Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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Exploring the Potential of a Serious Game Concept for Dental Anxiety Prevention in Children

Master's thesis in Informatics
Supervisor: Yngve Dahl
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Abstract

Dental anxiety is a widespread problem that affects both children and adults and that can cause long-lasting dental health problems. It typically emerges during childhood, and preventive approaches targeted at children can therefore be effective in reducing the total number of people afflicted. This thesis aims to explore the potential of digital technology in preventing dental anxiety in children, with a particular focus on serious games. This thesis sets out to answer the following research questions: (1) What kinds of digital solutions for anxiety treatment are described in relevant literature?, (2) How do professionals involved in dental anxiety treatment view the use of a digital solution to prevent dental anxiety in children?, and (3) How do children experience the functional prototype of a serious game for such a purpose? To answer these questions, we conducted a structured literature review and a preliminary study of a dental anxiety treatment service, and we employed a user-centred approach to design and evaluate a functional prototype of a serious game. Results from the user evaluations show that the users enjoyed the game concept and that they gained more knowledge about dental treatments and dental anxiety. Nonetheless, the results also showed that the concept should be further developed to increase engagement and learning outcome. The study resulted in a serious game prototype for dental anxiety prevention and in five emerging design guidelines for serious games for anxiety prevention: (1) Include voice-over of in-game text and dialogue, (2) Repeat information to increase the probability of achieving the learning objectives, (3) Keep the story and anxiety-inducing elements realistic, (4) Provide freedom to explore, and (5) Use metaphors to visualize and simplify complex concepts. The thesis concludes that a serious game concept has the potential to be a helpful tool in preventing dental anxiety in children.

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Chapter 1

Introduction

Oral health is vital for overall health, and regular dental check-ups are an essential part of preventive oral care. For people with dental anxiety, however, regular visits to the dentist can be a challenge. They constantly anticipate that something painful or dreadful is going to happen during dental treatments (Klingberg & Broberg, 2007). As a result, they are therefore very likely to delay or cancel a treatment, and they receive treatment less often (Armfield et al., 2007). This may result in poor oral health and a need for extensive dental treatment later in life (Armfield et al., 2007). Since dental treatment is usually expensive, poor oral health is not merely a health problem; it is also an economical one. Patients with dental anxiety and odontophobia often require extensive and costly therapeutic treatment to be able to receive regular dental treatment. In Norway, a service that provides dental anxiety treatment has been allocated 100 million NOK in the National Budget since 2011 (Den norske tannlegeforening [NTF], 2020).

Dental anxiety is a widespread mental health problem that affects both children and adults. It often begins in childhood, and it may continue into adulthood (Oosterink et al., 2009). Therefore, preventive measures targeted at children might help reduce the number of both children and adults with dental anxiety.

Anxieties in children are often being treated with psychological therapy (psychotherapy). While this method has proven effective, it is also resource-demanding and costly. The potential of digital technology may open up for interesting innovation to supplement, or maybe even substitute, traditional treatment and preventive programmes, and attempts have already been made. These span from full-on digital treatments led by psychologists (e.g. Shahnavaz et al., 2018) to more accessible and low-cost preventive solutions (e.g. Schoneveld et al., 2018). In the treatment of mental disorders, serious games have shown to be effective (Lau et al., 2017). Serious games are a type of games created for other purposes than entertainment (Michael & Chen, 2006). They can make learning fun and engaging and have already been used for mental health purposes, such as Cognitive Behavioural Therapy (Fleming et al., 2017).

To our knowledge, no serious games have been designed specifically for the treatment or prevention

of dental anxiety. Nor has there been conducted much research on the designing and development of such games. Therefore, the main aim of this master's project has been to explore the potential of a serious game concept as a means of preventing dental anxiety in children. We sought to answer the following three research questions (RQs):

RQ1: *What kinds of digital solutions for anxiety treatment are described in relevant literature?*

RQ2: *How do professionals involved in dental anxiety treatment view the use of a digital solution to prevent dental anxiety in children?*

RQ3: *How do children experience the functional prototype of a serious game for such a purpose?*

We conducted a structured literature review (SLR) to answer research question 1, concentrating on the purpose of the solutions described, whom they are designed for, the anxiety treatment practices they are based on, and the design and evaluation approaches used. To answer questions 2 and 3, we developed a serious game concept based on findings from the SLR and a preliminary study of a treatment programme aimed at children with dental anxiety. This programme is offered by Trygge Barn i Tannbehandling (TBiT) ("Safe Children in Dental Care")[our translation], which is a part of the Centre for Oral Health Services and Research in Trondheim Norway. Stakeholders from the centre were involved throughout the concept development and design process using interviews and workshops. Children's experience of the game was evaluated by gathering and analysing data from observations, interviews, and questionnaires. The main contribution of this thesis is a set of emerging design guidelines for the design of serious games for the prevention of anxiety disorders.

This thesis consists of 14 chapters. Chapters 2 and 3 present relevant theory and background on dental anxiety and serious games, respectively. Chapter 4 outlines the methods and findings from our structured literature review. The following chapter, chapter 5, provides a case description of the TBiT service. Chapter 6 presents the research design methods employed in this thesis, and chapter 7 describes the results from the preliminary study. Chapter 8 describes the game concept, while chapters 9 and 10 detail the first and second iteration of prototype design and evaluation. Chapter 11 discusses the findings presented in this thesis. The following chapter, chapter 12, discusses limitations to our method. In chapter 13, we present some emerging guidelines for the design of serious games for anxiety prevention. Finally, chapter 14 summarises and concludes the thesis.

Chapter 2

Dental Anxiety

This chapter gives a definition of the disorder before outlining its prevalence, its causes and consequences as well as common treatment and prevention methods.

2.1 Definition and Prevalence

Negative emotions connected to the dental experience can be graded in terms of seriousness. Many of us experience some emotional response to one or more threatening stimuli in the dental situation, e.g. feeling uncomfortable at the sound of the dental drill. This response is known as dental fear (Seligman et al., 2017). Dental anxiety, however, is the constant anticipation that something painful or dreadful will occur during dental treatments (Armfield et al., 2007). If the anxiety experienced is severe enough, it can be classified as a phobia. Dental phobia is characterised by excessive and persistent anxiety about either specific situations (e.g. drilling, injections) or the dental situation in general (Klingberg & Broberg, 2007). Medically, odontophobia is a diagnosis that is classified as a specific phobia (Helsedirektoratet, 2010).

While there are no precise numbers available on the prevalence of dental fear and anxiety globally, it is estimated that between 11 and 25 per cent of adults in Western countries have dental anxiety or dental phobia (Oosterink et al., 2009; White et al., 2017). In Norway, a 2011 study found that the figures for dental anxiety in 2007 were 11.3% for males and 19.9% for females (Åstrøm et al., 2011). Based on studies from several countries, the prevalence of dental anxiety in children and adolescents ranges from 5.7% to 20.2% (Grisolia et al., 2020). Unfortunately, there are no recent numbers on dental anxiety among children in Norway, but it is reasonable to assume that the numbers are within this range.

2.2 Causes

For most, dental anxiety starts in childhood, but it can also develop in adulthood (Berggren & Meynert, 1984; Locker et al., 1999). The most common cause of dental anxiety or phobia is experiencing a traumatic dental experience (Berggren & Meynert, 1984). The negative experience can take many forms, but the most common ones involve pain or a loss of control (de Jongh et al., 2003). A feeling of helplessness or loss of control can occur, for example, from the dentist not providing sufficient information of what will happen or the patient not understanding the dentist (Humphris & King, 2011). As identified by de Jongh et al. (2003), other categories are negative behaviour of the dentist, serious treatment failures, and patient's feeling of embarrassment.

Another well-known factor in the formation of dental anxiety is modelling or social processes that influence the child (Morgan & Porritt, 2017). Modelling refers to imitating the behaviour of other people. A review of 45 studies conducted by Themessl-Huber et al. (2010) found a relationship between parent's and their children's dental fear. The relationship was most evident in children aged eight and under. Children can also learn to be fearful due to negative information about the dentist they see or hear from family, friends, television, or social media (Townend et al., 2000).

2.3 Consequences

People suffering from dental anxiety or phobia are more likely to delay their dental treatment (Armfield et al., 2007). The delayed treatment due to dental anxiety can create a vicious cycle where avoiding treatment leads to serious oral health issues, which can be painful and expensive to fix. This experience can again exacerbate their level of fear. This cycle is known as the vicious cycle of dental fear, and this idea has been supported in several studies explaining dental fear (e.g. Armfield et al., 2007; Klepac et al., 1982; Moore, 1991). Figure 2.1 shows a model of the cycle.

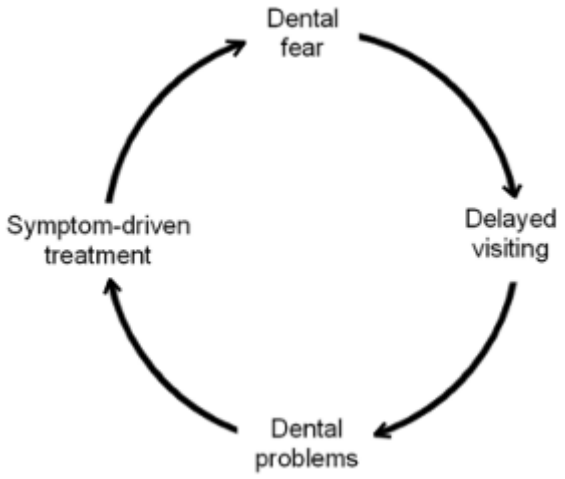

Figure 2.1: Model of the vicious cycle of dental fear (Armfield et al., 2007, p. 2).

In addition to the physical pain, untreated dental anxiety in childhood may hinder the child's overall development and may also be a risk factor for serious systemic disease in adulthood (Seligman et al., 2017).

Dental anxiety also has economic consequences for society as a whole. While there are no calculations available on the societal cost of dental anxiety, most high-income countries spend five per cent of total expenditure on dental treatment on average (OECD, 2017). Some estimates suggest that dental expenditures for the 32 OECD countries amounted to US$316bn in 2020 and that this will rise to US$434bn by 2030 (Jevdjevic et al., 2021). One of the most common oral diseases is dental caries (tooth decay) (Patel, 2012), a disease that will most likely worsen if left untreated. It has also been found that dental avoidance behaviour in parent and child are risk indicators for caries in young children (Wigen et al., 2009). Avoiding dental treatment is a common behaviour for individuals with dental anxiety (Armfield et al., 2007). When an individual has developed dental anxiety, this can result in the need for more extensive and individualised treatment. In Norway, a service for adults with severe dental anxiety has been allocated 100M from the National Government since it was established in 2011 (NTF, 2020). It may therefore be effective and economical to put a more significant focus on prevention. A comprehensive report on the state of oral health in Europe found strong evidence that the benefits of preventing tooth decay exceed the costs of treatment (Patel, 2012). As studies have found a positive correlation between dental anxiety and poor oral health (e.g. Kanaffa-Kilijanska et al., 2014; Ng and Leung, 2008), preventing dental anxiety from manifesting in the first place can help improve general oral health and reduce the need for more expensive treatment.

2.4 Treatment and Prevention

Cognitive behavioural therapy (CBT) is a widely accepted psychological treatment for anxiety tied to specific situations or objects (Choy et al., 2007; Roth & Fonagy, 2005). Reviews have confirmed that this is also the case when looking specifically at dental anxiety (Gordon et al., 2013; Wide Boman et al., 2013). CBT is a type of psychotherapy, which can be defined as a treatment that has the following characteristics: based on psychological principles, led by a trained therapist, purpose is to remedy the client's problem and adapted to the particular client's disorder or problem (Wampold & Imel, 2015). CBT consists of several techniques which help individuals identify and change destructive thought patterns that negatively impact their emotional state (Hofmann et al., 2012). One technