constipation, dry mouth, sore throat, and chest tightness can be caused as a result of smoking cessation. [6]
These physical withdrawal symptoms are the strongest two days after quitting, decrease over time and disappear after three weeks. The psychological dependence is much stronger and even years later the urge for a cigarette can arise. Therefore the dependence of nicotine is comparable with kokain or heroin. [7]

Apart from the physical dependence it is also a mentally triggered behaviour. Over time smoking becomes a habit which is often linked with activities. To the point where a certain activity can trigger the desire to smoke. These rituals are an important part of the addictive behaviour and with these links established it is even harder to break the habit. These links between environmental stimuli and smoking are also called conditional relationships. [6, 7, 20]
Typical situations for conditional relationships are after meals, when drinking alcohol or coffee, during social situations with friends or other people who are smoking, being in a car, being outdoors, or on a work break. This was determined in a study conducted by Shapiro et al. [21] where connections between emotions, activities and smoking were inspected. 21 female and 26 male smokers self-reported to an electronic diary their locations, activities, posture, consumption, social context, moods, and internal states. Participants stated to be less likely to smoke while reading, working, writing or typing, being with co-workers, or lying down. The selected moods for them to report were an urge to smoke, hungry, bored, happy, irritated, relaxed, stressed, and tired. The results showed the moods connected with smoking are an urge to smoke, feeling happy, feeling stressed, and a decreased feeling of hunger. The associated feelings were both negative and positive.

2.1.3 Cessation vs Reduction

The prime reason why people want to quit smoking are health issues. From the health perspective smoking cessation is more desirable than smoking reduction, nevertheless smoking reduction is still better than regular smoking. Smoking reduction is defined as smoking less cigarettes from the individual amount of cigarettes that were smoked before. [16]

Three of the main fatal conditions caused by smoking are ischaemic heart disease, lung cancer, and chronic obstructive pulmonary disease. These diseases have a dose-response relationship, which means that the level of smoking and the risk of developing or dying from one of these diseases is connected. Smoking reduction results in a decreased exposure to tobacco and other toxins contained in a cigarette. [20]

Smoking reduction should be considered for two groups of people [16]:

- People who are willing to quit, but unable
- People who are not willing to quit, but to reduce

A study conducted by Godtfredsen et al. [22] with 19,714 participants showed a 27% decrease in lung cancer risk, when smoking was cut down by 62%. This shows that lung cancer risk and smoking reduction have a disproportional correspondence. Light smokers, classified as people who smoke less than 15 cigarettes a day, and smokers who quit smoking had a considerably lower risk compared to regular smokers. [22]
A smoker who successfully quits can halve the risk of developing lung cancer after 10 years of not smoking. [5]

Shah et al. [23] showed with a collection of studies the dose-response relationship between tobacco consumption and stroke risk. Whereas light smokers, defined as smoking less than 10 cigarettes a day, were found to have a decreased risk for stroke. An increase in stroke risk was shown with an increase in smoking. [5, 23, 24]
It was also shown that quitting leads to a continuos decreasing risk for stroke, to the extend that former smokers have the same stroke risk as a non smoker after 5 to 15 years. [4]

Reduction can also serve as an intermediate step to complete cessation. Evidence shows that smoking reduction can lead to smoking cessation. The reasons for this are manifold. The reduction of tobacco could reverse the adaption to tobacco. The two main reasons that hinders people from quitting are withdrawal symptoms, and their craving for a cigarette. Both of these obstacles can be weakened by reduction. Reduction helps to decrease the severity of withdrawal symtoms and carvings are weakened. With reduction the typical situations to smoke are not proceeded as usual and therefore the formed conditional relationships between environmental stimuli and smoking can be disrupted. This helps to reverse the behavioural pattern which once lead to smoking and tobacco addiction. Beside these effects the self-efficacy, which is a persons individual believe in the ability to succeed, can be encouraged by the progress a smoker experiences with smoking reduction. [20]

The quit rate among smokers who reduced their consumption by 50% were 1.7 times higher compared to smokers who did not reduce their consumption first. The highest quit rate could be determined among those who reduced to 15 cigarettes or less per day. Maintaining the reduction over extended periods of time was found to be an issue. [22, 25]

A variety of methods can be used to support a smoker to quit. Programms for smoking cessation are often based on a combination of drug therapy and behavioural therapy. In behavioural therapy a therapist supports the smoker to identify trigger situations, develop suitable countermeasures, and avoiding relapses. Drug therapy focuses on

reducing withdrawal symptoms by using nicotine replacement products. Most common products are patches, chewing gums, sprays, and pills. Chewing gums release nicotine through chewing which is absorbed through the oral mucosa and patches release nicotine continuously through the skin. The advantage is that these products do not contain the various other harmful substances that are inhaled while smoking. The nicotine dose is gradually decreased over time and the patient can focus on changing their behaviour. Whereas 10 out of 100 people are able to quit smoking successfully without nicotine replacement therapy, 13 to 16 out of 100 people are successful with the help of supplied nicotine. [9, 26]

An alternative approach to quit or reduce smoking, without nicotine replacement, is to use a protocol. The use of a protocol helps to understand trigger situations and actively think about the reasons why a cigarette is smoked. It is suggested by Bernhard et al. [16] to record at least the date, time and activity before smoking. More advanced protocols also include location, social situation, mood and reasons why the cigarette is smoked. In order to reduce smoking by using a protocol, the smoker has to record the data first, and is then allowed to smoke. The sequence of actions is important and this simple step is considered to reduce the amount of smoked cigarettes by a third. [16]

Zigarette Nr.	Uhrzeit	Wichtigkeit	Ort und Tätigkeit	Personen	Stimmung oder Grund
1	7:00	5	Frühstückskaffee	Familie	müde
2	7:45	3	an der Bushaltestelle	Hr. Müller	angeregtes Gespräch
3	8:10	4	am Schreibtisch	allein	gehetzt
4	...	...	...	...	...

Figure 2.2: Example of a smoking protocol [27]

Rauchfrei [28] is the austrian advisory service to quit smoking, it is proposed to use a protocol when the smoker wants to quit smoking. It is recommended to start using the protocol for at least three days, which should include one weekend day as well as two business days. The smoker records every smoked cigarette to learn about the smoking behaviour. The importance of each smoked cigarette is rated on a scale from 1 to 5. An example of a protocol can be seen in figure 2.2. [27]

Such a protocol can then be used to evaluate reasons why and when the need for a cigarette occurs. This is the foundation that helps the smoker to identify patterns that usually involve smoking. The smoker can then begin to evaluate strategies to be prepared for critical situations. It is suggested to carry the protocol with you all the time either physically or as a mobile application, so that every cigarette can be recorded immediately. Figure 2.3 shows an example of such a protocol. [29]

Rauchprotokoll

Anmerkung: Die Wichtigkeit der Zigaretten können Sie nach folgendem Schema eintragen:
5 = ganz wichtig **4** = sehr wichtig **3** = wichtig **2** = eher unwichtig **1** = unwichtig/unnötig

Zigarette Nr.	Uhrzeit	Wichtigkeit	Ort	anwesende Personen	Stimmung oder Grund	Tätigkeit
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Figure 2.3: Example of a smoking protocol [29]

2.1.4 WHO Framework Convention on Tobacco Control

The WHO Framework Convention on Tobacco Control (WHO FCTC) is a global control instrument that provides direction for tobacco control policies. [30]

Therefore MPOWER was introduced, a collection of measures directed towards countries to reduce the demand of tobacco products. Figure 2.4 shows how many people globally were covered by MPOWER measures in 2008. It collects essential elements and is based of six evidence-based components [10]:

- **M**onitor tobacco use and prevention policies
- **P**rotect people from tobacco smoke
- **O**ffer help to quit tobacco use
- **W**arn about the dangers of tobacco
- **E**nforce bans on tobacco advertising, promotion and sponsorship
- **R**aise taxes on tobacco

Monitor

Accurate measurements are collected so that tobacco caused problems can be analysed and effective countermeasures implemented. Collected data also helps to evaluate the effectiveness of the implemented MPOWER strategies. To ensure the significance of data monitoring must follow standardized and scientifically valid methods to collect and analyse data. Standardized questions and surveillance measures are used. [31]

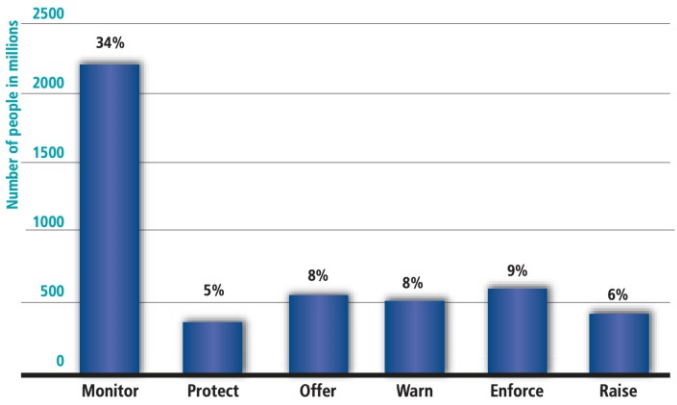

Figure 2.4: Percentage of global population covered by MPOWER in 2008 [31]

Protect

Smoking is the cause to many diseased and no level of exposure is safe. Therefore protecting people from tobacco smoke in indoor workplaces, public transport, indoor public places and other public places is necessary. Smoke-free environments not only protect non smokers from second-hand smoke, but it also helps smokers who want to quit. [32]

Offer

Quitting tobacco use is not easy, but most people who are educated about health risks want to quit. Successful cessation can be promoted by support and medication. Telephone help lines can offer advice to quit smoking, but abstinence needs to be maintained as well. Cessation support in combination with medications have shown to be an effective way to quit smoking. [33]

Warn

Addictiveness and health risks of smoking and second-hand smoking are often underestimated. To educate the public about the full extend of health risks, comprehensive warnings are critical. Especially in middle- and low-income countries risks are often underestimated. Two effective strategies are warning labels on tobacco packaging and anti-tobacco advertisement. [34]

Enforce

Tobacco advertisement, promotion and sponsorship increase the social acceptability of the use of tobacco products. Potential consumers falsely associate tobacco with desirable qualities. Therefore bans on advertising can protect people to fall for marketing tactics.

This is especially important for young people who have not yet started using tobacco. [35]

Raise

The most effective way to decrease tobacco consumption is to increase taxes on tobacco products. Higher pricing have the effect, that people consume less, are less likely to relapse after quitting, and young people are less likely to start using tobacco. [36]

2.2 Serious Games

This section gives an overview about Serious Games. After a definition, the areas of application will be discussed, and a classification of serious games will be given. Limitations of serious games and explanation of related concepts will give a clear understanding of serious games.

The idea of applying games to a serious aspects of our life is based on the idea of utilising fun to increase certain behaviour. Fun is a feedback mechanism that makes us repeat certain activities over and over. Therefore a system that is fun will be used more compared to a system without fun. [37]

Serious Games were first defined by Abt [38] as games with an educational goal compared to games which are played just for fun. However the serious purpose as a primary goal does not exclude entertainment. A serious game always needs to be entertaining as well. This means that serious games combine learning and having fun, but go beyond teaching facts and help memorisation. They include all aspects of education, such as teaching, training and informing. The balance between education and entertainment is important. [39]

Serious games can be distributed on a variety of platforms, such as consoles, smartphones, etc. Every platform comes with its own advantages and disadvantage. Therefore the platform that features the purpose of a serious game the best, should be favoured. Topics of serious games vary depending on the goal of the game. Serious games can not only improve the users knowledge or skills but can also lead to a behavioural change. [40] This can be done by demonstrating the user how to apply newly earned knowledge to situations within the game, which then be transferred to the real world and therefore make an impact on the users everyday life. Different techniques can be used to provide knowledge to the user, such as teaching a lesson, or providing an experience. By choosing the right technique the influence of a serious game can reach way beyond the screen of a device. [41]

These techniques can be applied to a broad area of application. So that serious games have been used in military, education, professional training, marketing as well as medicine and health. [39, 42]

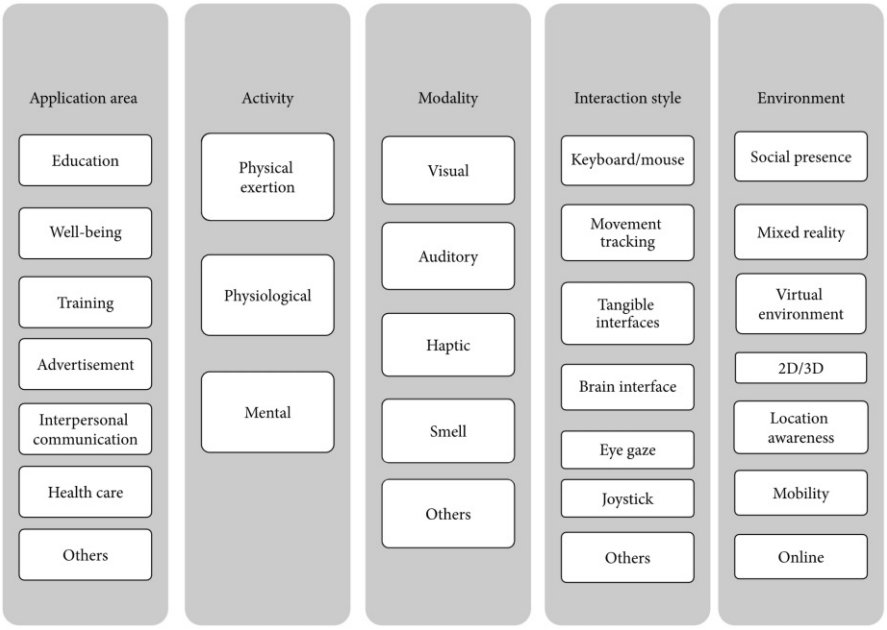

Figure 2.5: Taxonomy of serious games [43]

2.2.1 Classifying Serious Games

A taxonomy for serious games was developed by Laamarti et al. [43]. The taxonomy is build on the characteristics that were identified to potentially make a significant difference in the success of a serious game. The taxonomy consists of five main categories, as seen in figure 2.5 and further described in the following [43]:

- **Activity:** This referes to the activity that the player performes in order to succeed in the game. Activities can be physical exertion, physiological or mental activities. Physical activity is used in games for well-being or obesity related games. Games for rehabilitation or the detection of health conditions use physiological activities and mental activities are associated with education, training or interpersonal communication.
- **Modality:** Modality is the channel by which information is communicated from the application to the user. From a users perspective this is how serious games are categorised by how the player experiences the game. Modalities are separated in visual, auditory and haptic. Depending on the purpose of the application, appropriate modalities can enhance the users experience and increase the success of the application.
- **Interaction Style:** The interaction style defines the interaction of the player with the game. Traditional interfaces are keyboard and mouse, more advanced interfaces are brain interface, eye gaze, movement tracking and tangible interfaces. Biosensors

that collect biological data such as a heartbeat rate can add valuable input for the game. The interface decision has an tremendous influence on the success of the game.

- **Environment:** The environment of a serious game can be manifold, also a combination is possible. The first category for environments is whether the serious game is 2D or 3D. The next category focuses on virtual and mixed reality environments. Virtual reality means a computer-generated immersive environment, that can be purely imaginative or representing the real world. Other categories are location awareness, for games that make use of the users current location, mobility, internet ability, and social presence (single or multiplayer).
- **Application Area:** This refers to the possible application fields of serious games. The most important application areas are education, advertisement, health care, well-being, cultural heritage and interpersonal communication.

Ratan et al. [44] developed a classification system based on a dataset of over 600 serious games. Serious games were categorised in four dimensions, with each dimension being separated into further categories [44]:

- **Primary educational content:** This is the reason why the game exists. It elevates the game from being simply entertaining to a serious game with a purpose. The primary educational content types are: academic education, social change, occupation, health, military and marketing. It is explicitly stated that a serious game can include more than one primary education content.
- **Primary learning principles:** Serious games have the unique advantage to deliver educational content in a variety of methods such as exploration, experimentation and problem solving. Learning principles used in serious games are categorised in: practicing skills, knowledge gain through exploration, cognitive problem solving, or social problem solving.
- **Target Age Group:** The target group of a serious game is often classified by age. Four age groups were defined: Preschool and below, elementary school, middle school and high school and college, adult and senior. The category of adults and seniors includes a broad age range, because serious games for that age category are not targeted at a specific age range but rather for a specific target group. Therefore further separation would not offer an additional advantage.
- **Game Platform:** The chosen platform has an impact on how effective the serious game can transport the content to the user. Different platforms have different control interfaces, screen sizes, and mobility characteristics.

The two classifications provide different categories for serious games. Interaction Style and Game Platform are both focusing on the interaction between user and device. The

other categories show different aspects of serious games. A combination of both results in a detailed classification for serious games.

2.2.2 Serious Games in Healthcare

One area of application for serious games is healthcare. These games have a direct or indirect positive effect on the users physical or mental health. [39]

The special characteristics of serious games in healthcare are especially interesting within the target group, as well as the area of application. These two categories are explained subsequently in more detail.

Target Group

Serious games for health have two main target groups. The first group is medical staff. Serious games are used during education and further training to support medical staff in learning new skills and expertise. Serious games offer training in form of simulations e.g. surgical training. [39, 40, 42]
The second target group are patients. Serious games in this category are developed specifically to positively influence the users health by providing knowledge and forming new habits. [42]

Area of Application

Serious games can be used as therapeutic support for psychological and physical diseases. They can also provide coping mechanisms to enable the player to deal with specific challenges.
Serious games can for example be used for prevention, to raise awareness and therefore reduce risky behaviour. [40, 42, 44]
They can also be used for awareness campaigns to promote a balanced diet, physical exercise as well as educational campaigns for HIV/AIDS, cancer or diabetes prevention. [40]
Another important area of application is the support of recovery and rehabilitation for certain conditions or after surgery. They provide specific exercises to increase motor skills. The diagnosis and treatment of mental conditions is another area of application. Serious games have been used for diagnosing and treating mental illnesses. [39]
Furthermore serious games can increase physical fitness, often referenced to as exergaming - which is a composition of exercise and game. The goal is to be physical active in order to succeed in the game. [39, 42]
Distraction therapy is another application area of serious games. For patients who are chronically ill, a game can provide distraction during uncomfortable treatments. This can help patients, especially children, to deal with pain. [39]
Another advantage of serious games regarding chronic diseases is that they can help to improve self-management. Patients suffering from diseases like asthma and diabetes are often confronted with the need to adapt their lifestyle and habits in order to deal with

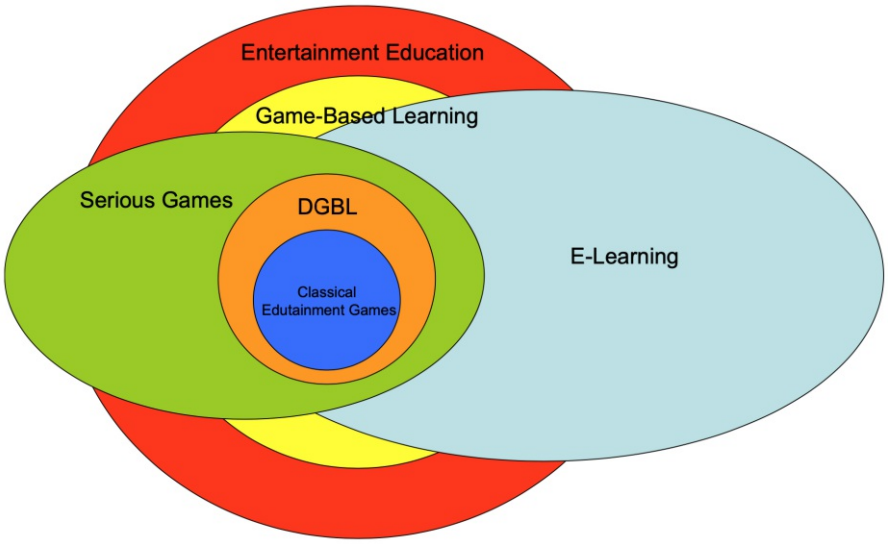

Figure 2.6: The relations between serious games and similar educational concepts [45]

the disease. Games can also promote changes in the player's behavior or future choices to establish a healthy lifestyle. [41]
Serious games can also help to improve the control of mental and emotional states. These games make use of biofeedback equipment. By measuring heart rate and skin conductance the game can give feedback on the players emotional state. [39]

Serious games for health are no alternative to doctors or therapists. They can only support and enhance the treatment. An observer mode for the therapist or physician, to monitor the patients progress, offers a beneficial feature in order to supports the therapy. The possibility to adapt the difficulty for patients individually and create patient-specific levels leads to a customisable game with a high value for the patient. The risk of exacerbating a problem or creating a new one with an inappropriate game needs to be taken into consideration as well. [41]

2.2.3 Related concepts

The idea of using the potential of games to teach educational content is not unique to serious games. A variation of related concepts emerged over time. [39]
The most relevant are edutainment, e-learning, game-based learning, and gamification. The basic idea of these concepts are similar and often overlap. Therefore a clear separation between the categories is not possible. [40, 42]

Figure 2.6 shows an overview of related concepts, the most common concepts are described and compared to serious games in the following section.

Edutainment

Edutainment is defined as education through entertainment and usually refers to video games with educational goals. The definition does not exclude any non-digital educational methods as long as they are entertaining as well. [39]
It can also be described as a playful multimedia learning environment or an entertainment providing educational aspects. [40]

Edutainment also uses games as a reward for learning and is targeted at preschool and young children. Therefore the topics covered are school related like languages, mathematics, physics or chemistry. [42]

According to Ratan et al. [44] every edutainment game is also a serious game but not vis versa. Serious games extend beyond the concept of edutainment. Edutainment is considered a subset of serious games. [41]

E-learning

E-learning is a concept that can be described as computer-enhanced learning or interactive technology as well as distance learning. [39, 42]
Therefore E-learning is a more general category where digital media is used for the presentation and distribution of teaching content as well as communication support. Serious games are partly in the same category as E-learning. [40]

Game-based learning

Game-based learning is a term that summarises games used for education and teaching. These games are designed to make the user feel more like playing rather than learning. Engagement and learning are equally important, otherwise the game is an educational game or a regular game. The game is creating the motivation and the player is unaware of the ongoing learning process. [40]
So that learning happens informally and the main reason to play the game is the entertainment the player gets from it. Game-based learning is based on the concept, that having fun playing does not exclude learning at the same time. [42]

A distinction is made between game-based learning and digital game-based learning, where digital game-based learning as the name suggests is restricted to digital games. [39]

Comparing the approach of game-based learning to serious games has one determined difference which refers to the consciousness of learning. Game-based learning tries to sneak in content without the user knowing it while serious games are based on conscious decisions made by the player. [41]

Gamification

Gamification is used to promote learning and engagement with elements that are usually known from game design. These elements are used in a non-game context to initiate game thinking. [46]
These elements are used to increase motivation as well as the the users activity. Typical game elements used for gamification are points, badges, levels, and leader boards. Game elements are defined as a set of building blocks characteristic to games. They are found in most games but they do not make everything automatically a game. The difference between gamification and serious games is evident. A serious game is a wholesome game with an additional non-entertainment purpose. An application which is gamified incorporates some game elements but it is not considered a game. [47]

Kapp [46] defines serious games as a subset of gamification.

2.3 Game Elements

This section provides the fundamentals of games in general and game elements. Starting with a definition of games and followed by a collection of the most commonly used game elements.

A definition for games is given by Abt [38]:

> *"Reduced to its formal essence, a game is an **activity** among two or more independent **decision-makers** seeking to achieve their **objectives** in some. **limiting context**"*

The four major terms used in this definition are described by Salen et al. [48]. A game is an **activity**, a progress or an event. The player is called **decision-maker** and every game requires players that actively make decisions. The **objectives** are the goals of the game. The rules of the game are called **limiting context**, these rules provide limits and structure to the activities.

The problem is that this definition is too broad and too narrow at the same time. It is too narrow because not all games are a contest where players work against each other. This excludes cooperative games, where players work together to achieve a common goal. The definition is at the same time too broad because it includes everyday situations e.g. elections. [38]

Salen et al. [48] compared various definitions of games and aggregated the principles. The result is the following definition:

> *"A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome."*

In this definition the participants of a game are called players. Players interact with the system of the game. The system itself is a defined set of objects which stand in a relation to one another and form a complex whole. Because of the boundary between real-life and the game, the conflict is defined as artificial, both in time and space. The central element of a game is the conflict which embodies the contest of powers, this can be cooperative or competitive. A conflict can occur between a single player and the game system or between multiple players. [48]

The rules provide structure and specify the possibilities of action within the game. Rules create the artificial structure where a defined sequence of play can happen. The outcome of a game is a quantifiable goal, which means that at the end of a game a player has either won, lost or earned some kind of numerical score. In other words the outcome is quantifiable. The player clearly knows if the game is lost or won. [46, 48]

Games can be categorised in two major categories: non-digital games and digital games. The main advantage of digital games compared to non-digital games are the following four characteristics [48]:

- **Immediate interactivity** refers to the instant feedback a player receives after some form of input. The ability of a digital game to respond to user's input seamlessly and dynamically is a trait that digital games master gracefully. According to Kapp [46] feedback should be instant, direct, and clear. This helps the user to change their behaviour.
- **Information manipulation** is used to hide information from the player and reveal it when the time has come. This can be used to teach the rules of a game while playing, without overwhelming the player.
- **Automate complex system** means to abstract the complexity of a system and make game play easier for the player.
- **Communication over a network** has become very easy with digital games. With a wide variation of communication types reaching from text chat, audio, and real-time video communication. Especially long distance communication in real-time has been enabled by the use of digital networks.

These characteristics are not unique to digital games and can be implemented in non-digital games as well, but they are usually more pronounced in digital-games.

Information manipulation can also be used to introduce a new user into the system. This is a sensible time where the user needs time to experience the system without being interrupted or overwhelmed. Excessive explanations at the very beginning can reduce the interest of a novice user. Explanations should be saved until the user actually cares about the system. Interactive experiences combined with rewards are a good way to introduce users to a system. Users should not fail on the first interaction with the game.

Complexity is revealed slowly so the user can absorb the new information and learn as it goes. This is training the user how to achieve rewards. [49]

Hunicke et al. [50] defines the distinct components of a game as the three components: rules, system, and fun. These components are established by three levels of abstraction: mechanics, dynamics, and aesthetics. The meaning of the three components are described in the following [50]:

- Mechanics: Components of the game at the level of data representation and algorithms.
- Dynamics: Behaviour of the mechanics during gameplay, reaction to player input.
- Aesthetics: Players emotional response during interaction with the game.

These three levels of abstraction are used by the designer to create engagement from the player by using mechanics to create a dynamically behaving system, that offers an aesthetic experience for the user. [49, 50]

Designing a game in iterations helps to tune for the desired outcome and behaviour. By adjusting the mechanics the game's dynamics changes. This helps to create a well balanced game. An example is to change the value of penalties and/or rewards to even out gameplay. [50]
Zichermann et al. [49] describes game mechanics as building blocks of a gamified experience. Although the number of mechanics is finite by combining different mechanics, a endless variation of games can arise.

In the following sections the most common game elements are categorised.

2.3.1 Rewards

Rewards are a basic building block of any game. Depending on the game, a wide variation of rewarding systems are available to fit every specific game. Rewards can be granted to players by status, access, power, and game related items. These are applied to a game by using leaderboards, badges, items, etc.[49] The most frequently used rewarding systems are described in more detail subsequently.

Badges

Badges are commonly used as a reward system in games and gamified applications. A badge is a visual acknowledgement showing the user that a task or action has been completed successfully. [49, 51]
They can also be utilised to be shared with other players and therefore to gain social recognition for their success in the virtual world. [52]
Badges target at the urge to collect. Users try to collect rare and special items in a game, which is a strong amplifier for engagement. [53]

This can have a powerful impact on players and their playing behaviour. Badges can also be used as a surprise. The unexpected reward is pleasantly surprising the user and therefore triggers a pleasant feeling. The balance between predictable and surprising badges needs to be considered. [49]
Unpredictable rewards are able to create a long lasting engagement, whereas fixed-interval reinforcement tends to result in a low engagement with the player. [52]

Points

Points are used to reward players and provide instant feedback. [52]

According to Zichermann et al. [49] points are the base of any gamified system. Users can gain points for a multitude of reasons. They can be categorised in a variation of point systems [49]:

- Experience points (XP): These points are used to watch, rank and guide players. They are earned by actions the user performes within the context of the game. XP is defined so that they never decrease.
- Redeemable points: Redeemable points are used to be exchanged for items in the game. In contrast to XPs redeemable points can fluctuate. They function as a currency and are the foundation of a virtual economy. They are often named coins, bucks, or cash.
- Skill points: Skill points are earned by users by performing a specific activity. They are used as an additional set of points to guide the player to pursue alternate tasks and subgoals.
- Karma points: The user has no benefit to keep karma points, the benefit only arises when they are shared. They are used to create a behavioural pattern and promoting certain behaviour.
- Reputation points: Reputation points are the most complex point system. They are used if a system requieres trust between several parties.

Different points systems can be combined to meet the objective of the game design. The use of multiple currencies within a game can establish a system where different points can be used for different objectives and therefore enrich the game experience. [49]

A currency of any kind can be used to simulate virtual economies and therefore providing the base of a virtual marketplace. [49, 53]
This is especially useful for multiplayer games. It gives users the ability to assign values to items and therefore enables trading. [53]

Access

A reward in form of access can be granted by giving a player prioritised and early access to certain areas. The concept of rewarding a user with power can often be found in gamified systems where the user gains moderation rights and is therefore more powerful than a regular user. [49]

2.3.2 Progress

Progress and the communication of such is a important source of feedback for the user and builds intrinsic motivation.[37]
It helps the user to understand the purpose of the game by following activities that advance the progress. [49]

Level

Levels are one way of defining progress in a game. By travelling through levels the user also experiences different levels of difficulty. Every successfully finished level leads to the next level, which is more complex and the user has to put in more effort to be successful. [52]
It is recommended by Zichermann et al. [49] to increase difficulty in a curvilinear manner and not linear. Level design needs to follow three basic rules [49]:

- Logic: Levels need to be logical, so that the player understands the goal of the level.
- Extensible: The ability to add new levels helps to make the game extensible by adding new levels, even after an initial end level.
- Flexible: This means that levels are testable and the design of the level can be refined. This is important for level balancing.

Being logical is also emphasised by Salen et al. [48] as in, the user need to understand what contributes to the success of a level. A clear winning and loosing condition is therefore indispensable. One way of indicating the users progress within a level are progress bars. They are basically used to show the user how much more is needed in order to complete a task. [49]

Challenge

Challenges are defined as a progress performed by the user towards a defined objective. [52]
They are used in games to add depth and meaning for the player. Ideally a player is able to choose from multiple challenges. [49]
In a more abstract sense the game challenges the players so that they achieve goals. As

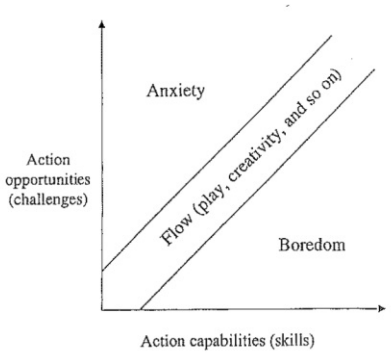

Figure 2.7: Flow State [54]

soon as the player is no longer challenged the chance that boredom occurs is highly increased. This leads to a rapid loss of engagement. [46]

To reinforce the motivation of the player towards the game it is crucial to keep a state between anxiety and boredom. This interplay of emotions keeps the player interested and with the feeling of wanting more, therefore the player keeps playing. [46, 49]
This feeling of wanting to play more is a concept that is called flow. The concept of flow was first introduced by Nakamura et al. [54] and is defined as follows:

> *"Flow is experienced when perceived opportunities for action are in balance with the actor's perceived skills."*

This means that the challenges the player is facing always need to be appropriate to the abilities. Although players will bounce out of the flow state it it important that there is a way to regain the flow state. To find the balance between challenge and skill is important for the user to stay in the flow state. By mastering a challenge the user's skill level will increase so that the activity needs to evolve as well. This keeps the user challenged and further improvement is needed. This will lead to a continuous experience of flow. Figure 2.7 shows the balance of the user between anxiety and boredom. [54]

Achieving flow means that the player is in a state between anxiety and boredom over a period of time. If the challenge is too complicated the anxiety level rises, the user is overwhelmed and goes into a shut down mode. If however the challenge is too easy the user will get bored and engagement drops. The difficulty in designing challenge for a game is that it needs to increase in proportion to the skills of the player. [49]

Feedback

Feedback is a crucial part of progress, because feedback helps the user to progress towards the objective. Typically feedback is instant, direct, and clear. This helps players to adapt their behaviour according to the received feedback. Feedback can be positive and

negative. When the player gets feedback, the player will attempt to correct or reinforce the behaviour accordingly. [46]
To ensure that the players interaction can adapt with feedback, it needs to be delivered to the player immediately. Quick feedback creates an immediate and continuative interaction between user and application. [53]

2.3.3 Competition and Collaboration

Competition between players occur when they are struggling against each other within the artificial conflict of the game. Competition is defined such that one player will win, while the other one will lose. [48].
Reeves et al. [53] defines competition as a social motivation, social because of the participation of multiple players.

Collaboration on the other hand is when players work together against the game system. The players will win or loose as a group. [48]
It enables individuals to work together to achieve a beneficial outcome for the group as well as for each individual of the group. [46]
This means that the goal can only be completet as a team. The success of the team is depended on the skillset of the team. Different characters often come with different skills which are needed to success in collaborative challenges. [55]

Leaderboards

Leaderboards are used to show users their state compared to others. The state in the form of results and achievements are usually used for the ranking on a leaderboard. Enabling comparison is encouraging competition. This can be a very powerful tool to maintain motivation. [49, 51, 52]

2.4 User-Centred Design

The success of a software project is dependent on the degree to which it meets the purpose for which it was intended. Requirement Engineering is the process of discovering that purpose, therefore stakeholders and their requirements need to be identified. [56]

Requirements can be researched from documents but according to Maiden et al. [57] it is a better approach to acquire requirements from stakeholders. The acquired requirements provide a specification for design and implementation. A wide variety of techniques can be used to gather requirements. The most common methods are observations, interviews (structures and unstructured), questionnaires, brainstorming, etc. To elaborate which strategie is the best for the individual project can be tricky.

User-centred design (UCD) is a concept for software design where the user is included into the requirement engineering process as well as the design and development process from an early stage. Norman [58] describes UCD as a designing technique based on users

needs and requirements. The system has the purpose to serve the user and fulfil their needs. This means the requirements of the user define the design of the interface and the remaining system is built based on the needs of the interface. According to Abras et al. [59] UCD is not a strictly defined process with fixed methods to use, rather it is a broad term for a design technique in which users have a great impact on the design. A wide range of methods can be used to involve users in UCD. Most relevant methods are explained subsequently in section 2.4.3. The strong participation of users in the design phase, and continuously throughout the development, helps to shape the system according to user needs. The advantages are two-sided, the system benefits from the provided user input and the user is rewarded with a well designed system. [60]

UCD is a design process that is suitable for game development as well. A cycle of prototyping, playtesting, evaluation, and refinement is invaluable to develop a game that is fun playing. From a paper version with only fundamental rules and core mechanics the experience of playing improves iteratively. As many users as possible should play the game throughout the entire design process. [48]

The aim of UCD is a high quality interface. According to Gould et al. [60] it is impossible to design a flawless user interface at the first try, but it can be determined empirically. To develop a useful and easy to use application three fundamental principles are recommended [60]:

- Early focus on users and tasks
- Empirical measurement
- Iterative design

The application of these principles is described in the following.

The user is the one who will be using the application and is therefore of great significance to the success or failure of a product. This is why the first principle concentrates on the user and their task. The designer needs to understand who the user is and what the user wants to accomplish by using the application. [61]
The fundamental understanding of the purpose of an application in combination with an understanding for the user are the building blocks of the design process. The second principle is empirical measurement which means to test early prototypes against users from the target group. [60]
The incorporation of users gives them the chance to react to the proposed design. The presentation of the system needs to be understandable for a user. The most used method of presentation are prototypes. [61]
Observing and analyzing intended users while they are using prototypes, provides essential feedback about the interface. The gained knowledge is used to identify problems and subsequently improve the prototype. The result is an improved prototype that itself needs to be evaluated. The steps of observation, analysis, problem identification and

improvement are repeated, as often as necessary, resulting in an iteratively improved design. [60]

UCD is generally separated into two phases. These phases are not named consistently throughout literature. Gould et al. [60] calls them initial design phase and iterative development phase. And Mayhew et al. [62] referes to them as requirement analysis and design/testing/development. For this thesis the naming convention of Gould et al. [60] - initial design phase and iterative development phase - will be used.

An alternative design approach to user-centred design is participatory design. The main similarity to UCD is the involvement of the user in the design process. Participatory design also builds on prototyping as a design method. While the purpose of the user in UCD is to give feedback on the prototypes that were developed, which means that users are used as a passive source of information and feedback. In contrast to participatory design which includes the users into the design process. [62]
Abras et al. [59] describes the users as co-designers. They play an active role in multiple tasks such as requirement analysis and designing prototypes. Gould et al. [60] emphasises the advantage that the users who are ultimately using the system are also designing it. The high investment of users makes participatory design a good choice for in-house products.
Two main limitations are described by Mayhew et al. [62]. First of all, users are not design experts and UI guidlines are foreign to them. The second limitation is the realisation of including users in the design process, because an active design would cost users a lot of time which they may not want to invest.

2.4.1 Initial Design Phase

The initial design phase is based on the principle of early focus on users and tasks. One activity of this phase is to collect information about users, their needs, and tasks. [60]
The goal of this phase is to understand the users' way of thinking and how the user accomplishes tasks. This will give the designer an insight into the usability requirements of the system. [62]

The direct contact between designer and user is an integral element of this phase. Meetings where designer and user meet, are held prior to system design. Meeting a user in person helps the designer to learn about users expectations and challenges, which the designer might not have been aware of. [60]

Defining behavioural goals are, according to Gould et al. [60], an important activity in the initial design phase. To define behavioural goals means to define development targets in order to keep usability in focus throughout development. The behavioural goals provide a basis to measure the system and thus provide a management tool to evaluate whether the development is right on track. By having testable goals the design can be evaluated in order to decide if changes in the design will help to contribute to the goals, or lead further away from it. The behavioural goals are separated into three main categories [60]:

- Intended users: The description of the intended users helps to keep the focus on the target group. Each iteration the new developed design needs to be aimed at the characteristics of the target group.

- Task: The task which the user is intended to complete with the system should be described, as well as the circumstances in which it is performed. It should be considered whether it is a task to be performed in an office at a computer with additional hardware or on the go on a smartphone. Different hardware comes with different limitations.

- Measurements of interest: Measurements of interests are learning time, errors and number of requests for help. Such measurements and their target values need to be defined.

If a current system exists it is relatively easy to specify these goals, by analysing the parameters of interest. For newly developed systems it can be tricky to define these criteria and the goals need to be refined with each iteration.

2.4.2 Iterative Development Phase

After completing the initial design phase, iterative development begins. This phase is based on the concept of fast and flexible adjustments of the design until a satisfying solution is found. The aim is to find a design which satisfies the previously defined behaviour goals. The designer must be aware that early designs might be changed radically or abandoned completely, while new ideas should be pursued. Early user-based testing and cheap modifications are an integral part of the process to keep the cost and time requirement feasible. As recommended by Gould et al. [60] the implementation strategy is characterised by fast and flexible adaptations, and a highly modular implementation. Ideally the implementation of interface and functionality is well separated, so that adjustments and changes in the interface do not affect the underlying functionality. The goal is to develop a satisfying user interface based on user feedback and designer expertise. The ideas of the designer must be presented in a comprehensible way for the user in order to provide constructive feedback. Each iteration consists of two steps: First the designer creates a design, second the design is evaluated by intended users. This is where the second principle of empirical measurement is applied. Empirical measurement helps to measure learnability and usability of the designed system. Performance of users and reactions to the design can be observed and analysed and further they help to improve the design. Users reactions and comments are the best source for feedback. They can help to draw attention to existing problems, errors and also reasons why they occur. This evaluation step with the help of users provides feedback. Based on this feedback problems can be identified and the design is revised. This ongoing cycle of design, test and redesign is a continuous process of modification and evaluation which reflects the third principle, the iterative design. [60]

A step-by-step procedure of preparatory, executing and postprocessing steps of a user feedback session are described by Mayhew et al. [62]:

1. The first decision the designer needs to make is whether to focus the test on ease of learning or ease of use.

2. Then the tasks with which the user will be confronted needs to be identified. It is recommended to choose core tasks of the application.

3. Test tasks are designed. Tasks should be realistic and representative for the proposed application. An estimate of the duration on the testing session, including all preceding and subsequent activities, should be made. A rule of thumb is that a session does not exceed two hours.

4. Supporting materials are developed. This includes pretest questionnaire, training material, test tasks, data collection sheets and post-test questionnaires.

5. Decide on appropriate test environment. It is recommended to find a test environment which is as similar as possible to the typical place where the user would use the application.

6. A pilot test is scheduled. The pilot test user should be representative of the target group. This helps to evaluate the prepared material.

7. The pilot test is conducted.

8. Adjustments and improvements to the test procedure and materials are made as a result of the pilot test session.

9. The last preparatory step is to find representative test users and schedule a test session.

10. With the preparation steps completed, it is time to run the test and collect data.

11. After the test session, the collected data is summarised. The total number of errors per task, the types of errors as well as a collection of user comments, especially before and after errors are determined.

12. The collection of data needs to be analysed and interpreted. The focus is on the areas of most errors or where common confusion occurred.

13. Problems are prioritised according to their impact on the usability and the cost of a solution. A problem with a heavy influence on usability and cheap solution is ranked with a high priority. Low priority problems are defined by little influence but expensive solution. The result is a prioritised list of recommended design changes.

14. Document findings with descriptions of identified problems and recommended changes. A summary of the data, interpretations and recommended design changes should be prepared as well.

The user test session itself consists of several activities, each activity needs to be planned and the supporting material needs to be prepared. The user test session usually starts with a pretest questionnaire that helps to collect information about the test user characteristics. The aim is to query general information like demographics and more specific questions related to the application in development. After finishing the questionnaire the next activity begins. Before the design is presented, the test user receives training, depending on the focus of the test - ease of learning or ease of use. The training differs depending on this focus. If it is an ease of learning test, the user does not get explicit instructions. A brief description of the functionality is sufficient and the user can start exploring the design. For an ease of use test, it is necessary to provide sufficient training. In this case the goal is to simulate expert usage, therefore the test user needs descriptions and walk throughs of the functionality. Then the prepared test tasks are presented to the user and the user performs the tasks. Independent of the focus chosen, the tester is observed and anything of interest is documented on a so called data collection sheets. These were prepared beforehand and help the person observing to document observations during a test. Of particular interest are errors the user makes. This can indicate problems within the design. Other observations and user comments can also be documented on data collection sheets. To conclude the test session a post-test questionnaire is handed to the test user. The user is asked about subjective reactions to the test design and ideas for improvement. [62]

The recommendations regarding the number of users to get feedback from varies, depending on the literature. Mayhew et al. [62] suggest to consult three to ten users per iteration. Nielsen [61] does not state a precise number of users but introduces two guidelines. First, the set of users should not be too small and second the set of users should change. The importance to introduce new users at an advanced stage of the project is emphasised. Because they are more likely to notice potential problems since they are not aware of the preceding development and history of the design. Gould et al. [60] made the contradictory statement: *User Diversity is Underestimated* and *User Diversity is Overestimated*. The statement *User Diversity is Underestimated* is based on the fact that peoples expertise differs, especially between designers and users. It is impossible to imagine whether or not users will have problems with the design. In contrast the statement *User Diversity is Overestimated* reflects on the issue that only a small set of people will not be representative for everyone and unless hunderts of people are tested the result is meaningless. Summarising this means that identifying some problems is better than identifying none, and a small user sample is feasible and can reveal at least the most problematic errors.

2.4.3 Methods

UCD is an approach based on direct user contact. A wide variety of methods exist which have a strong emphasise on the user and are therefore often used in UCD. Different methods serve different purposes while some are ideal to acquire requirements others help to evaluate a user interface. Therefore the different methods are either used in the initial design phase or in the iterative development phase, some are even useful in both phases. The most common methods are described subsequently.

Questionnaire

Questionnaires are according to Mayhew et al. [62] a common method used during the initial design phase as well as during the iterative design phase. Nielsen [61] also recommends questionnaires for task analysis as well as follow-up studies.

A questionnaire usually consists of mostly closed questions where the user has to choose from a checklist or share their opinion on a rating scale. A basic rule to questionnaires is to only ask questions whose answer will have an impact on the project, otherwise there is no point in asking them. The questions can either be printed on paper or represented on a digital medium. Questionnaires be filled in by the participant all by themselves. No additional person needs to be involved, which lowers the effort for this method and can therefore be handed out to a vast number of potential users. The distribution is easy and the results can reveal information about user categories and specific needs. The response rate depends heavily on the quality of the questionnaire, it should not be too long, too hard to understand or unprofessional. In order to guarantee the success of a questionnaire, it is recommended to do pilot testing with the questionnaire. The questionnaire has to stand on its own, this means the questions should be short, easy to understand and easy to answer. The pilot test can reveal confusions and misinterpretations and helps to develop a high quality questionnaire. A questionnaire can itself be improved through several iterations. Open questions, which the user replies to in natural language, are rarely used in questionnaires. Participants statements are usually as short as possible and can therefore be cryptic and hard to interpret. The preferred types of answer schemas are eiter checklists, rating scales or closed questions where the answer is either yes or no. Checklists often provide the possibility to write a custom answer but it is highly recommended to prepare the answer possibilities as complete as possible since the given answers are more accurate. Rating scales are a good possibility to ask users about how much they liked various features of the system under test. Due to the nature of questionnaires the analysis is easy, since the answers can be easily compared. [61]

During the iterative development phase, questionnaires are used to evaluate the user interface. It is not a method to study the user interface, but it is a method to study to users' opinion about the user interface. According to Nielsen et al. [61] most useful answers can be derived if the test user has been using the system beforehand. Mayhew et al. [62] takes it one step further and recommends questionnaires before and after the user uses the system. It is also recommended to reuse the same questionnaires at

later occasions to ensure that the performed changes in design are improving the user experience. The reuse of the same questionnaire reveals the evolution in user attitude over the course of the project.

Interview

Interviews are a common method to learn about users needs and requirements as well as task analysis. It can also reveal which features users particularly like or dislike. Interviews are recommended throughout literature [60, 61, 62].

Compared to a questionnaire an interview requires significantly more effort. Although the preparation is easier or equally laborious, the execution requires the interviewer to be present at all times during the interview. Due to the more individual answers the analysis is also more time-consuming as well. To perform an interview an appointment is scheduled with an intended user. The interviewer reads the questions to the participant who then gives an answer. The interviewer takes notes during the session, but it is also recommended to record the session in order to conduct a detailed analysis of the given answers after the interview is done. On the one hand it is time consuming to be present during each individual interview but the presence of the interviewer might actually be beneficial to the results of the interview. The interviewer can evaluate the answers constantly during the interview and adjust the interview accordingly. This means that the interviewer can rephrase a misunderstood question or ask a follow-up question. Being more flexible compared to a questionnaire is the main advantage of an interview. This characteristic makes interviews a good method for exploratory studies where it is not yet clear what one is looking for. On the other side a free-form interview is even more difficult to analyse. Typical interview questions are open-ended, meaning the questions encourages the person being interviewed to give a more detailed answer. Compared to closed questions where the answer is a simple yes or no. By phrasing questions open and neutral the user is encouraged to answer in full sentences and give a more in-depth explanation. It is necessary for the interviewer to stay neutral, by not agreeing or disagreeing with what the user says. Otherwise the result might be affected by the interviewers opinion.

It is necessary to keep in mind that users' answers might not be totally trustworthy. Depending on the question, the answer might be adapted by the user to avoid an embarrassing or socially unacceptable answer. Answers in interviews are more prone to be altered, compared to questionnaires, but also answers in questionnaires might be adjusted to be less embarrassing or more socially acceptable. Therefore it is necessary to keep in mind that answers to sensitive questions tend to be less accurate and the reality is different. A minimum of 5 participants is recommended. [61]

Observation

Observations as a method of finding user requirements and task analysis is mentioned by several sources [60, 62, 61]. This method can only be used if an already existing

system will be replaced with a new system. If a new system is introduced to the user which is not replacing an already existing one, then this approach can not be used, since there is no behaviour that could be observed. Observations often reveal that users use software in an unexpected way. Gould et al. [60] describes it as a process where the designer observes the user while using the current version of the application. This helps the designer to understand which problems the user solves by using the application and reveals the limitations of the current solutions. The execution is described by Nielsen [61] and is very simple. The observer visits the user and does as little as possible in order to not distract the user from their work. The user continues to perform their work in the same way as usual. The observer takes notes and additionally videotaping can be used to record the user. Any question that may arise is held until after the session. The observation is often followed by a short interview to clarify questions that were not answered.

Brainstorming

Brainstorming is described by Maiden et al. [57] as a method for requirement engineering. It is a technique to gather new ideas and stimulate participants to creative thinking by using the subconscious mind. Besides general requirement engineering Schell [63] describes brainstorming as an effective approach to gather ideas for game designs. Clark [64] describes brainstorming as a technique that produces a large number of ideas in a short amount of time. There is no right or wrong in executing a successful brainstorming session. This means there are no strict rules or regulations, rather it is a technique that can be adapted to every problem. Although it is a process without strict rules four behavioural guidelines are suggested in order to create an atmosphere that promotes creative thinking [64]:

- Ideas should not be criticised during the session
- Exceptional ideas are desired - the wilder the better. It is easier to calm an idea down instead of extending it
- The greater the number of ideas, the better the chances of having good ones
- Combinations and improvements of already mentioned ideas are welcome

During a brainstorming session the ideas of one participant can ignite new ideas from another participant and participants can also modify or expand ideas of others. It is necessary to document all ideas instantly, otherwise they could be forgotten. Furthermore it is necessary to document every idea without judgement. Only after the session ideas are prioritised and checked for feasibility. It is often suggested to have a group consisting of 12 participants but according to Clark [64] group size does not have an impact on the success of a brainstorming session. Instead of picking the right number of participants it is more important to pick the right people. People with different backgrounds have

different perspectives on the problem. Some familiarity with the problem is desired but participants do not need to be experts in order to brainstorm successfully. A mixture of different backgrounds is welcomed and often ignites good ideas in contact with one another.

Prototype

Prototyping is an opportunity to transport the designers vision into a shape that can be interpreted and evaluated by users. This provides the possibility for intended users to provide feedback and the designer can collect relevant information concerning the prototype. The behaviour of users is unpredictable and the confrontation with a prototype can bring unexpected results. Prototyping is an effective and popular approach to identify design problems in an early stage and keep the effort of adjusting the design low. [60]

Prototyping is faster and easier than a full-scale implementation because it does not simulate the entire system. The most relevant features and functionalities should be chosen as a representative sample. To keep prototyping feasible either the number of features or the level of functionality per feature needs to be cut down. These approaches are called horizontal and vertical prototypes. Horizontal prototypes contain the entire user interface without providing any real functionality. This helps to evaluate the workflow and the feel of the entire user interface. A vertical prototype on the other hand has only very few selected features but these are realised with an in-depth functionality. Therefore a vertical prototype only tests a limited part of the full system. [61]

According to Mayhew et al. [62] prototyping is evolving according to the iterations and improvements of the product. As the design gets more advanced with each iteration so does the prototype development. Each iteration consists of a designing phase, where the designer is creating or improving a design, and an evaluation phase, where the design is evaluated. Early prototypes are called low-fidelity prototypes and can be characterised as fast and simple. The fundamental advantage of low-fidelity prototypes is the minimised effort which makes it easy to receive fast feedback from users. Low-fidelity prototypes are usually paper-based mock-ups. Advantages are that it is easy and fast to create a design on paper, which means the designer is investing only litte time. Improvements can be incorporated easily and a new design suggestion can be produced cheap and quick. In case the design idea is rejected as a whole, it is also easier to throw away a paper based mock-up instead of a software prototype. As the iteration cycles continues, prototyping gets more complex and is then a so called high-fidelity prototype. The level of detail as well as the effort increases. The product gets closer to the end product. Within the last iteration cycles the design is completed and every detail is elaborated. Depending on the user feedback low- and high-fidelity prototypes can go through several iterations each. [62]

The development of each prototype is described in a three-step procedure [62]:

1. The first step is to select the functionality. Advanced applications consist of a

wide variety of features. At this stage it is important to select a small subset of important features.

2. Subsequently the design is sketched for the selected functionality. The sketch can include some explanatory text.

3. Finally the ideas and thoughts of the sketch are refined into a prototype. Either paper-based or more advanced, depending on the iteration.

After these steps the prototype needs to be evaluated. In early iterations the focus is on quick feedback. The prototype represents only a small section of the overall functionality, and the design is not yet matured, but major design flaws can still be detected. A representative set of users should run through a realistic test task. Depending on the application and its intended usage, the focus is either on ease of learning or ease of use. This decision influences the usability testing. In case the focus is on ease on learning the participating user receives only limited instructions, by doing so it is simulating the real situation where the user has to figure out how the design is supposed to work themselves. On the other hand if the prototype is tested for ease of use the user gets appropriate instructions. It is recommended to record the session with the user on video. This enables designers to evaluate the session in more detail later. In order to understand what and why the user is doing something, the thinking aloud method is a recommended method during the session. This method is explained subsequently in section 2.4.3. In this early stage there is no point in collecting timing data. The focus is rather on finding major problems by collecting and summarising error data. The improved design is then retested to confirm that problems have been eliminated and to ensure that new ones have not been introduced. The goal is to eliminate major problems by iteratively carry out design and testing.

As the design evolves and the general concept of the user interface is meeting the users requirements it is necessary to design complete details of the user interface. The stages are described as follows [62]:

1. The identification of all pathways between windows, dialog boxes and messages are completed.

2. The design of menu bars and all other action controls is completed. These elements allow users to navigate through the application.

3. The design of content of all windows, dialog boxes and message boxes is completed.

4. The design of all interactions with input devices is completed.

Prototyping comes with limitations. Gould et al. [60] describes two major disadvantages. First of all, the prototype is usually designed in a separate system, which is specialised in designing the user interface. The work invested into the development in the separate

system will get discarded. The second disadvantage is that further work is necessary in order to incorporate the design into the final product.

Generally the development of a prototype and the evaluation by the user is time-consuming and resources need to be available. But sooner or later user testing will take place, the only question is whether it happens in a test or production environment. The combination of building a prototype and user testing are improving the quality of the final product and are therefore a great advantage especially for end-users.

Thinking Aloud

Thinking aloud is, according to Nielsen [61], a technique where the user verbalises their thoughts while using a system. It is also referred to as thinking-out-loud [62].

The execution is straightforward, the user gets a set of tasks and performs them while speaking their thoughts aloud. This allows an observer to get an insight into the users' though process and their way of viewing a system. It reveals the reasons why the user is performing certain steps. In case the user is not following the correct path of anticipated steps the observer knows why the user is doing these steps. This helps to understand the misconception and subsequently eliminate confusing elements from the user interface and consequently result in an improved design. The advantage of this approach is that even data from a small number of users can improve the system tremendously. A disadvantage is that it might feel strange to the participants to verbalize their thoughts. [61]

Thinking aloud is a technique used during the iterative design phase. This method helps to understand the users' perspective on the design and has a focus on finding misconceptions. [61]
It is recommended to choose participants which are representative of the intended user, experienced users will not have the same problems real users will have. [65]

The execution of a thinking aloud session is relatively simple. The user is given a prototype of the current design. Depending on the progress this might be a paper-based mockup or a running prototype. Then the user gets a set of tasks and performs them on the prototype, while speaking their thoughts aloud. This enables an observer to see the prototype from the users view and this insight into the mind of the user helps to identify misconceptions and problems. The observer is not supposed to interfere with the user or the way the user is using the system, since that could influence the users behaviour. In case a question arises during task execution the observer should not answer the question but instead ask a counter-question to keep the user talking. Whenever the observer asks a question it must not hint the user in a certain direction. [61]

Participants are easily influenced by questions and comments, the observer is supposed to observe and not interview the user. The session is not for the observer to ask what they want to know, it is the participant who is allowed to share their thoughts. Help is only given when it is really needed. Generally thinking aloud sessions are video-recorded and the observer makes notes on particularly interesting comments or actions during

the session. To analyse a session the notes and recordings are viewed and problems are listed. Then the root of the problem need to be determined. Finally specific suggestions for change can be made. [65]

Lewis [65] mentioned limitations for the thinking aloud method. The first one being realism. Due to the observation the user might be more conscientious and methodical, compared to an unobserved work situation. Therefore the performance could be increased during a thinking aloud session. On the same note timing was mentioned as a limitation. Reaction time and task completion time are not accurate during thinking-aloud. Nielsen [61] argues that the continuous verbalisation slows the user down and decreases performance. The user is not channeling their focus on the performance of the task but on keeping a steady stream of talking. Either way performance measurements are not accurate and should not be paired with the thinking aloud method.

Another limitation is that the approach is generally labor-intensive. To collect data from a vast amount of users is difficult and the analysis is time consuming. Protocols and recordings need to be scanned for important information. The information gained during a session is versatile and differs from user to user. The then found information needs to be transformed into actual design improvements. [65]

The unnaturalness and the difficulty of talking continuously was described by Nielsen [61] as a limitation of the approach. To help the user get an idea of thinking aloud a short video of someone performing thinking aloud can be shown or the observer can demonstrate a short thinking aloud test before the session starts.

Despite the limitations this method of user interface evaluation has many advantages described by Lewis [65]. First of all, it helps to pinpoint the problems in a user interface. The struggles of the users show up in the comments during the usage. This helps to track back to the origin of the problem. It is relatively easy to find where a problem occurs but finding the root cause of a problem is more difficult. Analysing the user comments before the error occurred reveals the root cause of the problem. This knowledge helps to identify what needs to be fixed.

Another strength of the approach is that a problem is caught when it occurs. There is no need for the user to remember the problems they had or even the specific reason that lead to the problem. But especially this knowledge is of importance, and thinking aloud helps to capture that information. The approach also turned out to be effective in finding minor problems. During a session the users will mention minor irritations and confusions in the system. These problems usually do not have a measurable impact on learning time or task completion but are still disturbing to the user and decrease the users' overall impression of the system. The users comments will also reveal the feelings towards the system and helps to study the attitude of users. [65]

As mentioned before it is a technique that is labour intense and therefore often only conducted with a small amount of people. According to Lewis [65] despite the small number of participants it still results in useful information. Even one person can provide valuable feedback to improve the design. Another advantage of the approach is that

it can be used with low-fidelity prototype. This is especially important to gather user feedback in early design phases. The representation of the design is secondary since user behaviour can be studied on a paper-based design as well as on a running system.

Logging

Logging can also be used to collect data about prototypes to then be evaluated and reveal interesting facts about prototypes. Logging happens automatically when the system is used by users. It is recommended as a supplementary method to collect detailed data about users using the system in test. Usually events of interest are logged, but also frequency with which a user uses certain features can be logged. Occurrences of error are of especial interest. The collection of data over a extended period of time is also possible with minimal effort. Logging data enables to reconstruct user behaviour. Because logging can be revealing it is important that it is not possible to identify users from log data, therefore results need to be reported in a form so that users can not be identified. After a test phase where logging data was collected it is recommended to do a follow-up interview. This can be used to understand why certain features were used or not used. [61]

CHAPTER 3

State of the Art

This chapter describes the currently existing approaches to help smokers reduce or quit smoking. A wide variety of applications that are supporting smoking reduction or cessation are available. Mostly these applications are tracking each smoked cigarettes and try to motivate the user with data like saved money and a counter of cigarettes which were not smoked. Some are also including health facts to further increase motivation to quit smoking. Another approach to motivate the user is gamification.

Only a small number of applications is based on scientific foundation or research. The main focus of this chapter are applications including a game with a scientific background, so that these applications can be classified as Serious Games. This chapter also includes a brief insight into conventional methods. The summary section at the end of the chapter classifies the different aspects of applications and helps to compare existing solutions on different parameters.

3.1 Crave-Out

Crave-Out [66] is a game developed for smokers. The general idea was to develop a game which offers smokers a distraction whenever cravings for a cigarette arise. According to DeLaughter et al. [66] cravings are a major contributor for failed quit attempts because smokers can not resist the intense desire for a cigarette. The result of the first development stage was a web-based prototype to help smokers manage their cravings. Different items appeared on the screen some are positively associated e.g. longer life, saving money, sense of smell, etc. and others are negatively associated with smoking e.g. heart problems, wrinkles, coughing, discoloured teeth, etc. Some items were textual and others were images representing above mentioned associations. The player had to ignore the negative associated items and click on the positive associated items to which the game responded with a appealing sound and a green tick. After the alpha testing phase two major changes were realised:

1. Negative associated items were removed. Test users reported that seeing items associated with smoking triggered a desire for a cigarette.

2. The platform was exchanged from a web-based game to a mobile phone game. The proliferation of mobile devices and the increasing number of users playing games on their phones provides an opportunity to offer craving management exactly when and where smokers need it.

Figure 3.1: Crave-Out [66]: Beta-Testing Phase

After redesign the game was a pattern memory game. The player has to memorise a certain sequence of different fruit which was shown at the beginning of the game. The player can horizontally move a virtual bucket at the bottom of the screen. Different fruits are falling down the screen as seen in figure 3.1. The player has to catch fruits in the before shown sequence. The modifications which lead to the beta testing prototype helped to rule out the problems from the alpha testing phase. Crave-Out provides multiple levels with increasing difficulty. According to the author determine the right level of difficulty is a balancing act between boredom and frustration, which when not done right could lead to a desire to smoke. The increasing difficulty was the length of the sequence which players need to remember. Additionally to the distraction the game also rewards the player with a sticker that represents a benefits of quitting smoking e.g. better health.

3.2 QuitIT

QuitIT [67] is a prototype video game developed to establish skills which are required for tobacco cessation. During gameplay the smoker is rehearsing strategies and therefore enhancing their skills to cope with smoking urges. This helps the player to identify tobacco use triggers, model and practice substitute coping behaviours. The game does not focus on monitoring the users' current smoking habits but rather teaches how to handle certain situations without smoking.

Figure 3.2: QuitIT [67]: After-Dinner Scenario

The game is designed as a series of intertwining episodic stories which virtually present tobacco cues incorporated into narrative and personally relevant stories to the player. The story telling game is designed to represent realistic environments. The player is introduced to four characters which relate trough their stories of how they quit smoking. The player can then play through flashback scenarios where the characters experience trigger situations. The goal is to reenact the situation without smoking. The next flashback is unlocked when a flashback scenarios is solved successfully. The narrative story-based structure of the game targets to involve the player emotionally and simulating experiences which the player can relate to. The chosen scenarios are everyday situations which the smoker probably already has or is likely to encounter in the future. A common situation can be seen in figure 3.2 where the character Ray is trying to suppress the urge to smoke after dinner.

A core element towards smoking cessation is to monitor and manage urges. Within the game this is simulated with an urge meter. This shows the player how good or bad the decisions their making are. If the urge meter is full the characters slips and smokes. This means the player failed and has to play the scenario again.

By playing the game the player identifies with the characters and also takes on the goals of the virtual characters. The players' internal dialogue should change and the player learns how to deal with urges and slips.

3.3 Inspired

Inspired [68] is a game-based mobile phone application that promotes smoking abstinence by rewarding the user with virtual goods. It is based on contingency management which is commonly used in the field of substance abuse and according to Raiff et al. [68] an effective aid for smoking cessation. Contingency management is based on the idea to reward people contingent on objective evidence, usually financial incentives are used.

The original execution of contingency management has various limitations, two of which

Figure 3.3: Inspired [68] Start Screen

Figure 3.4: Inspired [68] Game Play

are relevant for *Inspired*.

- Financial rewards must be provided and therefore the amount of people which can be supported is limited.
- Self reporting is not accurate enough and likely to be false when rewards are involved therefore the results of the abstinence has to be monitored objectively. In the case of smoking this can be done by measuring levels of carbon monoxide in the exhaled breath. Breath samples need to be taken twice per day which is very time consuming for participants, due to travel time to the clinic.

To tackle the first challenge *Inspired* replaces monetary rewards with virtual rewards which represent a benefit for the player within the game. The second limitation is tackled by providing participants with a breath CO monitor to remotely submit breath samples twice per day. A video of the participant taking the sample is also transmitted, to make sure the breath sample is actually from the participant. The application includes also a social support system with rewards that only could be obtained if the majority of a team reached a specific smoking cessation goal.

The game setup is a lush vegetative environment where the player can use earned resources to build structures as seen in figure 3.3. The player could earn resources by color matching pollen-gems on lotus flowers, by swiping the pollen-gems from a queue onto the lotus flowers as seen in figure 3.4. The players have to be fast otherwise the lotus flowers would vanish. The level of difficulty was increased with each level the player succeeded. The game is designed to play whenever the user fancies it and a level lasts for approximately five minutes. Submitted breath samples will unlock the access to the next level.

3.4 Quittr

The mobile phone application Quittr [69] was developed with gaming characteristics to support smokers to quit. The focus of the development was to have a high engagement of the user with the application and therefore also the delivered cessation content. Keeping users interested beyond the first days is a major goal of Quittr and is an important aspect of potential effectiveness. Another goal of Quittr is to provide education and

support content to positively influence smoking cessation outcomes. Educational content is embedded within the application and the game is used as a hook to keep the user interested. The user keeps engaging with the application and also the educational content and in exchange the player receives benefits within the game. The app is currently available in the App Store and Google Play Store and users are informed that by using the app they are agreeing to take part in a study.

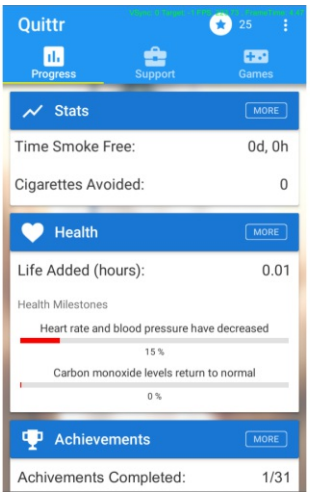

Figure 3.5: Quittr [69] Progress Page

The application is divided into three main pages: Progress, support and games.

- The **progress page** as seen in figure 3.5 contains an overview of the current quitting attempt statistics such as financials, health and social outcomes. This part of the application provides the user with meaningful feedback and education about benefits of quitting. An achievements section is also part of the progress page which includes predefined goals and the user is also able to define custom goals for financial savings.

- The **support page** offers helpful information and support, such as a quick dial button to the local Quit Support hotline. This page also includes the Information Toolbox which includes a wide variety of educational material. Information about various therapies and on cravings, coping strategies, benefits of quitting and the consequences of smoking is available in this section.

- In the **games page** the user can find several games. By providing a variety it is more likely that smokers with different interests are able to find a game that tickles their interest. The games included can be classified into two main categories: Distraction and incentivization. Games which are designed for distraction have certain characteristics to provide an alternative to the act of smoking. They can be played in stand-alone sessions which take a few minutes, they demand mental focus

as well as boths hands. Currently Quittr provides one distraction game where the player has to find a certain object within a cluttered environment. There is also a time limit. An incentivization game is designed to be played over a longer period of time, in Quittr a quit attempt is limited to 28 days and therefore the game is designed to be played over the 28-day duration. The characteristics of an incentivization game is to involve long-term goal setting and planning, frequent monitoring by the user and in the case of Quittr a currency system called QuitCoins. When the user is engaging with the smoking cessation content the reward are QuitCoins. Quittr includes a incentivization game which is called "Tappy Town" as seen in figure 3.6, a city builder game where the user grows a town which creates resources some of which are collected passively and others need to be collected manually. This encourages the player for frequent check-ins and additionally provides some distraction from their cravings. QuitCoins can be used to purchase high performance buildings and visually impressive structures.

Figure 3.6: Quittr Incentivization Game "Tappy Town" [70]

The impact of the application on its users is still being determined in a study. Users are randomly assigned into one of two groups. One group has access to the whole range of features (including incentivization game and QuitCoins) and the second group has access only to the distracting game. It will be determined whether or not the incentivization game has a positive impact on engagement, retention and cessation rate

3.5 Summary

The goal of all researched applications is to help the user to quit smoking. The approaches differed in many ways. One difference between the applications is that Inspired and Quittr ask the user to report their cigarette consumption. Contrary QuitIT and Crave-Out are not interested in the smoking habits of the user, these applications focus is on educating the user. Quittr is also offering educational material to the user. Furthermore Quittr and Crave-Out are applications that attempt to distract the user from the urge of smoking.

The game genre is another characteristic that can be used to classify the games. While there is a wide variety of game genres to choose from, the researched games focused on two genres: action and strategy. Crave-Out and Inspired can be classified as games from the action genre. Quittr was developed to compare different game types and therefore includes a game from the action and the strategy genre. QuitIT is classified as a strategy game.

One important feature of Inspired is that it needs additional hardware. Inspired is the only application that objectively verifies that the user is not smoking, all other applications are based on trust and the fact that the user has no personal interest in cheating.

All applications except for QuitIT are developed for mobile devices. The prototype for Crave-Out was developed as a web application but the final version was ported to a mobile game. QuitIt was developed web-based. The applications use different game elements such as time, levels, rewards, social support and story. A classification of the presented applications can be found in table 3.1. The used taxonomy is a combination based on the classification presented by Laamarti et al. [43] and Ratan et al. [44] and is also described in 2.2.1. These classification were extended by additional categories, with categories more specific for applications designed to support smokers.

The application developed within this thesis was called *Game of Smoke* and is also incooperated into table 3.1 for better comparability. The main differentiator is the target group, where *Game of Smoke* focuses on people willing to reduce their daily amount of smoked cigarettes, every other application was developed for smoking cessation. It is therefore also the only application where the user can set and adjust a custom limit. Another main difference to existing solutions is the documentation of smoked cigarettes, emotions, and other notes. No other application offers the user a possibility to include their personal feelings and struggles. This enables a later analysis of the trigger situations, which can help the user to analyse the personal smoking behaviour. Although this was not implemented for this thesis, it could be easily added, since the needed data is already collected. Another distinguishing feature is the evaluation of the application. Only *Game of Smoke* and *Quittr* were used and tested by users in real-life situations, other applications were only evaluated in laboratory environments.

[1]Not yet implemented, but analysis mechanisms could be added with data already collected

Table 3.1: Comparison of State of the Art applications

		Crave-Out	QuitIT	Inspired	Quittr	Game of Smoke
Modality	Visual	✓	✓	✓	✓	
	Auditory	✓	-	-	-	
Interaction Style	Phone	-	✓	✓	✓	✓
	Mouse & Keyboard	✓	-	-	-	-
	Biological data	-	-	✓	-	-
Environment	2D	✓	✓	✓	✓	✓
	3D	-	-	-	-	-
Learning principles	Practicing skills	-	✓	-	-	
	Learning through exploration	✓	-	-	✓	
Platform	Mobile	✓	-	✓	✓	✓
	Web	✓	✓	-	-	-
Aim	Smoking Reduction	-	-	-	-	✓
	Smoking Cessation	✓	✓	✓	✓	-
Documentation	Cigarettes	-	-	-	-	✓
	Emotions	-	-	-	-	✓
	Notes	-	-	-	-	✓
Self-Analysis	Statistics	-	-	-	✓	✓[1]
Distraction	Distraction	✓	-	✓	✓	✓
	Develop coping mechanism	-	✓	-	-	-
Custom goal	Cigarette consumption	-	-	-	-	✓
	Financial savings	-	-	-	✓	-
Evaluation	In Laboratory Environment	✓	✓	✓	-	-
	Real Life Test	-	-	-	✓	✓

CHAPTER 4

Results

This chapter describes the practical execution and results of this thesis. First, the adjustments of the user centred design will be described. Some general information about participants and the performed iterations will be given. Then the two main phases, the initial design phase, and the iterative development phase, will be described in more detail. The methods used during these phases as well as the results for each method will be presented.

4.1 Application and Adjustment of User Centred Design

The theoretical fundamentals of the user centred design and methods have been explained in section 2.4. This section describes the implementation of the user centred design and gives an overview of iterations and the demographics of participants.

4.1.1 Target Group

The aim of this thesis is to support people in reducing their smoking consumption. Smoking and nicotine addiction is affecting people of all ages and is independent of gender. Therefore the target group of the prototype does not aim at a specific age group or gender. The difficulty to overcome the craving for a cigarette is concerning a versatile group of people.

The target group can be separated in two groups of people, because people who are interesting in reducing their smoking consumption have either one of two motivations. The first group of people would like to quit smoking but is unable to, due to the addictive nature of tobacco. They are well aware of the consequences and how harmful their behaviour is for their health. They would like to quit but are unable to change their behaviour. Reduction can offer an alternative to increase health as well as the possibility to quit smoking at some point in the future.

The second group of people is also aware of the health consequences smoking is responsible for. They are interested to reduce smoking to increase their health. But contrary to the first group, this group does not aim to quit smoking. They see smoking as a part of their life which they are not willing to give up completely.

4.1.2 Iterations

The methods were selected and adapted accordingly to the possibilities and resources of this thesis.

Table 4.1: Overview of iterations, their used method and Participants

Iteration ID	Method	Participant ID
IT-0	Brainstorming	P1, P2
IT-1	User Session	P3
IT-2	User Session	P4, P5, P6, P7, P8
IT-3	Questionnaire	P9, P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, P29, P30, P31
IT-4	User Testing	P3, P7, P32, P33, P34, P35

An overview of iterations, used methods, and participants for each iteration can be found in table 4.1. In order for completeness Iteration 0 was added to the table, partially representing the initial design phase.

Figure 4.1 provides a visual overview of the process with every step, the main method used, as well as supporting questionnaires, and their interim results. For each iteration the participants are listed. The separation of the initial design phase and iterative development phase are shown as well.

The initial design phase focused on user requirements and collecting information about smoking. Therefore a literature research was conducted and brainstorming sessions with smokers were organised. The literature research helped to gain a fundamental understanding of the problem and a first concept was developed. Brainstorming was the first interaction with potential users and the preparation for the iterations. Therefore it is subsequently referred to as IT-0. During brainstorming sessions users shared their personal impressions and experiences with smoking, their reasons to smoke, triggers, and problems regarding quitting and reduction. The gathered requirements were summarised, categorised and prioritised. The idea for the diary and the game was developed and a low-fidelity prototype was designed.

The iterative development phase was planned with multiple iterations. The focus of the iterations varied according to the needs of the design. Every iteration considered user feedback to ultimately increase the value of the resulting application for the user.

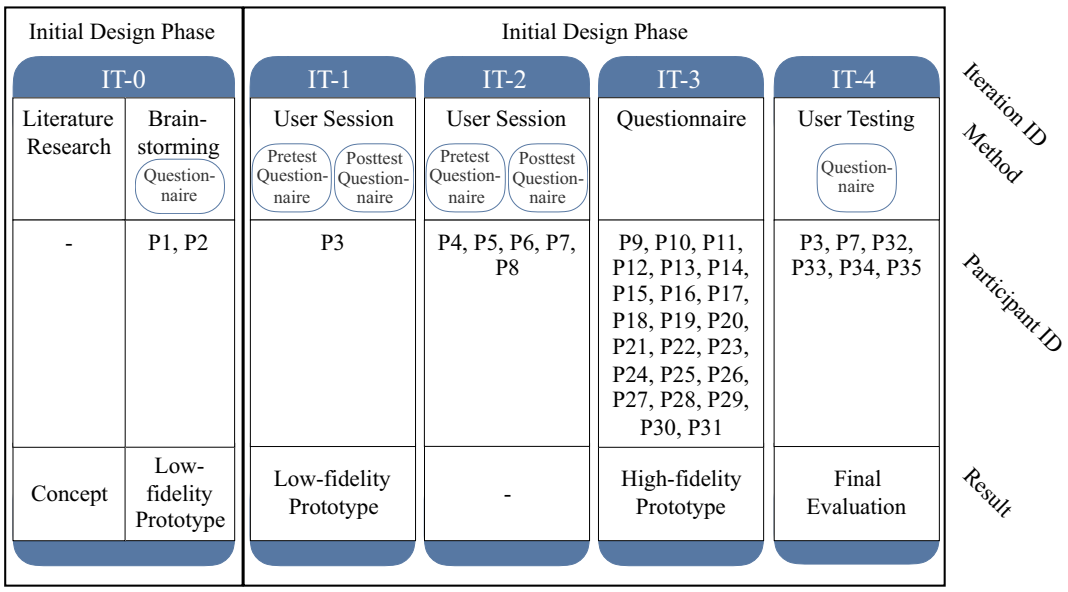

Figure 4.1: Detailed Overview of Iterations

The first iteration, also referred to as IT-1, used user sessions, which meant sitting down with a potential user and evaluate the design. This iteration was based on the low-fidelity prototype which was presented to the user as paper mockups. The focus of this iteration was usability.

The second iteration, also referred to as IT-2, was conducted with the redesigned paper mockups. This iteration had also a focus on usability. A total of five participants participated in IT-2.

The third iteration, also referred to as IT-3, had a focus on requirements. Therefore a questionnaire was designed to specifically collect requirements regarding gaming mechanisms and motivation. With the gained knowledge of the previously executed steps the high-fidelity prototype was developed.

The finished version of the game was tested by pilot users to review the level of difficulty of the game. Afterwards the application was distributed to participants for the final user testing, also referred to as IT-4.

A more detailed description of every iteration including the results is given subsequently in section 4.2 and 4.3.

4.1.3 Participants

All selected participant, independent of the attended iteration, filled in a questionnaire. This questionnaire was filled in anonymously to gather demographical data and general

information about the personal smoking behaviour. This evaluation includes results from the questionnaire in IT-0, pretest questionnaire in IT-1, pretest questionnaire in IT-2, partially questionnaire in IT-3 and IT-4. Figure 4.2 gives an overview of evaluated questionnaires.

Some participants attended multiple iterations. Others were not able to participate multiple times, because the participant quitted smoking, were not interested enough, had time constraints, or was geographically not available for each iteration. IT-3 was an online questionnaire, which was filled in anonymously and therefore did not allow to trace those participants back to other iterations. Therefore the total number of participants includes potential duplicates. A total of 35 participants were involved.

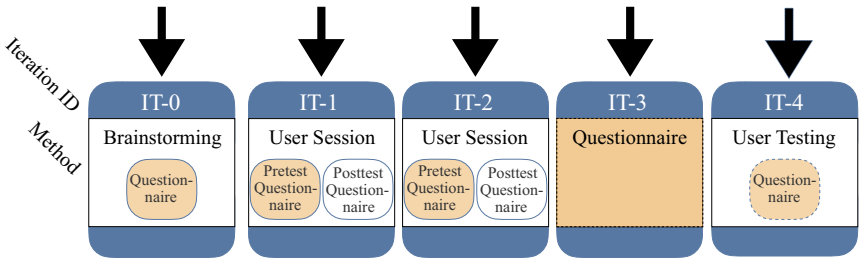

Figure 4.2: Overview evaluated questionnaires

Three participants were participating, but were no smokers themselves. They did test runs for user sessions, and reviewed the difficulty of game play. Therefore they are excluded from the following evaluation. Table 4.2 gives an overview of participants, their gender, age, smoking goal, and iteration they participated in.

The youngest participant was 20 and the oldest was 43. One participant did not specify their age. The figure also shows the distribution among genders. In total 15 (43%) were female and 20 (57%) were male.

The majority of participants aiming to reduce smoking. Figure 4.3 shows the personal goal of the participant regarding their smoking behaviour. 5 (14%) participants stated that they have no intrest in reducing or quitting their smoking behaviour. 11 (30%) would like to quit smoking and 21 (57%) stated that they would like to reduce their cigarette consumption.

The following questions were not asked within the final evaluation, therefore the number of participants is lower than the total amount of participants. Figure 4.4 shows the amount of years each participant has smoked. The years of active smoking were categorised into four categories. The first one being less than a year of smoking, which none of the participants selected. 6 participants (19%) stated that they have been smoking between 1-5 years, 14 participants (45%) stated to smoke 6-10 years, and 11 participants (35%) stated to smoke more than 10 years.

Table 4.2: Participants

Participant ID	Gender	Age	Goal	Iteration ID
P1	female	24	Reduction	IT-0
P2	male	28	Cessation	IT-0
P3	female	20	Reduction	IT-1.b, IT-4.b
P4	male	28	Reduction	IT-2
P5	male	28	Cessation	IT-2
P6	male	20	Reduction	IT-2
P7	male	20	Reduction	IT-2, IT-4.b
P8	male	28	Reduction	IT-2
P9	female	26	Reduction	IT-3
P10	male	43	Cessation	IT-3
P11	male	43	Cessation	IT-3
P12	female	24	Reduction	IT-3
P13	male	26	Cessation	IT-3
P14	female	29	Reduction	IT-3
P15	male	33	Cessation	IT-3
P16	female	29	Reduction	IT-3
P17	female	29	Cessation	IT-3
P18	male	31	Cessation	IT-3
P19	female	38	Reduction	IT-3
P20	female	25	Cessation	IT-3
P21	female	25	Reduction	IT-3
P22	female	25	Reduction	IT-3
P23	male	29	Reduction	IT-3
P24	male	32	Cessation	IT-3
P25	male	28	Cessation	IT-3
P26	male	30	Reduction	IT-3
P27	female	26	Cessation	IT-3
P28	male	not specified	Cessation	IT-3
P29	male	24	Cessation	IT-3
P30	female	24	Reduction	IT-3
P31	male	27	Cessation	IT-3
P32	female	23	Cessation	IT-4.b
P33	male	32	Reduction	IT-4.b
P34	male	33	Reduction	IT-4.b
P35	female	28	Reduction	IT-4.b

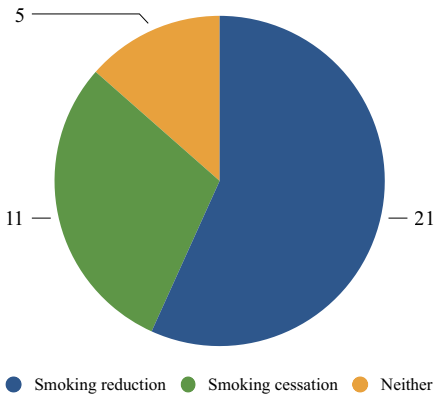

Figure 4.3: Participants goal for their smoking consumption

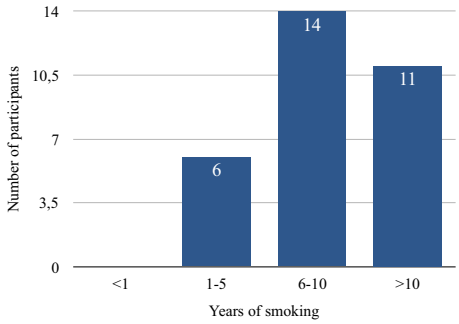

Figure 4.4: Years of active smoking by participants

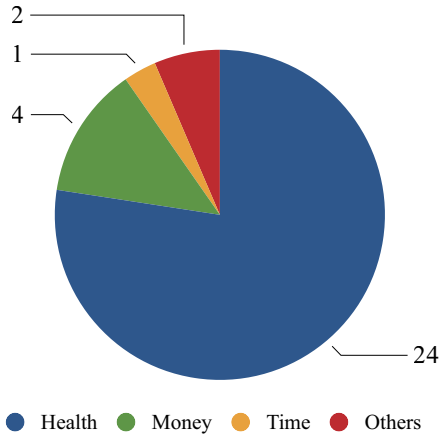

Figure 4.5: Reasons to reduce or quit smoking

Figure 4.5 shows the reasons why people want to quit smoking. The smokers who had no interest in reduction or cessation were excluded from this question. Therefore a total of 26 participants answered this question. The possible answers listed in the questionnaire were money, health, and time. Multiple answers were possible for this question, therefore a total of 31 answers were collected. The participants were also able to expand the list with their own reasons. Only one participant did not chose any of the possible answers and stated that no motivation was available. The votes for reasons to stop or reduce smoking were distributed as follows: 24 votes for health, 4 votes for money, 1 vote for time and 2 others.

4.2 Initial Design Phase

The initial design phase is the start of the user centred design. General information is gathered and combined to an initial prototype. Methods used were literature research and brainstorming. This section describes the results from these methods.

4.2.1 Result Literature Research

Various sources have been used for literature research. Articles and scientific papers were sourced from online databases such as ResearchGate, JMIR Publications, IEEE Explore and Google Scholar. Books and specialised literature were found on Google Books or at libraries such as the library of the technical university of Vienna and the library of the university of applied sciences in Dornbirn. Books which were not available at any of these sources were purchased. Google was also used for general internet research. The most important findings from the literature research are summarised in the following and subsequently collected as requirements.

People struggle to quit smoking, because nicotine is a addictive substance. Due to withdrawal symptoms and conditional relationships smokers are trapped in their behaviour. The problems a smoker faces when quitting are both mental and physical. Reducing the amount of the daily smoked cigarettes offers an alternative that is achievable and desired by smokers. Also the smokers health would be improved by reduction. The reduction of cigarettes is still not easy. Trigger situations and moods linked with smoking need to be considered when a smoker is attempting to reduce. A crucial part of building coping mechanisms for the arising craving for a cigarette was found to be the analysis of ones behaviour as well as the identification of trigger situations. The use of a smoking diary was presented as an easy, cheap, and available solution to learn about smoking behaviour.

To support smokers in reduction, motivation needs to be a central focus. Also maintaining motivation is important to be successful in long-term. Games have the ability to build long-term motivation. By choosing the right game elements an engaging experience can be built. Especially useful are rewarding systems and elements that show progress. The challenge is to combine a variation of game elements to create a meaningful game.

Table 4.3: Requirements from literature research

ID	Requirement
L01	Distraction of cravings [66, 68, 69, 39]
L02	Ability to identify trigger situations and develop substitute coping behaviour [67, 29]
L03	Availability of the game at all times [66, 68]
L04	High engagement through gaming characteristic [46, 53, 52]
L05	Positive effect on the user [69, 39, 42]
L06	Progress page: financials, health and social outcomes [69]
L07	Report cigarette consumption [16, 28]
L08	Form new habits [67, 41]
L09	Provide coping mechanisms [67]

State of the art research showed that one strategy to help people quit smoking is distraction. To provide a good alternative to smoking, a distraction helps smokers to take their thoughts away from their cravings and therefore overcome the urge of smoking. Progress pages and visual representations of the progress are a common feature used to visualise the progress of the user. This is used to give an overview and further motivate the user. In order to gather the data to visualise the progress the possibility to document smoked cigarettes is provided. Documentation of smoked cigarettes is often used to control smoking behaviour.

The requirements that resulted from the literature research are summarised in table 4.3. The requirements are not listed in any specific order.

After the literature research a initial concept is developed. The idea is to combine documentation of cigarette consumption with gaming elements for motivation. This enables the application to react to the users smoking behaviour. The application can then reward the player with some element valuable within the game. Also the mere interaction with the application is supposed to reward the user within an integrated game. This means that the more the user interacts with the documentation and the app in general, the easier it is to make progress in the game.

4.2.2 Result Brainstorming

After the literature research was completed, brainstorming sessions with users were arranged. The theoretical method of brainstorming is explained in section 2.4.3. This iteration is also referred to as IT-O. In total two brainstorming sessions were held, with one participant each: P1 and P2. Figure 4.6 gives an overview of the current iteration step.

The evaluation of the questionnaire can be found in section 4.1.3.

The brainstorming sessions were held in a casual atmosphere. Locations were an office and a park. Since participants have never used an application to help reduce or quit

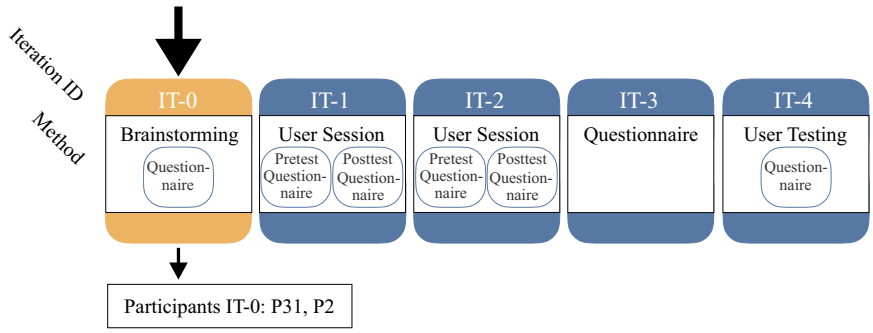

Figure 4.6: Iteration Step: Iteration 0

smoking, the application is not replacing another application. This means it is a new application the user is including in their daily life. Therefore the brainstorming sessions was scheduled as follows: first each participant filled in the general questionnaire (see appendix on page 122), then an interview was held, continued by explaining the idea of the application as explained in section 4.2.1. The interview helped to gain a general understanding how the participants smoking behaviour evolved and what they wish would be different. This provided an insight in problems, triggers, and motivations of smokers. Afterwards unstructured brainstorming was done and upcoming ideas were collected.

The brainstorming sessions were driven by ideas for games, motivation, and thoughts on smoking reduction in general. The participants were free to talk about their personal experience and opinions. In the following the most interesting findings and results drawn from the brainstorming sessions are summarised.

The participants revealed that various attempts to quit smoking have been made. Some of which were partially successful, meaning that the smoking abstinence lasted for a few weeks or even month. But the cycle of quitting and restarting repeated several times. Also attempts to reduce smoking were mentioned, these attempts also came to nothing as motivation decreased over time, and with no monitoring at hand the smoking behaviour relapsed to the usual amount. Heavy cigarette consumption was often a result of smoking out of habit instead of enjoyment.

Both participants stated that it is well known that smoking is a main risk factor to a lot of illnesses and both participants mentioned noticeable health restrictions particularly concerning their respiratory tracts and lungs. Especially in the morning noticeable breathing problem were perceptible. Regardless both participants stated that warnings or facts about health related issues are not motivational. Still the greatest intrinsic motivation for the participants to stop or reduce smoking are health issues. P2 already went through several phases without smoking cigarettes, which allowed to experience the differences at first hand. The most notable changes were described to be a positive emotional and physical enhancement, improved performance during workouts, and clearer

and healthier looking skin were mentioned. Apart from health issues the participant also mentioned money saving and the bad smell of furniture and clothes as a minor motivation. The problem described with reducing was that the new habit was difficult to maintain and sooner or later cigarettes smoked per day increased to the same undesirable amount as before.

One approach mentioned to quit or reduce smoking was to tell other people. Both brainstorming participants explained their experience with this approach. On the one hand it was seen as a way to build up pressure on oneself, because failing would be considered as bad and to additionally confess to other people that one has failed was described as devastating. On the other hand telling other people was experienced as motivational, because of the potential question about the progress and the then experienced pride that one would feel when reporting the success. Also seeing other people thrive and achieve their goals was motivational to the participant.

Regarding longterm motivation the participants mentioned that it is important that an application incorporates new impressions and surprises every once in a while. This helps to keep the application exciting and makes the user want to use it.

The participants were aware of the fact that smoking is unhealthy and the best option would be to stop. However quitting is difficult and some situations trigger the urge of smoking more than others. Both participants mentioned a strong correlation between smoking and stress. Also smoking as a reward for doing something good was mentioned. For example a smoking break during work hours was to reward oneself for doing a good job, it was compared to give yourself a pat on the back. Also after the completion of a task a cigarette was justified as a reward for the hard work done. This means smoking is used to reward oneself. The possibility of replacing smoking with another activity to get the same feeling of reward, was mentioned.

Another trigger for smoking are social situations. Seeing other people smoke triggered the urge to smoke a cigarette too. Therefore parties and social gatherings were mentioned as a very tempting situation which favoured smoking. Boredom was also mentioned as a reason to smoke.

During the brainstorming sessions several ideas regarding game mechanics sparked and were collected and categorised in the following.

The idea to document smoked cigarettes and earning rewards for successful reduction was perceived as very positive. The documentation should be as easy as possible to encourage a continuous documentation. Also defining a custom limit for smoked cigarettes per day was mentioned. This limit varies from person to person, also depending on the initial smoked cigarettes per day. It was also mentioned that the user should have the possibility to adapt that limit over time. In case the reduction is successful the user wants the possibility to reduce even more. This is also seen as a possible way to quit.

The use of smoking as a reward was mentioned several times. The idea to redirect this reward mechanism to something else where the avoidance of a cigarette is rewarded

seemed like a crucial element. The user could receive a virtual item that is relevant to the game progress for not smoking, or the user could get rewarded with a virtual currency that helps to build new structures. Encouragement with motivational quotes were mentioned as well. Unlocking new features when the user sticks to the reduction goal was also discussed. But rewards should not become something natural or obvious. It was stated as very important that the game is retaining the unforeseeable and surprises the player with items or actions.

Alternatively the idea of distraction was mentioned. From personal experience P2 reported that during non-smoke periods in the past, a distraction was needed. Other activities were practiced more extensively to avoid having too much time to think about smoking and compensate the urge. An application that includes a game that distracts from smoking could help to reduce smoking. Distraction is a possibility for some situations, but it does not apply to all situations, e.g. social situations, where the user is not eager to start playing a game.

Another idea mentioned was that the application learns about the smoking habits of the user and reacts to it. The application could for example learn about the usual times the user is reaching for a cigarette and remind the user to play the game instead.

Another idea was that an avatar could mirror the characteristics of the smoker who is playing the game. With continuing smoking the avatar could loose charisma, general performance decreases, or the avatar ages faster. A selected set of negative consequences from smoking would be portrayed accelerated in the avatar. It was also mentioned that an avatar could represent the user's smoking state. If the user is smoking more than the reduction limit, it significantly affects the avatars performance. On the other hand the avatars performance is improved when the limit is not exceeded.

A variation of different game types were discussed with the result that a persistente game world, where things happen while the player is not playing, would be interesting. This would also encourage the user to open the application and check if something happened. The high engagement rate with the application would also encourage the user to state if any cigarettes were smoked in the meantime.

P1 mentioned that it would be encouraging to play the same game as friends, play together cooperatively, or against each other in a competition. Doing something together can be motivating just like some people enjoy working out in groups more than they do alone. Also the motivation to be better than your peers could help the user to smoke less. It was stressed that playing with or against friends could be fun while playing against strangers could encourage cheating. If smoking less offers an advantage in the game, it could be tempting for the player to make false statements about cigarette consumption. Both participants stated that the game should have a single and multi player mode. Playing with friends and competing against each other could encourage using the app and ensure long term motivation. Furthermore if smoking goals and actual behaviour was accessible by friends who are using the same application that could increase motivation. This is based on before mentioned motivating factors. First it has a similar effect of

telling people the goal and second seeing peers succeeding also increases motivation according to P1.

The participants recommended to not incorporate any medical information or any health related context to the game. Since it would not increase motivation. This was explained by the fact that smokers generally know how unhealthy smoking is, also the picture warnings of illnesses caused by tobacco are not stopping people from smoking. Those warnings are often ignored and would according to the participants also be ignored in an application. It was also stated that the personal awareness needs to change in order to change the behaviour.

A good representation of the current state of the progress was mentioned several times. This is seen as very important to increase motivation. The idea came up to include a graphic representation of the lung which is black in the beginning (representing the unhealthy state of the lung) and when the user is successful in reducing the representation of the lung improves.

The participants also mentioned that a mobile phone would be their preferred platform for the application. The high availability of a mobile phone makes documentation of cigarette consumption easy.

The ideas resulting from the brainstorming session were very versatile. The feasibility of the ideas was ignored during the session. After the brainstorming sessions an exhaustive list of all ideas was compiled, see table 4.4. The list is arranged in categories. A considerable amount of ideas were mentioned by both participants independently.

The next step was to assess and analyse the collected ideas. Some ideas were already very concrete, e.g. graphical representation of lung. These ideas were mapped into requirements. Requirements are in contrast to the collected ideas more abstract. Multiple ideas can be summoned into one requirement. Requirements therefore try to generalise the ideas. Resulting requirements are summarised in table 4.5.

4.2.3 Initial Low-fidelity Prototype

The following section describes the first design concept of the application. This concept is a combination based on ideas gathered from literature, state of the art research, and brainstorming sessions (IT-0). For the low-fidelity prototype, paper-based mockups were designed with the cloud based tool Balsamiq Wireframes [71]. The selection of ideas for the first design draft are described in the following.

It was decided to develop a mobile smartphone application, subsequently also referred to as app. 3 out of 4 applications presented previously in Section 3, were developed for mobile devices and brainstorming sessions revealed that mobile devices are the option of choice. Mobile devices are characterised by their high availability, and therefore it allows easy and prompt documentation of smoked cigarettes.

The application is separated into two main parts. The first one is focused on documentation of cigarette consumption, while the other part is a game to keep the user interested

Table 4.4: Brainstorming Ideas

Category	Feature	Description	P1	P2
Avatar	Avatar represents consequences of smoking	Faster ageing		x
		Loss of charisma		x
		Performance decreases	x	
Game genre	Role play game	Player slips into the role of a main character		x
	Real time game	Where the construction of structures can take days	x	x
	Management game	User managees a virtual world	x	
Game strategy	Game for distraction	The game is playable at any time the player wants to play	x	x
	No education	No medical information, no health facts	x	x
Reward system	Reward player with item relevant to the game	The player earns a reward for achieving a milestone	x	x
		Motivational quotes	x	
		Virtual currency	x	
		Unlocking new features	x	
		Gain access to action within the game		x
Social	Cooperation	Play with friends	x	x
		Share goals with friends	x	
	Competition	Play against friend		x
		Snitching feature		x
Other	Artificial Intelligence	Application learns about smoking habit and reminds user to play the game instead of smoking		x
	Picture ageing	Application takes a picture of the user and shows the ageing progress		x
	Graphical representation of lung	Virtual lung improves when the user sticks to the goal	x	

Table 4.5: Requirements from brainstorming

ID	Requirement
B01	Easy and fast documentation
B02	Visual representation of progress
B03	Achievements
B04	Share progress
B05	Cooperation or competition with friends
B06	Optional gaming
B07	Mobile App
B08	Rewards for not smoking
B09	Single- and multi player mode
B10	No additional hardware
B11	Cross-platform ability
B12	Distraction
B13	Longterm interest to maintain a new habit
B14	Custom daily cigarette limit
B15	Customisable to user's progress
B16	Persistent game world

in using the app and focused on the reduction goal. The connection between the two parts is through the smoking behaviour of the user. Initially the user defines a custom reduction goal, which defines the amount of daily smoked cigarettes and throughout the day smoked cigarettes are documented. The game reacts to the documented amount of cigarettes and supports the user, with milestones and rewards, to not exceed the limit. Subsequently these two main parts of the application are described from an UI perspective as views, with the intended functionality.

The view in which the user documents smoked cigarettes is inspired by a diary. Figure 4.7 shows the first design of this view, subsequently referred to as diary. The focus is on the amount of cigarettes the user smokes every day. Journalising smoked cigarettes helps the user to keep track and the app can react to the user's behaviour. Documentation of smoked cigarettes needs to be easy and fast. The diary presents the current day, including the amount of the so far smoked cigarettes, as well as the custom defined limit. Additionally a historical view of the last couple of days will visualise the progress. A clear presentation of the daily consumption and limit helps the user to keep their goal in mind. Milestones are used to enhance long term motivation. A predefined number of days where the user does not exceed the limit will unlock a new milestone. The difficulty to reach a milestone will gradually increase with the user's progress. By achieving a milestone the user unlocks a new item, which will be useful in the second part of the application - the game.

The aim of the game is to plant trees and grow a forest. Figure 4.8 shows the design

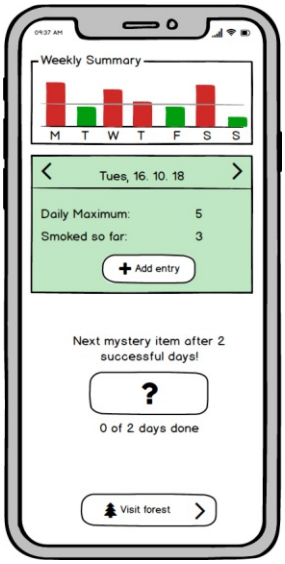

Figure 4.7: Mockup: Diary

Figure 4.8: Mockup: Game

for the game. The user plays the role of the forest ranger, whos task it is, to plant trees and other plants, as well as maintaining the forest. The forest deteriorates when it is not maintained properly. This should motivate the user to revisit the app regularly to check in on the forrest. The more the user interacts with the application, the faster the forest grows. The game is designed as a persistent game world, which means that the forest ranger can work on assigned tasks while the player is not actively playing. The connection to the diary is given by the performance of the ranger, which is dependent on the users cigarette consumption. If the player exceeds the daily custom cigarette limit, the performance of the forest ranger degenerates. With decreasing efficiency the tasks assigned to the ranger will take more time to be finished. Therefore the forest rangers efficiency mirrors the performance of the user regarding the custom limit of cigarettes.

The thriving forest is a visualisation of the progress the user makes, with the correlation between smoking and planting trees the forest represents how well the user is doing.

4.3 Iterative Development Phase

Once the initial design phase is complete, the iterative development phase begins. Within the iterative development phase the design is evaluated with feedback from the intended users and redesigned until a satisfactory solution is found. An iteration is separated into four main steps: preparation, execution, evaluation, and redesign. This section describes the results of every iteration.

4.3.1 Iteration 1

The first iteration (IT-1) used the low-fidelity prototype that resulted from the initial design phase (IT-0). Figure 4.9 gives an overview of the current iteration step and participants. The evaluation of the pretest questionnaire can be found in section 4.1.3, and the evaluation of the posttest questionnaire can be found in section 4.3.3. An essential step for IT-1 was to prepare the needed material for the user session. Therefore the steps explained in section 2.4.2 were executed: Preparation, Execution, Evaluation, Redesign.

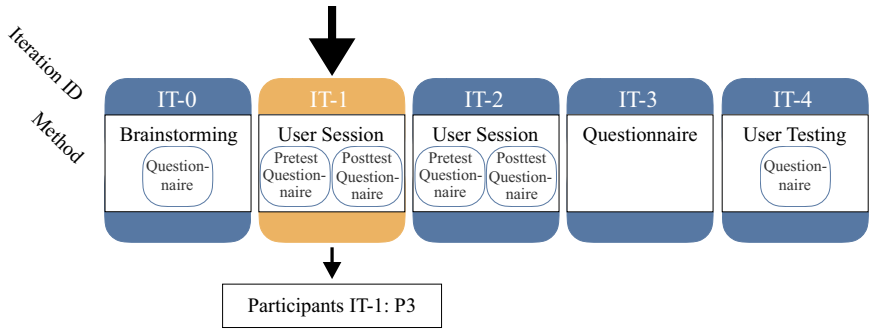

Figure 4.9: Iteration Step: Iteration 1

Preparation The application supports the user in reducing the amount of daily smoked cigarettes. Because this is in itself a difficult task, the application should not create an additional obstacle. Therefore the initial hurdle is minimised by focusing on ease of learning. The low-fidelity prototype included the most relevant views: diary and game. The selected tasks were core tasks e.g. adding a cigarette to the diary, and navigational tasks. The selected tasks were simple to achieve and the execution was estimated to take about 10 minutes. The prepared material included a pretest questionnaire (see appendix on page 122), data collection sheet (see appendix on page 124), posttest questionnaire (see appendix on page 125), paper mockups (see Figure 4.7 and 4.8), and additional UI elements to simulate the user's actions. Since there is not a typical place where the application is used, a public coffee shop was chosen for the meeting. To evaluate the prepared material, a pilot test session was scheduled. The participant was no smoker, but interested in mobile games. The pilot test session proceeded as if it was a regular user test session. The revealed issues were concerning the questionnaire, the data collection sheet, the time the user spent completing the tasks, and the coverage of tested functionality. The issue in the questionnaire was an unnecessary complex phrased question, which was rephrased accordingly. The data collection sheet did not offer enough space for notes and was therefore redesigned to fit more notes. During the pilot test session it was found that time spent to complete tasks was shorter than expected. Since there was still untested functionality it was the obvious thing prolong the time by adding tasks regarding the uncovered functionality. The uncovered functionality was affecting milestones and

achievements. Therefore the task list was extended by adding tasks regarding milestones and achievements.

Execution A representative test user (P3) was found and the test session was scheduled. To increase the information gain from the session, the thinking aloud method was used, as explained in section 2.4.3. With consent from P3 the session was recorded. The user verbally explained how the design is experienced and why certain steps were taken. Additionally to the audio recording, notes were taken, to document the behaviour of the user. The elements positively mentioned were the weekly overview in the diary as well as the milestones. Negatively mentioned was that the diary had no undo button, so that added cigarettes could not be removed, in case of a mistake. Only one error occurred during the session. It was when the user was asked to plant a tree, the new tree was not dragged to the planting location, instead the user tapped on the tree. The results are summarised in table 4.6.

Table 4.6: User Session, Task execution results: Iteration 1 (IT-1)

Task	Comment	Error Count
Add a smoked cigarette to the diary	Execution as expected.	0
Show yesterday's diary entry	Execution as expected.	0
Switch to the game	Execution as expected.	0
Plant a new tree	The user tapped on the tree in the menu	1
Switch back to the diary	Execution as expected.	0
Simulation: User unlocked a new item, where does the user expect to find the item	Execution as expected.	0

After all tasks have been completed and the questionnaire was filled in, the user had the possibility to give general feedback to the concept. A suggestion for improvement was that facts about health, would be motivational to the participant. The gathered requirements from users are collected and collectively documented with the requirements from IT-2 in table 4.9.

Evaluation Generally P3 had a good understanding of the design. The diary view was designed in greater detail and allowed more interaction with the user. All individual parts of the diary view were perceived as intended. All tasks in the diary view were completed successfully. The game view on the other hand was lacking possible interactions. The only task which proceeded entirely in the game view was to plant a tree. This was also the only task that the user had problems to complete. One explanation for this

problem could be the premature design of the view. Because of this the decision was made to terminate the IT-1 after one participant. The game view was incomplete and the participant gave a good overview of what was missing.

Another major issue in the design was that only the achievement section in the diary view revealed the connection between smoking behaviour and game play. But other ideas as the impact of smoking too much on the forest rangers' efficiency were not yet designed. As the game only offered a narrow set of features it did not offer a lot of interaction which will need improvement in the redesigned version. A list of potential improvements was created during the analysis of the results of the test session. The issues were collected in table 4.7. The table contains all found issues as well as the view they are assigned to. A description with an improvement strategie is given as well.

To conclude, a lack of essential features could be determined. A significant drawback is the missing connection between diary and game. The diary was generally perceived as good and would therefore only need minor improvements. Despite the positive feedback of the diary, some adaptation are necessary to emphasise the connection between game and diary.

Table 4.7: Evaluation Result: Iteration 1

View	Issue	Improvement
Diary	No undo for the diary, once a cigarette is added it can not be removed.	Add an undo button to design.
Diary/Game	Missing connection between smoking behaviour and the efficiency of the forest ranger.	Add efficiency display and visualise the relation between smoking and efficiency.
Game	Possible actions are not visible to the user	Better visualisation of actions.
Game	User is not sure if forest ranger is busy or bored.	Better visualisation of the ranger's state.

Redesign To finalise the IT-1 the application needs to be adapted according to the evaluation. One general adaption was the addition of a navigation menu. Initially the app had no navigation menu, because it only consisted of two views, which were stacked on top of each other. But the user session revealed that it was not intuitive for the users to navigate to the game and back. Therefore a tab navigation bar was added. Additional views for settings, e.g. custom limit, were added.

The diary view, as seen in figure 4.10, has two main adaptions. The main change is the progress bar that represents the daily limit as well as the amount of smoked cigarettes. The progress bar of the already smoked cigarettes is connected to and extends into the efficiency bar of the ranger. So that if the amount of smoked cigarettes exceeds the limit,

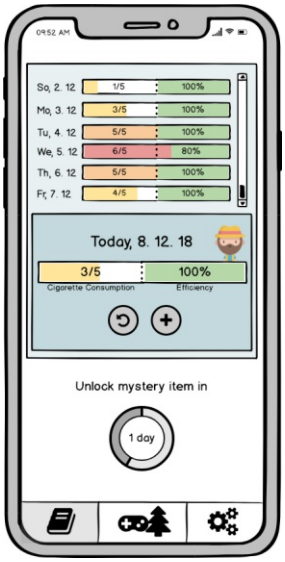

Figure 4.10: Mockup: Diary Redesign

Figure 4.11: Mockup: Game Redesign

the progress bar rised past the threshold for the limit and therefore reduces the efficiency of the ranger. The second adaption in the diary view was the addition of an undo button, which was added next to the add entry button.

The game view, shown in figure 4.11, has been undergoing profound changes. The plant selection menu was changed to a button, which unfolds on tap. The rangers status and efficiency bar is shown in the bottom right corner. To emphasise the connection between the views, this element is consistent with the progress bar seen in the diary. Another adaption was that every planted tree offers the option to play a mini-game. The focus of this redesign was that the game offers more possibilities for interaction and can be used as a distraction. The aim of the game is to help a little bird, that has fallen from its nest. By tilting the phone and tap to jump the player helps the bird back to its nest. By playing the game the user earns a virtual currency, which can be used to plant more trees. With every tree planted, the player can play more often, which increases the ability for faster success in the game. The self-enforcing circle of success is supposed to encourage the player's motivation.

4.3.2 Iteration 2

The second iteration (IT-2) used the improved low-fidelity prototype, which resulted from IT-1. Figure 4.12 gives an overview of the current iteration step and participants. The evaluation of the pretest questionnaire can be found in section 4.1.3, and the evaluation of the posttest questionnaire can be found in section 4.3.3.

Preparation For IT-2 the tasks and the data collection sheet (see appendix on page 126) were adapted. The redesigned mockups were printed and additional UI elements

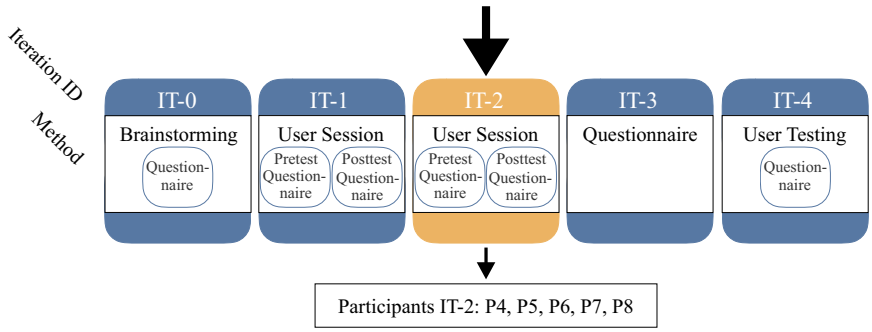

Figure 4.12: Iteration Step: Iteration 2

were prepared to simulate user action. The used paper mockups with the additional UI elements can be seen in figure 4.13.

For IT-2 no pilot test session was planned, since the material was mostly unchanged.

Execution The user sessions were scheduled with P4, P5, P6, P7 and P8. The locations varied depending on the individual participant. Each participant had a different background and due to feasibility the locations varied from a cafeteria, an office, to a library. Similar to the It-1 the thinking aloud method was used and sessions were audio recorded. The summarised results can be found in table 4.8. Main findings and more details are described in the following.

Thinking aloud revealed that the task where the undo button in the diary should be pressed was confusing to the users. The button was confused several times to be a reload button. Therefore a redesign of this button is added to the evaluation list. Another unclear designed button was the menu to plant new trees. It was confused with a map symbol. Therefore the planting a tree task was prone to errors. After unlocking the new milestones, participants tried to tap on it to see what they have unlocked. It was not the correct execution for this task but since multiple people showed the same behaviour, it seems to be more intuitive.

After the tasks were executed each participant was given the chance to provide feedback. This revealed a number of interesting facts. P8 stated that the concept is not challenging enough and that the overall goal is missing. It was also stated that reminders would help to keep focused on the goal, and also increase the sense of guilt if the limit is exceeded.

Another idea from P6 was to divide the day into equal timeslots, depending on the custom daily cigarette limit, and then allow the user to smoke one cigarette in each timeslot. The app could then visualise the time until the next cigarette could be smoked. This would give a guideline to the user if the next cigarette can be smoked.

The idea of a multiplayer game or a possibility to compare ones progress with friends was mentioned as well. It was also stated that the cigarette removal button needs to be

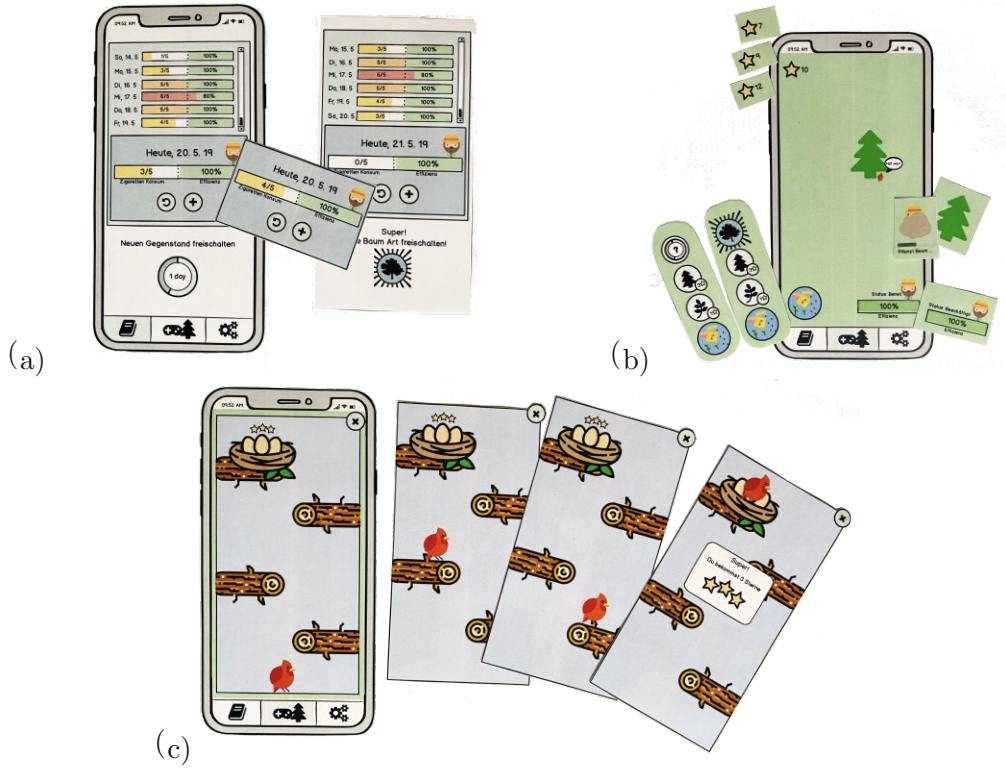

Figure 4.13: Paper Mockups for the IT-2 with additional elements, grouped by view (a) Diary View (b) Game View (c) Game

Table 4.8: Task results: Iteration 2

Task	Comment	Error Count
Add a smoked cigarette to the diary	Execution as expected.	0
Remove the just added cigarette	Execution as expected.	0
Switch to the game	Did not find game, tap on ranger.	2
Plant a new tree	Menu looks like a map.	2
Start Mini-Game	Mini-game not found.	1
End Mini-Game	Taps on screen.	1
Switch back to the diary	Execution as expected.	0
Simulation: User unlocked a new item, where does the user expect to find the item	Taps on achievement.	4

limited to a certain amount of undo-actions, otherwise the user could undo the whole day in the evening, to avoid negative consequences within the application. All requirements are collected in table 4.9.

Table 4.9: Requirements from User Sessions

ID	Requirement
U01	Notifications
U02	Challenge
U03	Timeslot to allow cigarette
U04	Multiplayer
U05	Health Facts
U06	Follow platform specific guidelines

Evaluation The variety of users, who participated within IT-2, revealed a broad set of errors and issues with the prototype. Most issues can be categorised to the navigation, and button design. A couple of issues need to be adressed in order to generate a more intuitive application.

The design limitations due to the paper-based approach were evident. Therefore the decision was made, to develop a prototype as a functioning application for the next user testing. Table 4.10 summarises the major flaws and shows how these issues are solved for the next prototype.

Table 4.10: Evaluation Result: Iteration 2

View	Issue	Improvement
Diary	Undo button is confused for reload	Redesign button
Diary	After achievement is unlocked, user taps on achievement	Redesign according to intentional usage
General	Navigation	Redesign navigation by using platform specific guidelines
Game	User did not find Mini-Game	Redesign to make it more eye-catching

Redesign Apart from the issues regarding the design, IT-2 also revealed how different the application is perceived by different participants. Therefore it was decided to gather requirements from a broader group of people. An online questionnaire seemed to be the appropriate method to do so.

That means that the findings from IT-2 are not implemented in a redesign immediately. The findings of IT-2 however are collected and will influence the redesign for the subsequent prototype.

One adaption that needs to be considered for future designs, are the design of the undo button in the diary view. This button was confused with a reload button several times and needed a different design. The navigation itself was not clear for some users, an in-depth analysis revealed that navigation tabs on the bottom of the screen are usually used on iOS devices and were therefore not intuitive to non-iOS users. The conclusion was that a cross-platform application needs to follow platform specific guidelines.

Users generally wanted to click on the notification that a new achievement was unlocked, rather than navigate back to the game and receive the achievement there. This could be a result of poor navigation or a misleading design. However the design of received achievements needs to change so that users are clear on whether it is a button or not. The mini-game included into the forrest was difficult for the participants to find, the game needs to be placed more obviously for the user.

4.3.3 Evaluation Posttest Questionnaire

The posttest questionnaire helps to evaluate the subjective opinion of the users. Participants from IT-1 and IT-2 filled in the posttest questionnaire. The evaluation is combined for IT-1 and IT-2, where the methodology of user sessions was chosen. Figure 4.14 gives an overview of the evaluated questionnaires. The questions were asked so that the participant could answer on a scale from one to five, where one means not useful or not likely, and five means very useful or very likely. The posttest questionnaire can be found in appendix on page 125.

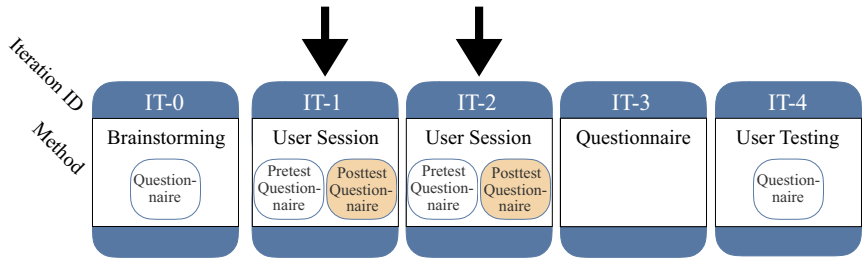

Figure 4.14: Overview of evaluated posttest questionnaires

The first question focused on the personal impression the shown functionality had on the user, and how useful those would be in an actual application. The answer possibilities reached from 1 to 5, whereas 1 stands for not useful and 5 meaning very useful. The average answer for this question was 3.3 which is slightly more on the positive side. The median for this question was 4.

The second question asked about the probability that the user would actually use such an application if it exists, the average of answers was 3, with the median also being three. This is exactly the middle, which means that participants were undecided if the application would be used in a daily routine.

The third question asked about the probability that the application would support the user and help to reach their goal. The average answer possibility chosen by the participants was 2.5 and the median answer for this question was 3. This is the question with the most negative result. Participants do not seem to think that the application could help to reach their goals.

And the last question that users answered asked if the game would increase motivation of the user to use the application. The average of answers was 3.3 and the median of all answers were 3.5.

One participant in particular answered every question with one, which is the lowest score. This was the only participant that chose the lowest score. The other participants tended to chose answers in the medium range, the most common answer was three, with a total of nine votes. The second most common answer was four, with a total of 7 votes.

The results from the posttest questionnaire showed that the concept has potential for improvement. But because user sessions are very time consuming and have a organisational overhead it was decided to change the process in order to reach a wider range of participants. Therefore IT-3 was executed as a questionnaire. To design the application more fitted to the users needs, which is a shortcoming of the prototype so far the focus was on requirements.

4.3.4 Iteration 3

The third iteration (IT-3) based on the experience and knowledge collected form preceding iterations. Figure 4.15 gives an overview of the current iteration step and participants.

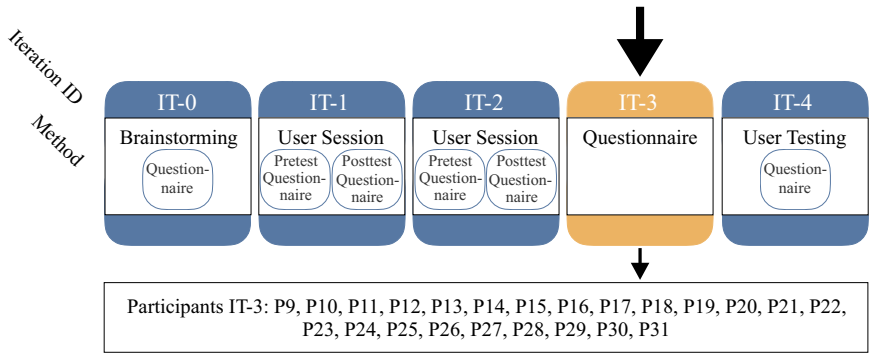

Figure 4.15: Iteration Step: Iteration 3

IT-3 had a strong emphasis on requirements. To increase the probability that users are supported in reaching their goals as well as increasing motivation, an in-depth requirement analysis was planned. To identify requirements from a broader range of participants an online questionnaire was designed. The questionnaire can be found in appendix on page 127. The representation in the appendix varies slightly since it was an online

questionnaire, where different visualisations like dropdown menus can be used. The questionnaire in the appendix was adapted to a reasonable paper version. The emphasise of the questionnaire was to figure out which aspects of the application are important to the users and what is motivational. The questionnaire was filled in by a total of 23 participants: P9, P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, P29, P30, P31. The findings are summarised in the following.

Demographic data that was gathered within this questionnaire is included in the overview of all participants in section 4.1.3 and not evaluated specifically in this section.

The participants were asked if they use their smartphone regularly to play games. The possible answers were daily, from time to time, and no. 12 participants (52%) stated that they are not using their smartphone to play games. 2 participants (9%) said that they are playing games on their smartphone on a daily basis, and 9 participants (39%) said that they play from time to time. The participants were asked to list games that they enjoy playing. An exhaustive list of all mentioned games, with the associated game genre, can be found in table 4.11.

Table 4.11: Games played by participants with genre

Game	**Genre**
Angry Birds [72]	Casual Game
Plague Inc. [73]	Strategy, Simulation
Yu-Gi-Oh! Duel Links [74]	Strategy, Collectible card game
Zombie Strike [75]	Role Play
Pokémon Go [76]	Augmented reality, location-based game
Candy Crush [77]	Puzzle
8 Ball Pool [78]	Sport, Simulation
Human Resource Machine [79]	Puzzle
Brawl Stars [80]	Real-time strategy
2048 [81]	Puzzle
Codycross [82]	Puzzle
Piano Tiles [83]	Music-game, Arcade
Hungry Shark [84]	Action

Some participants did not name their favorite game, but their favorite game genre, which were Quiz, Jump'n'Run and Strategy.

Another question was which emotions are linked to smoking. Possible answers were bored, happy, tired, hunger, irritated, relaxed, stressed, none, or others. It was possible to name multiple emotions. The evaluation revealed that the three main emotions linked with smoking are relaxation 15 (65%), stress 12 (52%), and boredom 12 (52%). The total of all answers and the distribution among the possibilities can be found in figure 4.16.

The questionnaire was targeted at smokers aiming to reduce or quit smoking. 5 partic-

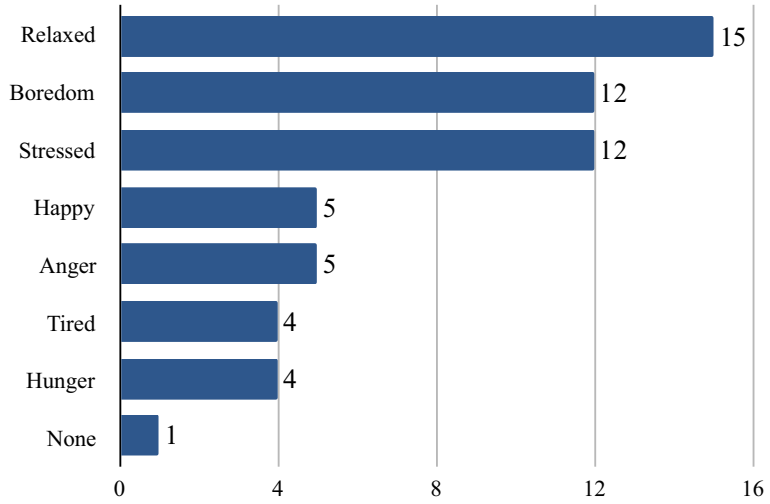

Figure 4.16: Emotions linked with smoking according to the findings from the questionnaire

ipants (22%) stated that they have no desire to reduce or quit and therefore did not qualify for the subsequent questions. On the other hand 10 participants (43%) stated that they would like to reduce their smoking consumption, and 8 participants (35%) said that their goal is smoking cessation. Smokers interested in reducing or quitting were able to continue the questionnaire.

The participants were asked what their reason is to reduce or quit smoking. The possible answers were health, money, time, and others, where the participant could name their personal reason. Participants were able to name multiple reasons. The most common reason to change the smoking behaviour is health, which was chosen by 16 participants (70%), the second most check reason is money, which was chosen by 4 participants (17%). Time was only chosen by 1 participant (4%), and 2 participants (9%) stated that none of the reasons are motivational.

Of the 18 participants that were interested in reducing or quitting only 2 (11%) have never pursued an attempt for either option. In total 10 participants (56%) already failed an attempt to quit smoking, and 6 participants (33%) attempted reducing their cigarette consumption. 10 (63%) out of those who attempted to quit or reduce, had not used an application for support before, but the other 6 participants (63%) have used an application. Only one application was named by the participants, this application is called Flamy [85].

An interest to document smoked cigarettes was stated by 8 participants (44%). 9 Participants (50%) stated that they have no interest in documenting their smoking behaviour and 1 participant (5%) did not specify. The participants that stated that documenting is interesting or did not specify, were further asked if they are interested

in specifying a custom reduction limit. 8 participants (88%) stated it as helpful to define a custom limit. 1 participant (11%) stated that a custom limit is not helpful. 8 participants (100%) of those who said that a custom limit is helpful stated that it is helpful to adapt the limit over time. 6 participants (66%) stated to be interested in documenting moods linked with smoking, 2 participants (22%) stated they are not interested, and 1 participant (11%) did not specify an answer.

The participants were asked which functionality is motivational to them to build long-term motivation. The participants could choose from seven possibilities, it was possible to pick multiple answers, and to specify a custom answer. Possible answers were visualisation of saved money, statistical evaluation of smoking behaviour, reminders and push notifications, health facts, visualisation of progress, motivational quote, none, and an answer specified by the participant. The three most picked answers were visualisation of saved money, due to smoking reduction, with 12 participants (66%), and another 12 votes (66%) chose the visualisation of progress to be motivational, and 10 participants (55%) stated that the presentation of health facts is helpful to stay motivated. The full evaluation of this question can be found in figure 4.17.

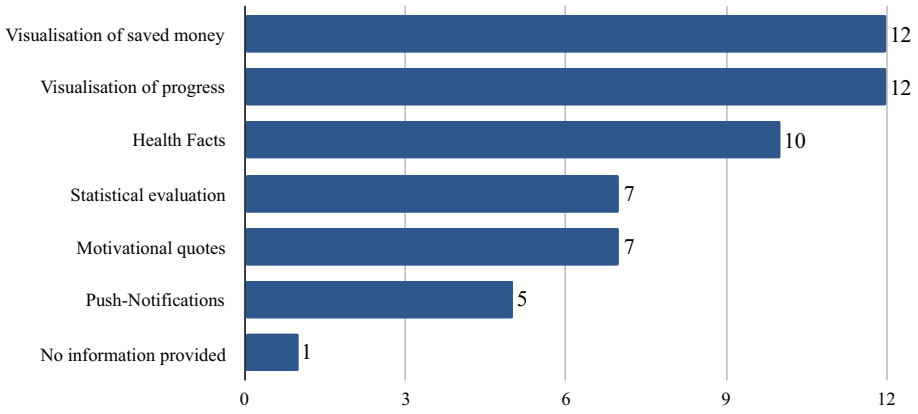

Figure 4.17: Motivational Features

Another question regarding motivation was asked concerning game mechanisms. The participants could choose from 7 possibilities and were allowed to pick multiple answers. The possible answers were point system, levels, highscores, virtual badge, challenges, none, or something else the user could specify. The most popular game mechanism was a point system with a total of 12 (66%) participants, the second most voted answer is to incorporate levels with 9 votes (50%), and the third most voted answer was challenges with a total of 7 votes (38%). An exhaustive evaluation of the question can be found in figure 4.18.

The next questions asked if the participants are interested to share their progress with others. 13 participants (72%) stated that they have no interest in sharing their progress with others, while 5 participants (27%) stated that they are interested to share their

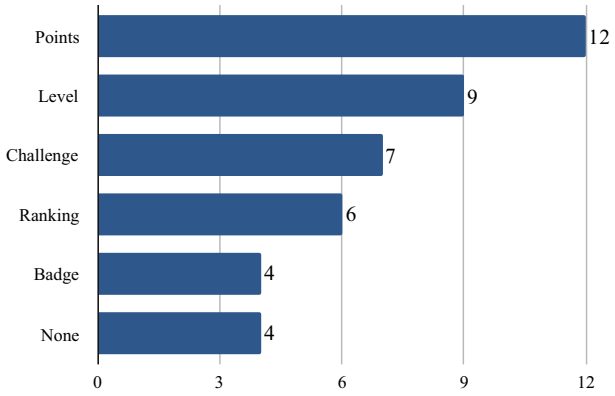

Figure 4.18: Motivational Game Elements

progress. 14 participants (77%) stated that they would prefere a single-player game, 3 participants (16%) would prefere a multi-player game, and 1 participant (5%) chose the third option where the participant could enter a self-defined answer. The participant stated that the preferred option would be to chose between single and multi-player mode.

The results from the questionnaire were evaluated and requirements were defined. Requirements with 7 or more votes were considered as meaningful and therefore summarised in table 4.12.

Table 4.12: Requirements from the questionnaire

ID	Requirement
Q01	Custom limit
Q02	Adaptable limit
Q03	Documentation of moods
Q04	Visualisation of progress
Q05	Visualisation of saved money
Q06	Presentation of health facts
Q07	Statistical evaluation
Q08	Point system
Q09	Level
Q10	Motivational quotes
Q11	Challenges
Q12	Single-Player game
Q13	Document emotions

Redesign The results from the second user sessions and the questionnaire were combined and the final low-fidelity prototype was designed. The initial idea was altered and refined according to the requirements by users.

The application includes a diary, where the cigarette consumption of the current day as well as the past days are visualised. The user is able to see how many cigarettes are allowed until the daily limit is reached. If the limit is not exceeded the users receives points. If the limit is exceeded the user does not receive those points, if however the user exceeds the limit by a certain amount the user gets a punishment and points are deducted. This means that the user is not punished if the limit is exceeded by a small amount, but proportionally to the cigarettes over the limit. According to the interviews held within IT-0, the punishment should not be too harsh, since that would encourage the user to be dishonest. The collected points are a link between diary and game and are used to level up.

The diary also supports adding emotions to each entry. The supported emotions are boredom, relaxation and stress. These are the three most commonly associated emotions with smoking, as the results from IT-3 revealed. The user can track the emotions experienced before, during or after smoking. This could be used for further analysis to help the user identify trigger situations and feelings and therefore support the development of coping mechanisms. The user is also able to add notes to every entry to add any extra information that might be of interest for the user. For every entry with tracked emotions the user earns a life for the game, which is explained in the following.

The game is separated into two components. One is a persistent game world where the user maintains a forrest. Milestones were replaced with levels. The user is able to level up every day, depending on the smoking consumption. For every new level a tree can be planted to grow the forest. The game page also includes a status indicator how many points are needed to level up. If the user does not exceed the limit and interacts with the application by playing the game and adding diary entries, it is possible to plant a tree per day. This helps to keep motivation high and therefore the user keeps interacting with the application. The second part of the game provides more interaction and can be used for distraction or just for fun. It is a platform jumping game where the player navigates in vertical direction over platforms to reach the goal of the level. Each level is designed individually and with increasing difficulty. The difficulty is increased by more advanced enemies and more skills are needed for advanced levels. The player can collect items in each level and will be rewarded with the virtual currency for collected items as well as for reaching the goal of the level. This will also help the user to reach the next level.

The user can customize the limit of cigarettes per day. Therefore the application includes settings where the user can specify the personal limit. This value can also be adapted over time, to help users reduce their consumption. It might be that a user starts with a relatively high cigarette consumption and slowly decreases the amount of cigarettes. It would also be possible that the user reduces the limit further and further until smoking cessation is reached.

4.3.5 Result High-fidelity Prototype

The high-fidelity prototype was developed as an actual application. The resulting prototype was used by participants for a test period to evaluate the effect it has on its users. During the test period data will be collected and analysed afterwards. This will reveal how the developed concept is working and what effects it has on its users. In the following the development and deployment of the final prototype is described.

In the initial design phase, IT-1 and IT-2, requirements were collected. At that time their feasibility and interaction were irrelevant. For each iteration the implemented use cases varied and changed according to user feedback. This helped to get closer to a satisfying and effective prototype. In the following these requirements are categorised into non-functional and functional requirements. Subsequently the most relevant use cases are described.

Functional Requirements

This section describes the functional requirements of the application. Functional requirements are defining the behaviour of the system. They specify what the system is supposed to do.

During the iterations a vast amount of functional requirements were collected. The finally implemented requirements are collected in table 4.13.

Table 4.13: Selected Functional Requirements

ID	Functional Requirement
FR01	Show diary
FR02	Show progress of past days
FR03	Add entry to diary (Report cigarette consumption)
FR04	Add notes
FR05	Add emotions
FR06	Unlock achievements
FR07	Collect rewards for not smoking
FR08	Start game
FR09	Stop game
FR10	Play game
FR11	Acquire game plays
FR12	Acquire points
FR13	Level up
FR14	Increase custom smoke limit
FR15	Decrease custom smoke limit
FR16	Provide Health Facts

Non-functional Requirements

When interacting with participants a lot of requirements were mentioned and, not all of them can be portrayed into a functional requirement. Still they are very relevant to the quality of the final product. So they are summarised under the term of non-functional requirements. They define how a system is supposed to be. In total five non-functional requirements could be determined:

- Usability
- Availability
- Platform compatibility
- Emotional factors
- Extensibility

Every item in this list is summarising multiple requirements mentioned by the participants. Therefore they are explained in more detail subsequently.

Usability as in user friendliness, in the sense that a user is able to perform a task effective, efficient and with satisfaction was a reoccurring theme during the whole time of developing the concept. Especially the performed user sessions had a strong focus on increasing the usability. Where usability was requested most frequently was for adding a diary entry. Multiple users stated that it is very important for them that documentation is easy and fast.

Availability is another quality trait that was distilled from the users statements. Users mentioned several times that they would like to use the gaming aspect of the game for distraction from the urge of smoking. In order to provide an alternative the game needs to be available at all time without obstacle that could frustrate the user and therefore encourage stress relieve in form of smoking. Another request from users was to not need any additional hardware. This would make it easy to use the application wherever and whenever, assuming the user carries their mobile phone. Not needing additional hardware also enables to distribute the application to a broader set of users, since the only thing needed is a mobile phone.

Platform compatibility is also of great importance. People are using different mobile phones with different operation systems. In order to be as inclusive as possible, cross-platform ability is important. This would mean that a great number of smokers are able to benefit from using the application without being excluded by the operation system they are using.

Emotional factors include multiple requests from users. Summarised it is the requirement of high engagement from the user towards the system by adding gaming characteristics. This adds fun to the application. It is adding surprises and an ambition to succeed in the game which is providing a reason to return to the application as well.

Extensibility especially for the game is of great importance to encourage long-term motivation. This prevents the game from getting boring and foreseeable. The game is designed so that levels can be added easily. New levels can introduce new challenges and therefore keep the users interest in using the application.

Implemented Use Cases

A form of describing the interaction of the user with the system is through use cases. Use cases are defined by Cockburn [86] as follows:

> *"A use case is a description of the possible sequences of interactions between the system under discussion and its external actors, related to a particular goal."*

Use cases are describing the system from the user's perspective. The system is treated as a black box and the user is on the outside. The user is interacting with the system. Use case diagrams are included in the appendix on page 133. Deriving from the before mentioned requirements the main use cases are described in more detail subsequently.

Use case *UC01: Set custom cigarette limit* is one that the user executes when the limit is not appropriate for the user for that time. It might be that the default value, which is 10 cigarettes per day, is not suitable for the user, or that the limit needs to be adapted, because the smoking behaviour of the user has changed. Smoking can change in either direction, the user can find the current limit too challenging and therefore wants to increase the limit, or the user adapted to the limit and want to decrease it. The following use case describes both paths.

Use Case UC01: Set custom cigarette limit
Primary Actor: User **Preconditions:** • Application is installed **Trigger:** User decides to adapt the daily custom cigarette limit
Main success scenario: 1. User opens application 2. User navigates to *Settings*

3. The user increases the value of the cigarette limit by pressing +
4. The custom cigarette limit is saved
5. The view is updated
6. The user is satisfied with the adapted value

Alternative:

3 a. Decrease cigarette limit

1. The user decreases the value of the cigarette limit by pressing -, continue with step 4.

6 a. The user wants to further adapt the limit

1. Continue with step 3

Use case *UC 02: Add diary entry* is a use case that is performed whenever the user smoked a cigarette. This is probably one of the most performed use cases.

Use Case UC02: Add diary entry
Primary Actor: User **Preconditions:** • Application is installed • Custom smoke limit is set **Trigger:** User smoked one or multiple cigarette
Main success scenario: 1. User opens application 2. User navigates to *Diary* 3. The user selects *Add diary entry* 4. The user selects the amount of smoked cigarettes 5. The user selects a value for each emotion: relaxed, bored, and stressed 6. The user adds notes 7. The user selects *Add* 8. The diary entry is saved

9. The view is updated and the current day includes the added entry

Extensions:

3-6 a. Cancel adding a entry

1. The user selects *Cancel*
2. The application discards any input the user has made

Use case *UC03: Play game* is performed by the user whenever the user want to play. This can be for distraction, or just for fun.

Use Case UC03: Play game
Primary Actor: User **Preconditions:** • Application is installed • Player has a life/game play is available **Trigger:** User wants to play the game
Main success scenario: 1. User opens application 2. User navigates to *Game* 3. The user selects *Start* 4. The game opens 5. The user plays the game 6. The user wins 7. The system shows the user the added score 8. The user selects *Ok* 9. The system updates the score 10. The system presents the updated score and navigates back to the game view Extensions: 6 a. Game lost 1. The user looses

2. The user looses one life
3. The system shows the user the score to substract, continue with step 8.

Technology Stack and Development

The selection for a development framework is based on requirements gathered throughout user-centred design and development phases. As already described in 4.3.5, platform compatibility is a decisive factor. Interviews and user sessions with potential users revealed that the two main mobile platform used are Android [87] and iOS [88]. To be able to include any interested participants and avoid platform incompatibilities, it was significant to offer the application at least to the two mainly used platforms. Therefore a framework was chosen which enables development for at least those two platforms.

The user sessions revealed that platform specific navigation is of great importance in order to increase usability. A native look and feel helps the user to navigate easier through the application. While iOS users are used to tab bars to navigate different sections of the app. Tab bars are visible at the bottom of the screen. [89] The most common navigation on Android are navigation drawers [90]. The navigation menu is hidden by default and shown by tapping on the navigation drawer icon. The limitation of resources for this thesis was also a crucial consideration. Therefore a single code-base for all provided platforms is desirable. A variety of different frameworks exist which support multi-platform development.

Since the application should also include a game, the use of a game engine was considered. Taking these requirements into consideration a variation of different frameworks was analysed and evaluated towards their features. The comparison of frameworks can be found in table 4.14. After an analysis of different frameworks and game engines the decision was made to use Felgo [91]. Felgo is a software development kit used for cross-platform application development. It was first released in 2012 under the name V-Play Engine and had a main focus on cross-platform mobile game development, also suitable for non-game mobile app development. To reduce the misconception of only being a game engine, it was renamed to Felgo in early 2019. Supported platforms are Android, iOS, embedded devices, and desktop devices. [92]

Table 4.14: Comparison of frameworks for mobile application development

Framework	Cross-platform ability	Native components	Game engine
Unity [93]	✓		✓
Flutter [94]	✓		
React Native [95]	✓	✓	
Felgo [91]	✓	✓	✓

Felgo is based on the Qt [96] framework, which is an open-source framework that enables

cross-platform development. Qt supports a declarative UI (user interface) language called QML [97] (Qt Modeling Language). QML is a user interface specification and programming language. JavaScript as an imperative language is used to define the behaviour of the application. [97]

For the development the Qt Creator [98] IDE (integrated development environment) was used. To enable fast and easy mobile application development the ability for testing on end devices is necessary, especially for sensor data readings. Therefore Felgo offers two variations of testing. The first one is a simulator to test the look and feel for different operating systems as well as resolutions. The other possibility is to test the application on a device, which is connected via WLAN (Wireless Local Area Network). Code changes were recognised immediately and all clients were updated to the newest version without loosing the current state. [99]

Although bottom navigation is also a pattern for Android, the user sessions revealed, that Android users were struggling with the tab bar that was used in the low-fidelity prototype. To minimise usability problems, users of each platform should be provided with the user interface they are used to. Using Felgo helped to reduce these issues to a minimum. The same code can be used to realise custom solutions for each platform. Figure 4.19 and figure 4.20 show the differences between Android and iOS specific navigation.

Figure 4.19: iOS: Navigation tabs

Figure 4.20: Android: Navigation drawer

SQLite [100] is a database engine that supports multiple platforms and is built into all mobile phones. [100]

SQLite is also supported by Felgo and can be accessed by JavaScript. The combination of two persisting solutions provided the possibility to flexibly use the technology that fitted each use case perfectly. Therefore configuration data, for example primitive data types were stored in the key-value store. An example from the application is the custom limit of daily cigarettes. Other more complex data types were stored in the SQLite database. This was used for diary entries. Although this would have been possible to store in a

key-value store it seemed more fitting to use a relational database. This enabled to use SQL queries in order to filter for specific data. A representation of the implemented database can be seen in figure 4.21.

The application was built without a backend. Both data persisting methods are solely on the users phone. This also means that the user needs no internet connection at any time to use the application.

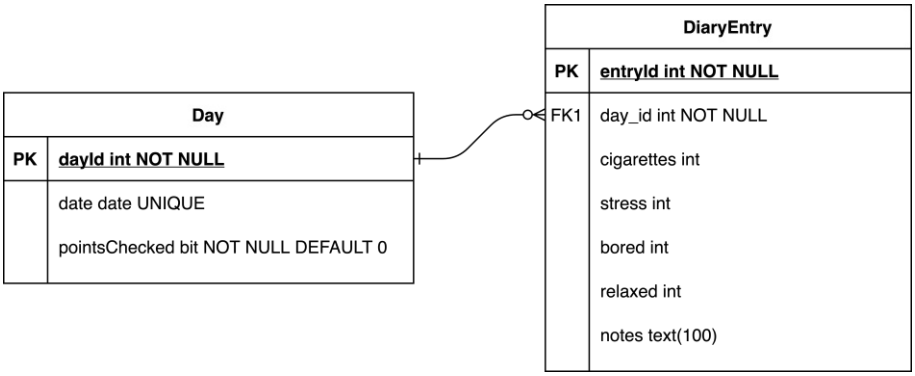

Figure 4.21: Database Diagram

As a version control system git [101] was used. Using GitHub [102] as a remote repository served as a backup of the current state of the development. The GitHub repository was also useful in a further step, the deployment.

Design and Game Mechanics

The design of the application was kept as closely to the mockups as possible, some minor adaptions were necessary. To provide a user interface that is very easy to understand, platform specific guidlines were followed as explained in section 4.3.5. Other than that the link between cigarette consumption and game was important to highlight. This was done by using the same icons. By using icons in the game that the user would recognise from the diary the connection between the cigarette consumption and gameplay was tried to be made. The priority to reuse components was a key cornerstone for the whole design and was an attempt to help the user navigate the application easier.

An overview of the diary page can be found in figure 4.19. The diary page is divided into two main parts. One of which resembles the current day. This segment includes the current date, a textual and visual representation of the custom limit and smoked cigarettes of today, a visualisation of the punishment the users would get if the limit is exceeded, a visualisation of the average for each emotion of the current day, and the possibility to add a new entry for today. This view is supposed to help the user keep track of the smoked cigarettes and always keep the custom limit present. This should operate as a reminder for the user to stay on track and not exceed the limit. The representation of the smoked cigarettes is realised as a progress bar. This bar fills with every cigarette

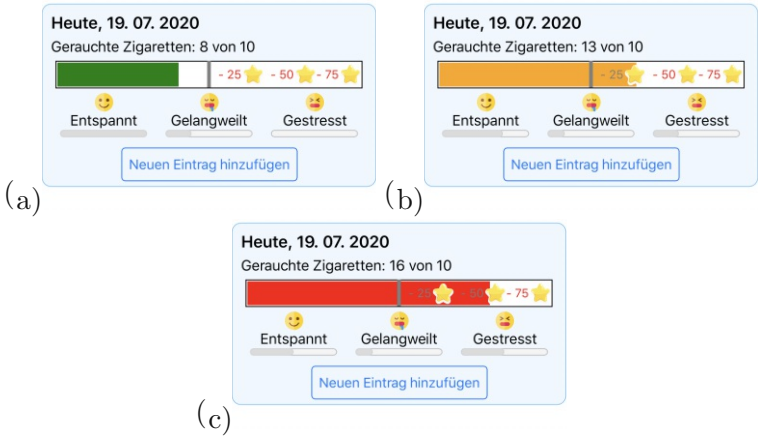

Figure 4.22: Evolution of progress bar

that is added to the current day. At first the progress bar is green, symbolising that everything is fine, see 4.22 a. When the bar fills up above the custom limit the color changes to orange, see figure 4.22 b. This shows the user that the limit is exceeded and no more cigarettes should be smoked. If the user keeps on smoking and exceeds the limit by 50% the color of the bar changes to red, see figure 4.22 c. This is the signal that the limit is exceeded and the user should not smoke another cigarette. The colors are chosen from the well known concept of a traffic light.

The visualisation of the punishment can also be found within the progress bar. In total the user can collect three punishments per day. This is represented by the amount of points that would be subtracted from the total score and the symbol of the items that are collected in the game, explained further down. Visually the punishment is applied when the progress bar fills up to the particular punishment. The first punishment is obtained when the user exceeds the limit by 25%. For a smoker that has a limit of 10 cigarettes per day this would be at 13 cigarettes. The second punishment is at 50% and the third is at 75%.

The emotions are stress, relaxation and boredom. Each emotions is represented by an emoji, that is symbolising the specific mood. The value represented is an average of all entries from the current day, where emotions have been filled in. Since emojis could be interpreted in different ways, a textual description of each mood was added.

When the user chooses to add a new diary entry, a dialog window opens where the user can provide details about the smoking habit. At the top of the dialog window a slider helps the user to select the amount of smoked cigarettes. The minimal value is 0 and the maximum value is 20. For more precise adjustments a minus and a plus button are provided on either side of the slider to add or remove one cigarette at a time. The user can add multiple cigarettes with one entry in case that a couple of cigarettes were smoked and the user forgot or did not want to track each cigarette individually. With every diary entry the user can also indicate an emotional state. Therefore three sliders are provided,

each one for a different emotion. For each emotion the user can choose a value between 0 and 10. Low values represent a low presence of that feeling, whereas a high value stands for a very stressed, happy or bored user. The act of tracking these emotions alone brings awareness and can therefore influence the smoking behaviour of the user. Additionally to cigarettes and emotions the user can add notes to every entry. These notes can be used for a variation of purposes. The user can track activities, places, or anything else that feels important in the current situation. Figure 4.23 shows the dialog to add a new diary entry.

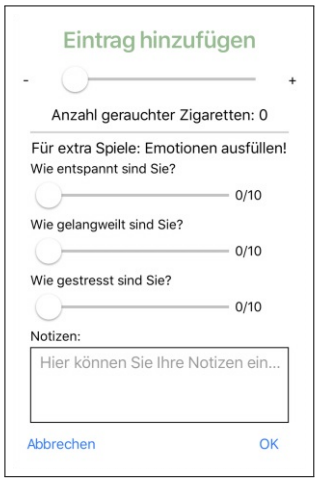

Figure 4.23: Dialog to add a new entry to the diary

After adding a new entry to the diary the user interface is updated immediately and the user can see the entry in the current day view. The second section of the diary view is the representation of progress of the previous days as a list view. Every record in the list represents a day, where the user added diary entries. Every record is titled with a date. This indicates from which day the entry originates. The record is a collection of all entries that the user made that day. The progress bar of smoked cigarettes is similar to the one from the current day view. This increases the continuity in the user interface and therefore helps the user with orientation. The progress bar is simplified as in that the punishment is not visualised since past days punishments do not have an effect for the present time. The three emotions are also visualised with the emojis that are familiar to the user from the current day view. The visualisation of the emotions is also simplified in the manner that no textual description of emotions is here. The list helps the user to have an overview of past days and can be interesting to see how the smoking behaviour and smoked amount of cigarettes changed within the past days.

Platform specific navigation helps the user to switch between the pages. Each navigation item has a textual description as well as a symbol to make it more clear what the user can expect when choosing that item. Additionally each page has a title, the same as the navigation item, to help the user understand where they are at any time. The second page is the game page. On top of this page the user finds the current score. This is a number

and the star-symbol that the user knows already from the diary page. Underneath the score a level progress bar can be found. This tells the user the current level and how much points are needed to unlock the next level. This is a textual description as well as a visual reprepresentation. The most part of this page is filled with the persistent gameworld, where the user can plant one tree per successful day. By planing a new tree the forrest grows day by day. A successful day is defined as one where the next level is unlocked. A huge part of unlocking the next level is to stay within the custom limit. For each day, where the user does not surpasses the limit he or she will earn 80 points. Every level is defined to be 100 points. The remaining 20 points can be collected by playing the game, which is described further down. The game offers more interaction for the user. Users are not forced to play the game but it helps to unlock new levels faster. The game is a vertical-scrolling jumping puzzle game, where the player is striving upwards by jumping from platform to platform. On the way up the player can collect goodies that are already familiar from the diary and game page. Every goody collected increases the score. At the end of each level a symbol can be found that is representing the goal of the level. By finishing a level the player receives additional points. If however the player dies on the way up, one life is deducted from the total lives and the game is finished. The player can die by falling down or hitting an enemy. The goodies that have been collected until that point are still added to the total score.

An exhaustive list of possibilities to collect and lose points and lives can be found in table 4.15.

Table 4.15: Possibilities to gain and lose points and lives within the diary and game

Action	Consequence	Amount
Successful day	Increase score	80
Successful day	Increase lives	3
Collect Goody	Increase score	1
Win game	Increase score	5
Exceed limit by 25%	Decrease score	25
Exceed limit by 50%	Decrease score	50
Exceed limit by 75%	Decrease score	100
Fill in emotions	Increase lives	1
Finish game	Decrease lives	1
Loose game	Decrease lives	1

When the application is initially opened the user is able to plant one tree and play the game three times. This gives the user the chance to get to know the application and understand the concept before points and lives need to be collected.

The first level is designed to help the user to learn the basics of the game. To provide the player with a easy level there are no enemies and the platforms are relatively wide. This gives the player the opportunity to learn how the controls and the physics work,

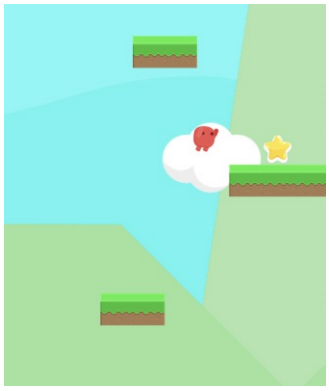

Figure 4.24: Level 1

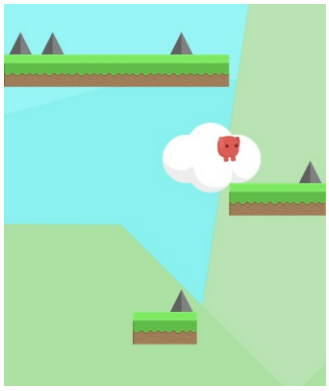

Figure 4.25: Level 2

and gives the player an initial idea of how to navigate the avatar through the world. To increase the encouragement of the player there are goodies to be collected. Figure 4.24 shows level one.

After succeeding level one the player knows how to control the avatar, so the level of difficulty is increased in level two. The first enemies appear, the so called spikes. Spikes are static enemies that kill the player when touched, this teaches the player to be careful and not touch spikes. The skill level of the user increases as it is more difficult to navigate the world without harm. Level two and its spikes can be seen in figure 4.25

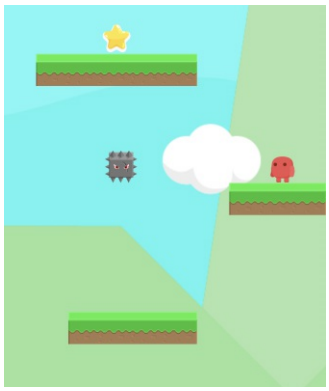

Figure 4.26: Level 3

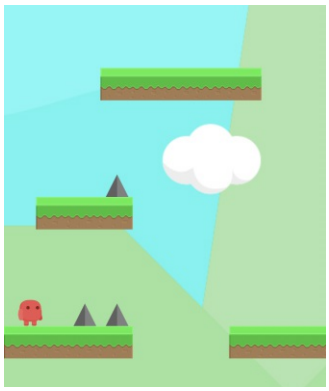

Figure 4.27: Level 4

In level three the first moving enemies are introduced. They are characterised by a movement from the left to the right side of the screen in a certain speed. The speed of an individual does not change, but they can move at different speeds. In level three they move relatively slowly, so that the player can adjust to the new situation. With moving enemies the player has to actively plan when to jump, in order to avoid touching them. Therefore timing is necessary and the user has to think about when to jump from one platform to the next, so that the enemy is at a save distance. Figure 4.26 shows the

newly introduced enemies.

Now the player learned about static and dynamic enemies, so level four is combining the two types of enemies. Additionally this level is teaching the player the new skill of switching to the other side by moving the avatar out of the screen. Moving the avatar out of the screen on one side makes it appear on the other side of the screen. This is the very first time the player has to use this skill, otherwise there is no chance to win the level. It might be that the player used the side switching before, but in the situation as seen in figure 4.27 the player has no other possibility.

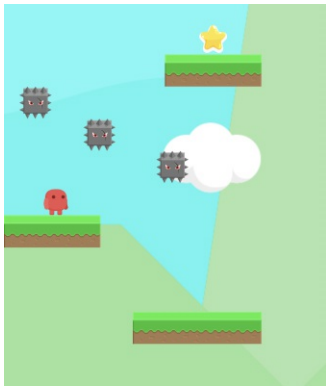

Figure 4.28: Level 5

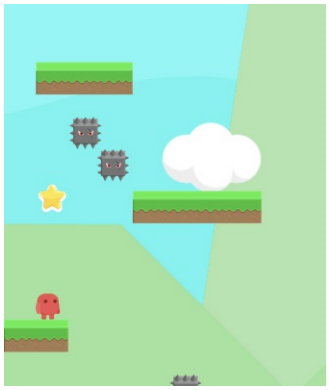

Figure 4.29: Level 6

Level five is introducing dynamic enemies that come in packs. They move with different speeds so that timing becomes even more challenging. It is necessary to make the right decision at the right time in order to succeed the level.

Level six introduces goodies, which are more difficult to reach. The player has to take special routes to collect all goodies. Level seven combines everything the user has learned so far.

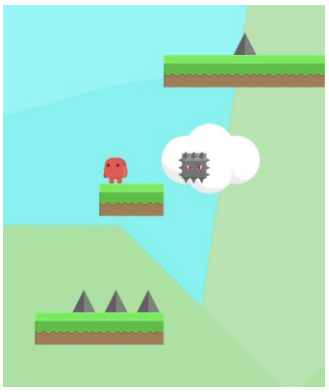

Figure 4.30: Level 7

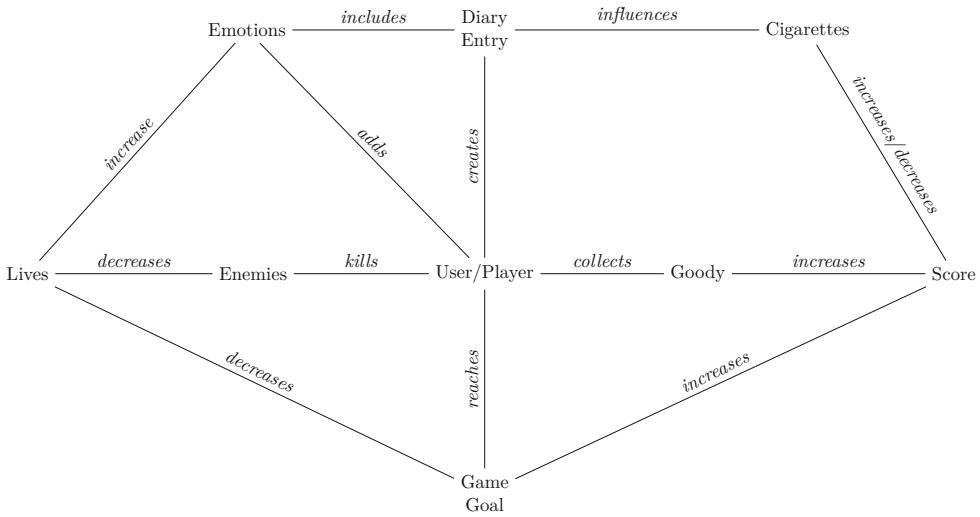

Figure 4.31: Game Mechanics

The connection between different elements from the game and diary have been visualised in figure 4.31. Represented as a directed graph, the nodes represent the main elements of the game, in this context called objects. The objects are assigned to either the diary or the game. Blue nodes represent objects connected to the diary and yellow nodes represent objects from the game context. Connected by directional edges the influences of each object on other objects is represented. Every edge is labelled with a verb that describes the interaction between the two objects.

On the health page it is planned to give the user information about health risks related to smoking and advantages for reducing, but for the prototype this page is only mocked and no information can be found here.

The settings page is where the user can edit the settings of the application. Therefore limit of daily smoked cigarettes can be adapted here. The default value for daily smoked cigarettes is initially set to 10. By pressing the + or - button the user can adjust to the personal goal.

The last page is the credits page, where information about designers for the emojis and game items can be found. This page can be seen in figure 4.33.

Deployment and Pilot Testing

The application was deployed with Felgo Cloud Builds [103]. This made the build process easier since no android SDK needed to be installed. Two versions of the application were build, each for the two platforms: iOS and Android. Both versions of the application were deployed. The first version was the previously explained application with all features, including the game. The other version had no game elements. The game page as well as all references to the game were removed from the diary and the about page.

Figure 4.32: Game

Figure 4.33: About

The application was named *Game of Smoke* and for the icon a lung symbol from Flaticon [104] was used. The game character was added on top of the lung. The lung was chosen as a reference to the harm smoking causes to the lung and the game character [105] was added as a reference to the game. The final icon can be seen in figure 4.34.

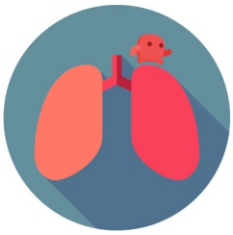

Figure 4.34: Icon of the application

Before the application was distributed for the final user testing, it was tested by two pilot test persons. These were no smokers, but did test the application for one week. One participante for each platform was selected. The application was tested on an iPhone 11 and OnePlus 5 with Android 10. This helped to find any bugs that might passed through testing during development or would only occur after a longer period of using.

The application was distributed as in two different ways. Android users received a link to download the APK (Android Package), this link started an automated download and users then had to install the application on their phone. iOS is more restrictive with installing software, therefore the final build of the application was uploaded to the App Store Connect, which is a platform for developers to manage their applications. It also offeres the possibility to register the application for TestFlight which is a application available in the App Store to distribute applications which are still in the testing phase. Users are registered as testers, which allows them to install the application on their device.

4.3.6 Iteration 4

The fourth iteration (IT-4) based on the high-fidelity prototype, which resulted from IT-3. Figure 4.35 gives an overview of the current iteration step and participants.

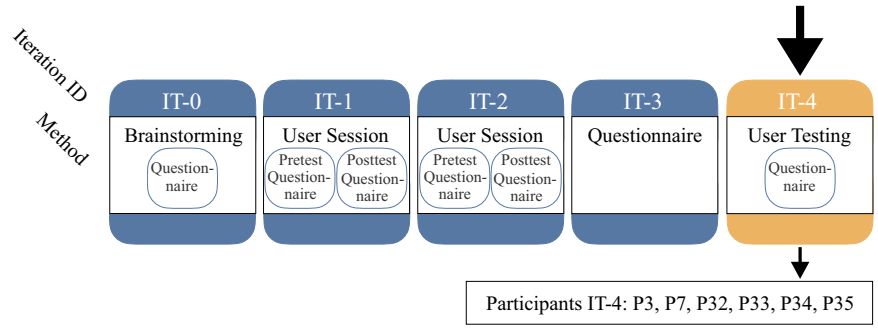

Figure 4.35: Iteration Step: Iteration 4

The application was distributed to a total of 6 users. These were selected according to their interest to test the application for one week. Participants from earlier iterations, IT-0, IT-1 and IT-2 were asked if they were interested in testing the application. IT-3 was anonymously and therefore these participants could not be contacted. Only two of all previously participants were were interested and had time to participate in IT-4. P3 and P7, who already participate in IT-1 and IT-2.

The distribution is different depending on the platform the users use. Felgo Cloud Builds is used to build the build artifacts. These artifacts are build for the two most common platforms: iOS and Android. Android uses the Android Package (APK) which can be distributed and installed to all Android devices. Participants using Android could get the APK through a download link. To install an application on an iOS device the artifact needs to be signed by a verified developer and can only be distributed through the AppStore or TestFlight. In this case the distribution via TestFlight was chosen. TestFlight is an application itself, that can be installed through the AppStore and enables distribution to iOS devices. This happens by sending invitations by email to testers. Through this invitation the testers are able to install the iOS App Store Package (IPA), which is a version of the developed application, on their phone.

To see the effect of the game on motivation only 3 (50%) of the users received the application with the full range of features. Table 4.16 shows an overview of testers, the platform they used and whether or not they had the game available.

During the test period of one week the activity of the users was logged for further analysis and evaluation. The logs revealed the activity of users including timestamps, type of activity, like opening the application, make diary entries, play, etc. The results from this evaluation are analysed in the following.

Table 4.16: Overview of participants for the user testing

Participant ID	Platform	Diary	Diary and Game
P7	Android	✓	
P32	iOS		✓
P33	Android	✓	
P3	iOS		✓
P34	iOS		✓
P35	Android	✓	

In total the participants made 132 diary entries. 116 (88%) of entries included the report of cigarettes, where a total of 283 cigarettes were logged. Diary entries could also be made without reporting a smoked cigarette, but instead emotions. 16 (13%) of entries were done by only reporting emotions. On average the users reported 2.1 cigarettes per entry.

The amount of entries made by each participant varied. Figure 4.36 shows the distribution of all entries separated by participant. This shows that one participant in particular was very active and made 75 (57%) of all entries.

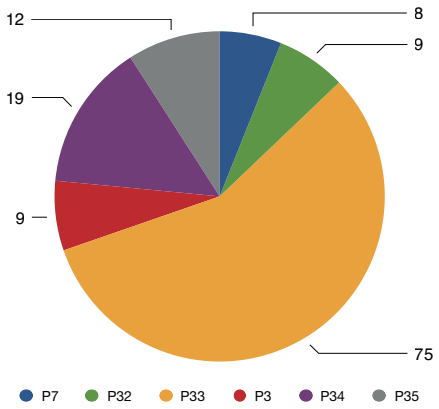

Figure 4.36: Amount of entries per user

Another interesting fact is the timely distribution of the entries. Figure 4.37 shows every entry made to the diary, separated by user on a one week time line. The vertical lines mark midnight for each day. This figure shows that P7 was invested in using the application for one day but then did not make any more entries. P32 and P35 did miss some days. P3, P33 and P34 did use the application consistently every day. And P33 made by far the most entries.

The activity of participants with the game and without the game varied. 37 (28%) of all entries were made by participants with the game, and 95 (72%) were made by participants

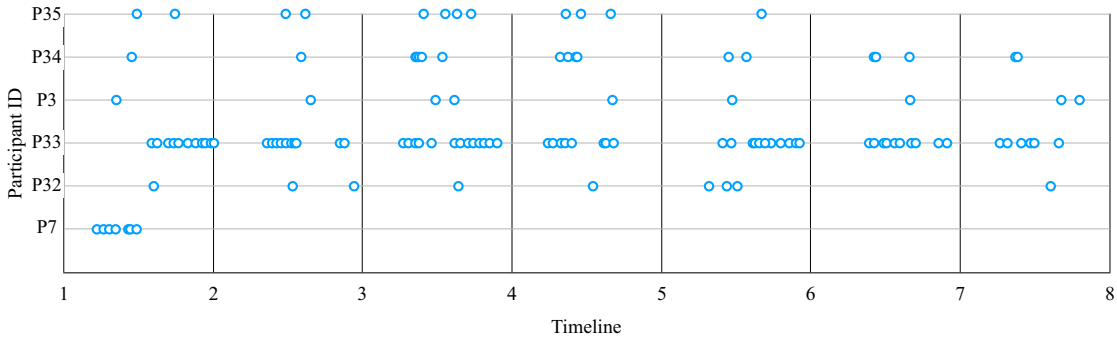

Figure 4.37: Diary entries separated by user on a one week time line

without gaming features. An explanation for this is, that as before mentioned, P33 was particularly active and this participant did not have the gaming options.

This can be explained in the different usage of the diary per participant. Whereas the participant with the most diary entries documented the cigarette consumption very frequent, others did not make as much entries, but instead documented more cigarettes with each entry. The participant with the most entries documented an average of 1.6 cigarettes per entry. The average for documented cigarettes of all other users is 2.8.

The preset default value for the daily limit of cigarettes was set to 10. Three users (50%) adapted the limit to their individual limit. In total the limit was only exceeded twice. The adapted values as well as how often the limit was exceeded, can be seen in table 4.17. The participant who adapted the limit, did this in the on the first day of the test period, no user adapted the limit after that.

Table 4.17: Customised limit per user

Participant ID	Limit	Penalties
P7	25	0
P32	10	1
P33	20	0
P3	10	0
P34	15	0
P35	10	1

The amount of documented cigarettes per user can be seen in figure 4.38. This figure shows a diagram for each user, where the total amount of smoked cigarettes per day is marked. The individual limit is shown as well. Participants who were using the application with gamification elements are marked.

This shows that the amount of smoked cigarettes can vary vastly from day to day and no tendency towards reduction could be identified in the short amount of time.

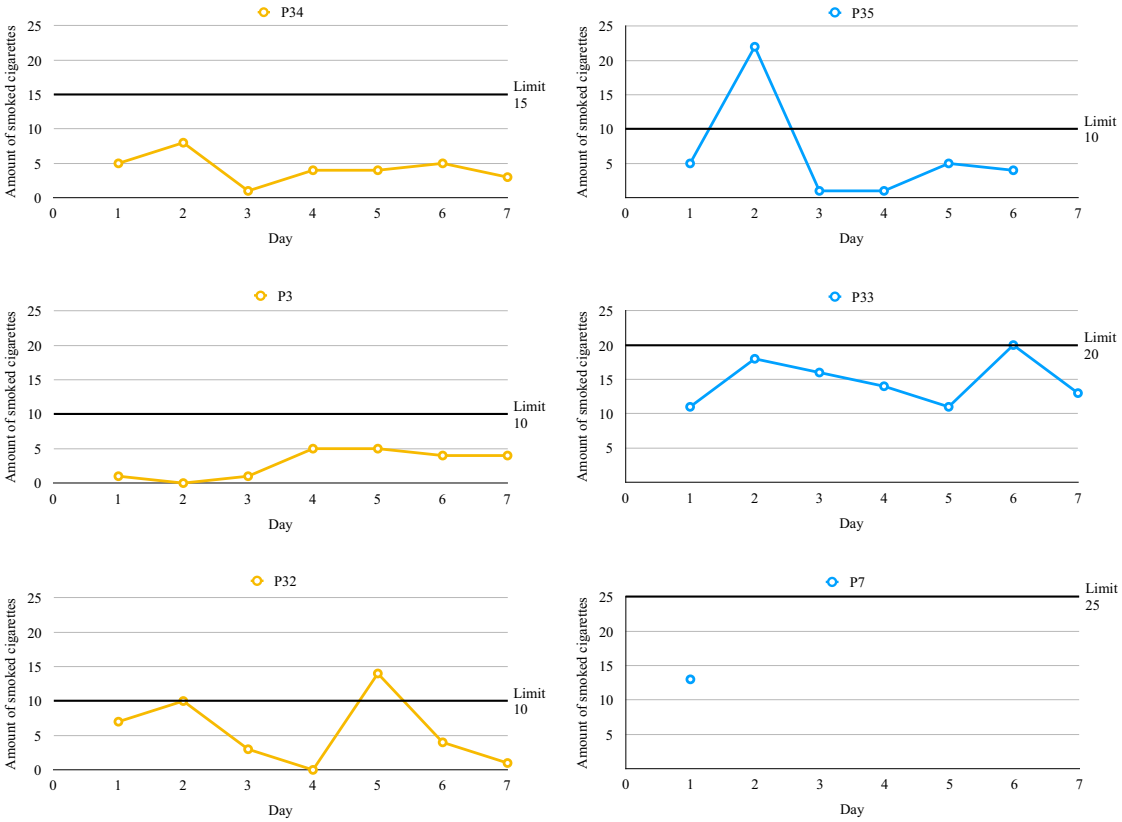

Figure 4.38: Smoked cigarettes per day, separated by participant

The feature to log emotions was used in 117 (89%) of all entries. The most commonly reported emotion was relaxation, which was reported in 113 (86%) entries. The second most common reported emotion was boredom which was reported in 83 (63%) of all entries. Stress was the least often selected emotion with 81 (62%) of all entries. For every reported emotion the users could select a value that represents the intensity of the present emotion. The user was able to select a value between 0, meaning that the emotion is currently not present, and 10, meaning that the emotion is very intense. It was found that the average value of all entries selected for happiness was 6, for bored 3, and for stressed 2.

The users were also able to add notes to diary entries, notes were added to 4 (3%) of all entries. This feature was only used by P7, the other five participants did not once add notes to diary entries.

Figure 4.39 shows the total amount of diary entries, and the amount that users used each feature, when adding a diary entry. The bars in the figure are sorted by the amount of

usage for each particular feature.

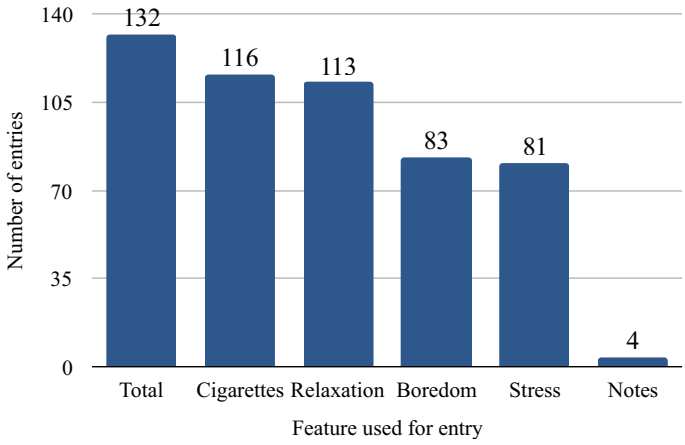

Figure 4.39: Amount of usage separated by feature

P3, P32 and P34 were using the application with the game. All three participants combined played the game 25 times, with a total duration of 12 minutes. All three players combined planted 14 trees. The game was conceptualised to be used for the one week test phase. In case the daily smoking limit was not exceeded and the player interacted regularly with the diary, it was possible to level up daily. Therefore 7 levels were designed. Two players reached the final level with a score of 743 and 616, the third player was able to reach level 4 with a total score of 393. By all players the limit was exceeded only once, which resulted in a score reduction by 25.

Questionnaire

After one week of testing the users were asked to fill in a final questionnaire. The questionnaire can be found in appendix on page 135. Demographic data collected were analysed in section 4.1.3.

Additionally to the demographic questions the users were questioned regarding their personal opinion and experiences towards the application. Those results are explained subsequently.

Users were asked about their personal perception of the prototype. The possible answer was a scale where they could choose a value representing their personal experience. The scale ranged from 1 to 5, where 1 means not useful and 5 means very useful. The average value selected was 3.8.

The next questions the users were asked was how likely it is that they would continue using the application. The participants were again able to choose a value from 1 to 5, where 1 stands for not likely at all and 5 meaning very likely. The average selected value was 3.2.

The users were asked about their favourite feature of the application. The answer possibilities were diary, weekly overview, game, or other, where the participant was able to fill in their favourite feature. Multiple answers were possible. No user entered a customised answer. Chosen features were the diary with 5 votes, the weekly overview with 3 votes, and the game with 2 votes.

The users were also asked if the application was helpful in reducing their cigarette consumption. The participants were able to chose between yes, no, or other which gave the participant the opportunity to give their opinion. 3 (50%) stated that the application was indeed helpful to reduce their smoking consumption, while 3 (50%) answered with no, meaning the application did not help in reducing.

The next question desired the participant to rate their own honesty towards documenting their cigarette consumption. The user had to rate their honesty on a scale from 1 to 5, 1 meaning not very and 5 meaning very honest. The average answer was 3.8.

The following question was asking the participant to give the reasons for not documenting accurately. The questionnaire offered the following predefined answers: Forgot to document, no desire, too complicated, to avoid the punishment in the game (if available), or others where the user was able to describe their reason to not be honest with the documentation. The participants were able to select multiple. The most common answer was that the participant forgot to document a smoked cigarette, this was selected by 5 (83%). No desire to document was stated by 1 (16%). The other answer possibilities were not chosen by any participant.

The next question asked the participant to rate the personal experience of documenting the smoked cigarettes on a scale from 1 to 5. 1 meaning easy and not complicated, and 5 meaning unpleasant and time-consuming. The average value was 2.6.

The participants were also asked if they think that the application would help them to reduce their smoking consumption in long-term. 4 (66%) answered with yes, and 2 (33%) said no.

The participants who had access to the game were asked if they experienced any positive effect resulting from the game to recude their smoking consumption. 2 (66%) of users answered with yes, and 1 (33%) answered with no.

None of the participants chose to give general feedback on their experience from using the application.

CHAPTER 5

Discussion

This chapter discusses the previously in chapter 4 presented results of this thesis. These will be analysed and their value and importance towards answering the research questions will be evaluated.

The aim of this thesis was to implement a prototypical application for smokers that are interested in reducing their daily cigarette consumption and evaluate the impact it has on its users. By choosing a user centred design approach the target group had a great impact on the concept, design, and implementation. Within 4 iterations, 44 requirements from 35 users were collected and evaluated for the development of the final prototype.

In the beginning a literature research was performed to build a fundamental understanding of smoking cessation, reduction, trigger situations, motivation, the individual and social impact of smoking. State-of-the-art research was building an understanding of current solutions, their shortcomings as well as their strengths. The research revealed that there is a lack of support for people interested in reducing their smoking consumption. A wide range of support for smoking cessation could be found, such as telephone help lines, therapy, medication, and an assortment of applications.

Therefore, an application supporting smokers in reducing their cigarette consumption was suggested and was found to encounter great interest from participants. The user centred design approach helped to include requirements and user needs from an early stage and continuously throughout the development. The concept and ideas were shaped and adapted to the feedback and requirements from users. The methodology for each iteration varied due to the demand and progress of the prototype. Questionnaires were used throughout the process to gather basic demographic information as well as the subjective impression the user had from the particular presented interim result. For the initial design phase, interviews and brainstorming sessions, with 2 individual smokers, were used to develop the basic concept of the application. The first concept was a diary style application to document smoked cigarettes. A custom daily cigarette limit is holding

the user accountable to the personalised goal. The diary was combined with a game, which was connected to the diary. The more the user interacts with the diary, the more benefits can be accomplished in the game. A total of 25 requirements were extracted from these steps.
Based on the results and ideas from the initial design phase a first low-fidelity prototype was developed. The paper-based prototype was then evaluated within the first iteration, which was conducted with one user. Basic tasks were defined and tested by simulating user actions, for a more detailed feedback the thinking-aloud method was used. Strengths and weaknesses were documented, evaluated, and for the next iteration estimated, ranked by priority, and redesigned. The second iteration was using the same methodology and had a strong focus on usability. 6 users participated in the second iteration. Iteration one and two generated 6 new requirements. The third iteration focused on requirements and was designed as an online questionnaire. This helped to reach a broader set of participants, and therefore 23 participants filled in the questionnaire. This iteration helped to refine the application. The game was restructured and levels were added to visualise progress, the diary was expanded to the possibility to add emotions to each diary entry, and health facts were added to the application. In total 13 new requirements could be determined from this iteration.

All findings were summarised and assembled into a high-fidelity prototype. This high-fidelity prototype was the final prototype that should be delivered to the participants as an actual application for one-week test phase. 6 participants were selected for the final iteration. These were separated into two groups, with 3 participants each. The first group had the full range of functionality, while the second group had no access to gamification elements. During the test week, user activity was logged, this data was then evaluated. The 6 participants also filled in a questionnaire after using the application for one week. This questionnaire helped to gather the subjective opinion from participants on the prototype.

The evaluation showed that people are generally interested in using an application to help them reduce their daily smoking consumption. One main problem was that they forgot to document every smoked cigarette. Participants were very different in the way that they used the application. One participant in particular did document smoked cigarettes very frequently, while others documented smoked cigarettes in bulks, meaning that the number of smoked cigarettes per entry was on average 2.7.

5.1 Research Question 1

> *"Which requirements can be identified for a gamified smoking diary to increase motivation on reducing cigarette consumption?"*

The requirements for a gamified smoking diary were collected from literature research, interviews, brainstorming sessions and an online questionnaire. A total of 44 requirements

were determined with the help of 35 participants. The main findings are collected and described in the following.

To be inclusive to a broad target group and not exclude someone because of their type of mobile phone, cross platform functionality was a requirement that showed up at an early stage of requirement analysis. To fulfil this requirement, the application should be platform independent and should not be reliable on the use of additional hardware.

Smoking is an addiction and cravings for a cigarette are the main reason for failure in smoking cessation. Coping with cravings is also a big deal when the goal is to reduce the amount of daily smoked cigarettes. Therefore, the application should provide a distraction from cravings, which was provided with the game. The users were able to play in order to distract themself from smoking. To counteract relapsing into old behaviour, it is important to keep the user engaged. Maintaining long-term interest was identified to be a crucial requirement for the application.

The ability to identify trigger situations was also found to be very effective to avoid cravings. Observation of the current behaviour is very important to change it. Documentation of smoked cigarettes could be determined to be very important in smoking cessation and reduction. Literature research as well as statements from participants were indicating the importance of documentation. Since certain emotions are more likely to be linked with the urge of smoking it is necessary to observe emotions that occur while smoking. The diary offers the possibility to document emotions and other notes. This can be used to individually analyse the situations and reasons when a cigarette is smoked.

Another requirement that could be identified was usability. Participants in 4 iterations emphasised the importance of good usability. Users want to be able to document a smoked cigarette as easy and fast as possible. Therefore it is important to keep the requirements for a diary entry as minimal as possible. The user needs to be able to provide only as little information as possible in order to create a diary entry. It is also necessary that the user does not feel any guilt when a smoked cigarette is documented, even when the limit is exceeded. The application is dependent on the honesty of users and it needs to be avoided that users smoke without documenting it to the diary.

The smoking behaviour can change over time, therefore it is necessary that the limit of daily smoked cigarettes is customisable at any given time. This enables the smoker to adapt the limit to the currently achievable goal.

The visualisation of progress is another requirement which was found to be important to users. For users it is important to see improvements, this can have an immense effect on the motivation.

The determined requirements are versatile and to condense these into an application, that supports the users, is a crucial part in order for it to be successful. Especially the use of gamification needs to be considered carefully, so that the resulting game has meaning and makes fun.

5.2 Research Question 2

"Which elements of Serious Games and Gamification can be identified to support smokers in reduce smoking?"

It was found that the interaction between diary and game provides an interesting opportunity for a Serious Game. The main idea was to influence the game directly with the activities from the diary.

The target group is very heterogeneous, people of all genders, ages, and through all social classes are smokers. The type of game that is of interest is very individual and differs depending on the personal interest and likings. This could also be shown by the evaluation of the questionnaire in section 4.3.4. The typically played games varied a lot and no common game genre interesting to the majority of participants could be determined. But it could be found that the interaction between diary and game is essential. The more the user interacts with the diary the more advantages are gained for the game. A well-chosen game genre and well-designed game mechanics are able to increase the user's interest to use the application.

To provide the interaction between diary and game a point system was found to provide a solid base to incentivise the users interaction with the application in general. Points can be used for positive feedback to reinforce reduction of smoking and boost the progress in the game. Points can also be used for negative feedback, to indicate that certain behaviours are undesired, like exceeding the amount of smoked cigarettes a day. This can help guide the user towards a better behaviour.

Levels were also found to be a popular element of gamification. Requirement analysis showed that the target group sees the involvement of levels as a good way to visualise progress. The user gets the feeling of success when a new level is reached, and it also enables the comparability with friends. Apart from that levels can also indicate the level of difficulty to the user. The level of difficulty needs to be chosen deliberately; it is important to not overwhelm the user with level design that is too challenging. Levels also enable to further extend the game, which is important for long-term usage of the application.

Another way to visualise progress and keep users motivated was the use of a persistent game world. This gives the user a reason to come back to the game and see the progress in the game world.

Additionally, a game which is available to the user at all times was found to be a valuable addition. This enables the user to use the game as a distraction, from the urge of smoking. The combination of persistent progress in a persistent game world and the availability of consistent game play is providing a variation of gameplay that different people from the target group can identify with.

Although the wishes form users for a single or multi-player game are very individual it was found that the majority would prefer a single-player game. This helps the user to

focus on oneself and pursue the personal goal as good as possible without being distracted from the success or failure from others.

5.3 Research Question 3

> *"In what way can the consumption of cigarettes be reduced within the evaluation period by using a Serious Game?"*

In total 6 participants were selected to test the application for one week. The participants were separated into two equally sized groups. The first group had the application with all features available, while the second group had only the diary without any game elements. This means, that the application with gamification was used by a total of three users for the test period of one week. Three different users tested the application without gamification. All 6 users successfully finished the test phase.

The data analysed in order to answer this research question was taken from logs, that were collected throughout the test period, as well as a questionnaire.

The 6 participants created a total of 132 diary entries, documenting 283 smoked cigarettes. Of all entries 116 included the documentation of associated emotions. The user (P33) with the most individual diary entries, made a total of 75 entries. Table 5.1 shows the amount of entries per participant.

Table 5.1: Number of diary entries per participant and group

Participant ID	Diary Entries	Group
P3	9	Diary and Game
P7	8	Diary
P32	9	Diary and Game
P33	75	Diary
P34	19	Diary and Game
P35	12	Diary

The evaluation of log data revealed that 3 participants customised the daily cigarette limit. During the one week test phase the limit was exceeded two times, once by P32 (with game) and once by P35 (without game).

All 3 participants, who had access to the game, played the game a total of 25 times, collected 14 of 21 possible achievements, and 2 participants reached the final level 7.

CHAPTER 6

Conclusion and Future Work

Within this thesis a prototype was implemented to support users in the reduction of daily smoked cigarettes. Therefore, the fundamentals of smoking reduction and cessation were researched and state of the art applications were analysed. The documentation of smoked cigarettes was found to be a fundamental part to support smoking cessation. The use of gaming elements was considered early on and their ability to increase encouragement was researched. The combination of documentation and gaming elements resulted in a first concept for an application. A user centred design approach was chosen, to improve the initial concept, which was then shaped and refined throughout multiple iterations. A total of 38 participants gave feedback and supported the development of the application with their feedback and ideas.

Initial feedback was given by users in a brainstorming session. All ideas were collected, prioritised, and subsequently incorporated into the first low-fidelity prototype. The following two iterations had a focus on interface design. To gain a broader understanding for the requirements of the target group, another iteration with a focus on requirement engineering was performed. Therefore an online questionnaire was created. The UI was adapted and new features were added. It was found that the documentation of emotions linked with smoking can help smokers to analyse their behaviour, therefore the feature to document emotions was added. Another crucial identified feature was the customisable daily cigarette limit, where the user is able to adapt the limit at any time.

The learnings from all iterations were merged and the high-fidelity prototype was implemented. The final prototype is therefore the result of all previously conducted steps. The main feature set of the prototype is the diary to document cigarettes and emotions, a mini-game, and settings to customise the personal limit of daily cigarettes.

The prototype was tested for one week. To be able to evaluate the effect of the game the test persons were divided into two groups. Both groups were equal in size. One group tested the application with the full range of functionality, while the second group had no

access to the game. By separating the users into two groups the difference of motivation and involvement could be evaluated.

The implemented prototype and the evaluation of the iterations throughout the user centred design were able to provide valuable results and findings to support smoking reduction. There are still a multitude of opportunities to conduct further research:

- *Requirements Engineering.* A considerable amount of people were involved in the development of the application. The resulting concept shown was considered as a good foundation for an application to help people reduce their daily cigarette consumption. The weakness was that the game did not seem to be all that interesting for people. In order to reach a broader audience the game needs an in-depth analysis and requirements need to be more detailed requirement engineering. Due to the nature of very broad interest in games of the target group, it might be necessary to focus on a subset of the target group which enjoys one game genre altogether.

  The evaluation showed that the game did not increase the usage of the application as much as expected. The interest towards the game was reserved low. A thoughtful game design could increase the motivation of users, but would be out of the scope for this thesis.

- *Test duration.* The test period of one week revealed that the application is in general well received by participants. Smoking reduction however is a long-term process and one week of testing is not enough for people to reduce their smoking consumption. Participants adapted their custom smoking limit only at the first day. In order to evaluate smoking reduction a long-term test phase of a couple of month would be necessary. A long-term evaluation would reveal how much time the average users needs before the limit is reduced. Also if the user is interested in using the application long-term could be observed.

- *Advancement.* The application gives the possibility to document emotions with diary entries. This feature was used very often by participants. The documented emotions are visible for each day individually, but no further analysis is possible with the current stage of development. Accumulated analysis over several days and weeks could enable the user to understand trigger situations.

  The application also offers the possibility to add notes, which was not used very often by users. The possibility to add additional information to diary entries as an enhancement should be considered such as time, situations, location, etc. In total this could enable the user to analyse ones behaviour and could reveal trigger situations. This would enable the user to avoid certain situations or develop coping mechanisms.

- *Game play mode.* It was found that a cooperative game or leaderboard needs to be considered very carefully. Since the application is based on the honesty of the users documented cigarette consumption it is always a balancing act to not make the

user feel guilty or bad when cigarettes are reported. If the progress is shared with friends and the user realises that the current behaviour is not as advanced as their friends they might go in one of two directions. One possibility is, that the user feels unmotivated to further document the smoked cigarettes, the other possibility is, that the user tries harder to be better. This is however a very personal reaction and differs from person to person. A possibility that could be considered is a multi-player game that can be played with a limited group of people, such as the user's friends.

The developed prototype is supporting people who are interested in reducing the amount of daily smoked cigarettes. The prototype can be seen as a foundation for further development. Several improvements are possible and necessary in order to support people efficiently in reducing their smoking consumption.

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List of Figures

1.1 Overview of iterations 5

2.1 Daily smokers in Austria older than 16 years, separated by gender and in total [13] 8
2.2 Example of a smoking protocol [27] 12
2.3 Example of a smoking protocol [29] 13
2.4 Percentage of global population covered by MPOWER in 2008 [31] 14
2.5 Taxonomy of serious games [43] 16
2.6 The relations between serious games and similar educational concepts [45] 19
2.7 Flow State [54] 26

3.1 Crave-Out [66]: Beta-Testing Phase 42
3.2 QuitIT [67]: After-Dinner Scenario 43
3.3 Inspired [68] Start Screen 44
3.4 Inspired [68] Game Play 44
3.5 Quittr [69] Progress Page 45
3.6 Quittr Incentivization Game "Tappy Town" [70] 46

4.1 Detailed Overview of Iterations 51
4.2 Overview evaluated questionnaires 52
4.3 Participants goal for their smoking consumption 54
4.4 Years of active smoking by participants 54
4.5 Reasons to reduce or quit smoking 54
4.6 Iteration Step: Iteration 0 57
4.7 Mockup: Diary 63
4.8 Mockup: Game 63
4.9 Iteration Step: Iteration 1 64
4.10 Mockup: Diary Redesign 67
4.11 Mockup: Game Redesign 67
4.12 Iteration Step: Iteration 2 68
4.13 Paper Mockups for the IT-2 with additional elements, grouped by view (a) Diary View (b) Game View (c) Game 69
4.14 Overview of evaluated posttest questionnaires 71
4.15 Iteration Step: Iteration 3 72

4.16 Emotions linked with smoking according to the findings from the questionnaire 74
4.17 Motivational Features 75
4.18 Motivational Game Elements 76
4.19 iOS: Navigation tabs 84
4.20 Android: Navigation drawer 84
4.21 Database Diagram 85
4.22 Evolution of progress bar 86
4.23 Dialog to add a new entry to the diary 87
4.24 Level 1 89
4.25 Level 2 89
4.26 Level 3 89
4.27 Level 4 89
4.28 Level 5 90
4.29 Level 6 90
4.30 Level 7 90
4.31 Game Mechanics 91
4.32 Game 92
4.33 About 92
4.34 Icon of the application 92
4.35 Iteration Step: Iteration 4 93
4.36 Amount of entries per user 94
4.37 Diary entries separated by user on a one week time line 95
4.38 Smoked cigarettes per day, separated by participant 96
4.39 Amount of usage separated by feature 97

List of Tables

3.1 Comparison of State of the Art applications 48

4.1 Overview of iterations, their used method and Participants 50
4.2 Participants 53
4.3 Requirements from literature research 56
4.4 Brainstorming Ideas 61
4.5 Requirements from brainstorming 62
4.6 User Session, Task execution results: Iteration 1 (IT-1) 65
4.7 Evaluation Result: Iteration 1 66
4.8 Task results: Iteration 2 69
4.9 Requirements from User Sessions 70
4.10 Evaluation Result: Iteration 2 70
4.11 Games played by participants with genre 73
4.12 Requirements from the questionnaire 76
4.13 Selected Functional Requirements 78
4.14 Comparison of frameworks for mobile application development 83
4.15 Possibilities to gain and lose points and lives within the diary and game . 88
4.16 Overview of participants for the user testing 94
4.17 Customised limit per user 95

5.1 Number of diary entries per participant and group 103

Appendix

Pretest Questionnaire: Iteration 1 and 2

Fragebogen 1 - Iteration _, User _

1. Sie sind …

- ☐ weiblich
- ☐ männlich

2. Sie sind zwischen … Jahre alt.

- ☐ 18-25
- ☐ 26-40
- ☐ 41-55
- ☐ über 55

3. Benutzen Sie Ihr Smartphone regelmäßig um Spiele zu spielen?

- ☐ Nein
- ☐ Ja, jeden Tag
- ☐ Ja, mehrmals wöchentlich
- ☐ Ja, ab und zu

Wenn ja, welches sind Ihre beliebtesten Spiele?

_____

4. Seit wie vielen Jahren rauchen Sie?

- ☐ <1 Jahr
- ☐ 1-5 Jahre
- ☐ 6-10 Jahre
- ☐ >10 Jahre

5. Welches der Folgenden sind die häufigsten Auslöser dafür, dass Sie zur Zigarette greifen?

- ☐ Stress
- ☐ Langeweile
- ☐ Soziale Situation
- ☐ Andere. Bitte angeben:

_____

6. Bitte zutreffende Option ankreuzen. Ich möchte …

- ☐ mit dem Rauchen aufhören.
- ☐ weniger rauchen.
- ☐ genauso weiter rauchen wie bisher.

1

Die folgenden Fragen nur beantworten, wenn Sie weniger rauchen, oder mit dem Rauchen aufhören möchten:

7. Was ist Ihre Motivation das Rauchen aufzuhören/zu reduzieren? (mehrere Antworten möglich)

- ☐ Geld
- ☐ Gesundheit
- ☐ Zeit
- ☐ Andere. Bitte angeben:

_____

8. Haben Sie schon einmal versucht aufzuhören/zu reduzieren? (mehrere Antworten möglich)

- ☐ Ja, reduzieren
- ☐ Ja, aufhören
- ☐ Nein

9. Wenn Frage 8 mit Ja beantwortet wurde: Haben Sie schon einmal mit Hilfe einer App versucht aufzuhören/zu reduzieren?

- ☐ Ja. Bitte angeben welche:
- ☐ Nein

10. Wenn Frage 8 mit Ja beantwortet wurde: Wie lange waren Sie erfolgreich beim Versuch aufzuhören/zu reduzieren?

- ☐ <1 Woche
- ☐ 1-4 Wochen
- ☐ 2-3 Monate
- ☐ >3 Monate

11. Welche Gründe führten zum Scheitern des Versuches?

- ☐ fehlende Motivation
- ☐ fehlendes Durchhaltevermögen
- ☐ Stress
- ☐ Andere. Bitte angeben:

_____

Data Collection Sheet: Iteration 1

Data Collection Sheet, Iteration 1, User _

	Task	Korrekte Umsetzung	Korrekt		Probleme/Kommentare
			J	N	
1	eine Zigarette dem Tagebuch hinzufügen	auf den Button mit dem + Symbol drücken			
2	Gestern anzeigen	Pfeil nach links drücken			
3	zum Spiel wechseln	Auf den Button mit dem Baum drücken			

	Task	Korrekte Umsetzung	Korrekt		Probleme/Kommentare
4	einen Baum pflanzen	Baum nehmen und irgendwo im Wald pflanzen			
5	zurück zum Tagebuch wechseln	auf den Zurück Knopf drücken			
6	Nach Simulation: Wo würde neues Item erwartet werden?	Auf den Button mit dem Baum drücken			

1

Posttest Questionnaire: Iteration 1 and 2

Fragebogen 2 - Iteration _, User _

Bitte beantworten Sie die folgenden Fragen durch Angabe des Wertes, der am besten Ihre Meinung und Gefühle widerspiegelt.

1. **Basierend auf Ihrem persönlichen Eindruck der gezeigten Funktionalitäten, wie nützlich wäre eine solche Anwendung?**
   Bitte entsprechenden Wert auf der Skala markieren.

1	2	3	4	5
nicht nützlich				sehr nützlich

2. **Wie wahrscheinlich ist es, dass Sie eine solche Anwendung verwenden würden?**
   Bitte entsprechenden Wert auf der Skala markieren.

1	2	3	4	5
nicht wahrscheinlich				sehr wahrscheinlich

3. **Für wie wahrscheinlich halten Sie es, dass die Anwendung Ihnen dabei helfen könnte ihre Ziele zu erreichen?**
   Bitte entsprechenden Wert auf der Skala markieren.

1	2	3	4	5
nicht wahrscheinlich				sehr wahrscheinlich

4. **Wie wahrscheinlich ist es, dass das vorgestellte Spiel Sie zusätzlich motivieren würde Ihr Ziel zu verfolgen?**
   Bitte entsprechenden Wert auf der Skala markieren.

1	2	3	4	5
nicht wahrscheinlich				sehr wahrscheinlich

Vielen herzlichen Danke für die Teilnahme an der Umfrage! Ihre Reaktionen, Meinungen und Ideen sind sehr wertvoll für die weitere Entwicklung der Anwendung. Ich bedanke mich für Ihre Zeit und Mühe, und hoffe die Teilnahme war für sie interessant und ein angenehmes Erlebnis

1

Data Collection Sheet: Iteration 2

Data Collection Sheet, Iteration 2, User _

	Task	Korrekte Umsetzung				Probleme/ Kommentare
				J	N	
1	eine Zigarette dem Tagebuch hinzufügen	auf den Button mit dem + Symbol drücken	Neue Ansicht			
2	Aktion rückgängig machen	Undo Button drücken	Ansicht weg			
3	zum Spiel wechseln	Auf den Button mit dem Baum drücken	Neues Blatt			

	Task	Korrekte Umsetzung				Probleme/ Kommentare
4	Baum pflanzen	1. Menü öffnen 2. Baum auswählen 3. auf Wiese platzieren	Menü Hand Förster Sterne abziehen			
5	Vogel Baby retten	Auf „Vogel retten“ Button drücken	Blatt wechseln Neue Ansicht Neue Ansicht Neue Ansicht			
6	Spiel beenden	Auf X klicken	Blatt weg			
7	zurück zum Tagebuch wechseln	Auf Button mit Buch drücken				
8	Simulation: 1 Tag vergeht	Auf den Button mit dem Baum drücken	Neue Ansicht			

1

Questionnaire: Iteration 3

Rauch- und Spielverhalten

Herzlich Willkommen! Dies ist eine Befragung die im Rahmen einer Diplomarbeit an der Technischen Universität Wien ausgeführt wird. Die Studie befasst sich mit der Thematik wie Rauchverhalten mittels Spiel-Mechanismen beeinflusst werden kann. Das Ausfüllen dauert ca. 10 Minuten. Vielen Dank für Ihre Teilnahme!

* Erforderlich

1. Geschlecht *

Markieren Sie nur ein Oval.

- ◯ Weiblich
- ◯ Männlich
- ◯ Andere
- ◯ keine Angabe

2. Geburtsjahr

_____

3. Seit wie vielen Jahren rauchen Sie? *

Markieren Sie nur ein Oval.

- ◯ <1 Jahr
- ◯ 1-5 Jahre
- ◯ 6-10 Jahre
- ◯ >10 Jahre
- ◯ Keine Angabe

4. Benutzen Sie Ihr Smartphone um Spiele zu spielen? *

Markieren Sie nur ein Oval.

- ◯ Ja, jeden Tag
- ◯ Ja, mehrmals wöchentlich
- ◯ Ja, ab und zu
- ◯ Nein *Fahren Sie mit Frage 6 fort*

5. Welches sind Ihre beliebtesten Smartphone-Spiele?

_____

_____

_____

_____

_____

Fahren Sie mit Frage 6 fort

6. Welche Gemütszustände treten in Kombination mit Ihrem Rauchverhalten auf? Beispiel: Wenn ich rauche, verspüre ich oft ... *

Wählen Sie alle zutreffenden Antworten aus.

- ☐ Langeweile
- ☐ Glücklichkeit
- ☐ Müdigkeit
- ☐ Hunger
- ☐ Gereiztheit
- ☐ Entspanntheit
- ☐ Stress
- ☐ Keine

Sonstiges: ☐ _____

7. Bitte zutreffende Option ankreuzen. Ich möchte ... *

Markieren Sie nur ein Oval.

- ◯ mit dem Rauchen aufhören. *Fahren Sie mit Frage 8 fort*
- ◯ weniger Rauchen. *Fahren Sie mit Frage 8 fort*
- ◯ genauso weiter rauchen wie bisher.

8. Was ist Ihre Motivation das Rauchen aufzuhören/zu reduzieren? *

Wählen Sie alle zutreffenden Antworten aus.

- ☐ Geld
- ☐ Gesundheit
- ☐ Zeit
- Sonstiges: ☐ _____

9. Haben Sie schon einmal versucht aufzuhören/zu reduzieren? *

Markieren Sie nur ein Oval.

- ◯ Ja, reduzieren
- ◯ Ja, aufhören
- ◯ Nein *Fahren Sie mit Frage 12 fort*

10. Haben Sie schon einmal mit Hilfe einer App versucht aufzuhören/zu reduzieren? *

Markieren Sie nur ein Oval.

- ◯ Ja *Fahren Sie mit Frage 11 fort*
- ◯ Nein *Fahren Sie mit Frage 12 fort*

11. Welche App haben Sie dafür verwendet?

_____

Für die folgenden Fragen stellen Sie sich bitte vor, dass es eine Mobile App gibt, die sie dabei unterstützt weniger zu rauchen/aufzuhören.

12. Hätten Sie Interesse Ihr Rauchverhalten digital zu dokumentieren und somit die Anzahl an gerauchten Zigaretten besser überwachen zu können? *

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein *Fahren Sie mit Frage 16 fort*
- ◯ Keine Angabe

13. Schätzen Sie es als hilfreich ein, zusätzlich zu dieser Dokumentation, ein selbstdefiniertes Limit an Zigaretten pro Tag festlegen zu können? *

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein *Fahren Sie mit Frage 15 fort*
- ◯ Keine Angabe *Fahren Sie mit Frage 15 fort*

14. Würden Sie dieses Zigaretten-Limit gerne im Lauf der Zeit an Ihre Bedürfnisse anpassen? *

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein
- ◯ Keine Angabe

15. Würden Sie gerne auch im Bezug auf Zigaretten-Konsum relevante Gemütslagen dokumentieren können? *

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein
- ◯ Keine Angabe

16. Welche Funktionen hätten auf Sie eine motivierende Wirkung? *

Wählen Sie alle zutreffenden Antworten aus.

- ☐ Anzeige von bisher erspartem Geld
- ☐ Statistische Auswertungen im Bezug auf Ihr Rauchverhalten
- ☐ Erinnerungen/Push-Mitteilungen (als Erinnerung daran den Zigarettenkonsum zu dokumentieren)
- ☐ Präsentation von Gesundheitsfakten
- ☐ Visualisierung des Fortschrittes
- ☐ Motivierende Sprüche
- ☐ Keine Angabe

Sonstiges: ☐ _____

17. Welche Spiel-Mechanismen könnten Sie motivieren regelmäßig Ihr Rauchverhalten zu dokumentieren? *

Wählen Sie alle zutreffenden Antworten aus.

- ☐ Punkte-System
- ☐ Level
- ☐ Rangliste
- ☐ Virtuelles Abzeichen
- ☐ Herausforderungen
- ☐ Keine

Sonstiges: ☐ _____

18. Würden Sie Ihren dokumentierten Fortschritt gerne mit anderen teilen können? *

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein

19. Welchen der folgenden Spielmodi bevorzugen Sie? *

Markieren Sie nur ein Oval.

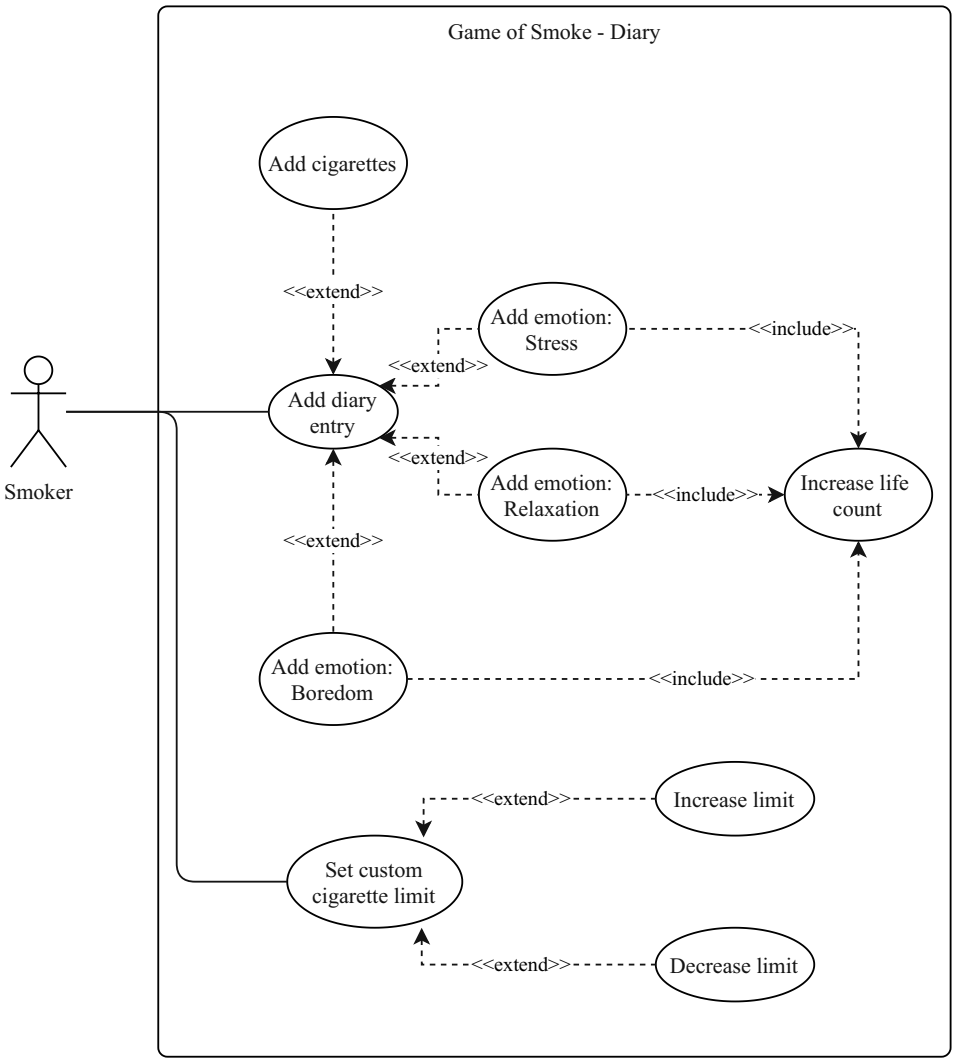
- ◯ Single-Player
- ◯ Multi-Player
- ◯ Sonstiges: _____

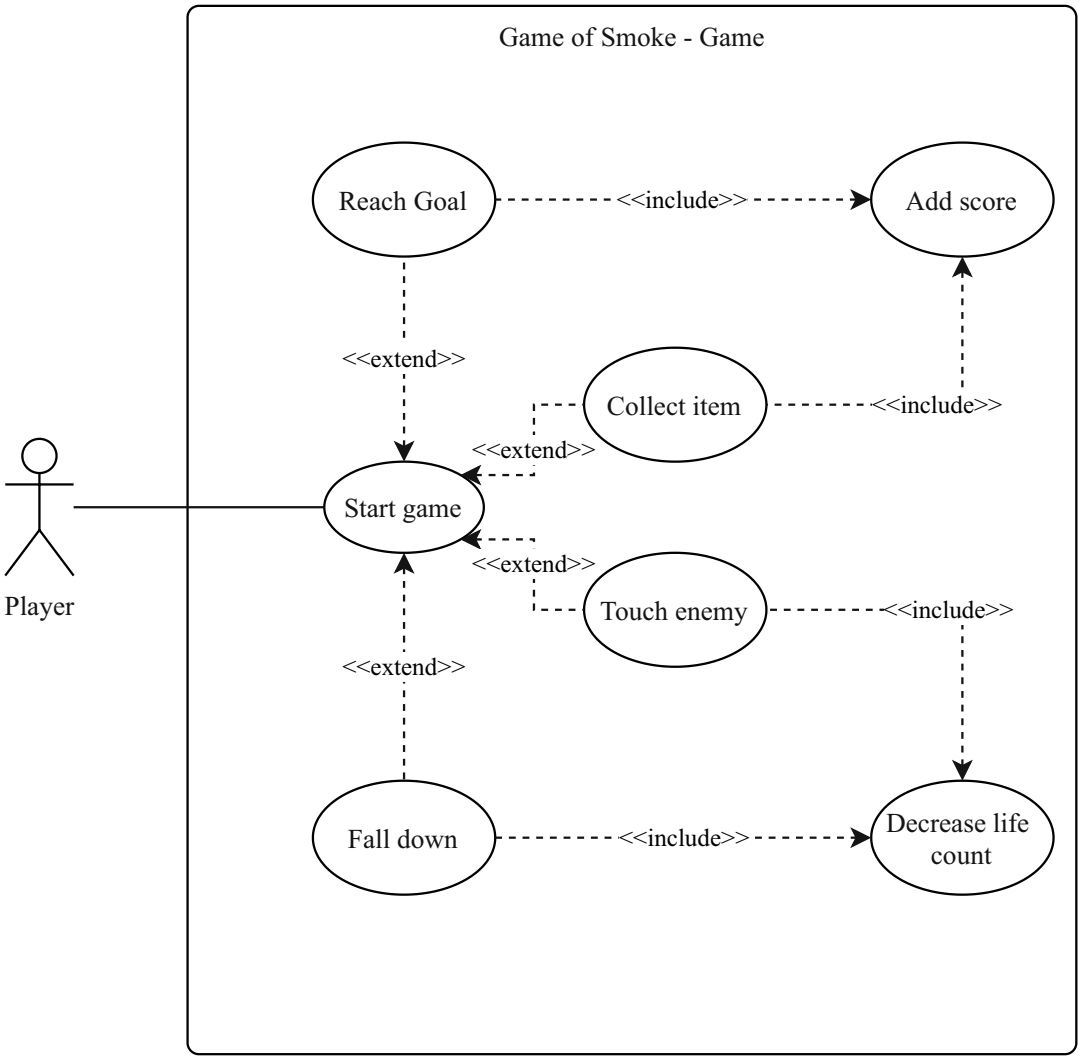
Fast geschafft!

20. Wenn das Thema bei Ihnen Interesse geweckt hat und Sie bereit wären einen Prototyp zu testen, können Sie hier optional Ihre E-Mail Adresse hinterlassen. Mit dem Hinterlassen der E-Mail Adresse gehen Sie keinerlei Verpflichtungen ein, Sie können sich zu jedem Zeitpunkt anders entscheiden.

_____

Use Case Diagram





Questionnaire: Final Prototype

Game of Smoke

1. Alter

_____

2. Geschlecht

Markieren Sie nur ein Oval.

- ◯ Männlich
- ◯ Weiblich
- ◯ Andere
- ◯ Keine Angabe

3. Welches Ziel verfolgen Sie im Bezug auf Ihren Tabakkonsum?

Markieren Sie nur ein Oval.

- ◯ Reduktion
- ◯ Rauchentwöhnung
- ◯ Sonstiges: _____

4. Basierend auf Ihrer persönlichen Erfahrung, wie nützlich empfanden Sie die Anwendung?

Markieren Sie nur ein Oval.

	1	2	3	4	5	
nicht nützlich	◯	◯	◯	◯	◯	sehr nützlich

5. Wie wahrscheinlich ist es, dass Sie die Anwendung weiterhin verwenden würden?

Markieren Sie nur ein Oval.

	1	2	3	4	5	
nicht wahrscheinlich	◯	◯	◯	◯	◯	sehr wahrscheinlich

6. Was hat Ihnen besonders gut gefallen?

Wählen Sie alle zutreffenden Antworten aus.

- ☐ Tagebuch
- ☐ Wochenübersicht
- ☐ Spiel (falls vorhanden)
- Sonstiges: ☐ _____

7. Hat Ihnen die Anwendung geholfen, den Rauchkonsum zu reduzieren

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein
- ◯ Sonstiges: _____

8. Wie wahrheitsgetreu waren Sie mit der Dokumentation der gerauchten Zigaretten?

Markieren Sie nur ein Oval.

	1	2	3	4	5	
eher nicht	◯	◯	◯	◯	◯	sehr

9. Aus welchen Gründen, haben Sie falsche Angaben gemacht?

Wählen Sie alle zutreffenden Antworten aus.

- [ ] Vergessen zu Dokumentieren
- [ ] Keine Lust
- [ ] Dokumentation war zu aufwendig
- [ ] Um Strafe im Spiel zu entgehen (falls vorhanden)
- [ ] Sonstiges: _____

10. Wie empfanden Sie die Protokollierung?

Markieren Sie nur ein Oval.

	1	2	3	4	5	
einfach und unkompliziert	◯	◯	◯	◯	◯	unangenehm und zeitintensiv

11. Können Sie sich vorstellen, dass die Anwendung Ihnen langfristig hilft Ihre Ziele zu erreichen?

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein
- ◯ Sonstiges: _____

12. (Falls vorhanden) Empfanden Sie, dass das Spiel einen positiven Effekt für die Rauchreduzierung hatte?

Markieren Sie nur ein Oval.

- ◯ Ja
- ◯ Nein
- ◯ Sonstiges: _____

13. Vielen herzlichen Dank, dass Sie sich Zeit genommen haben um an dieser Studie teilzunehmen. Hier ist noch Platz für Feedback und Verbesserungsvorschläge sowie generelle Anmerkungen: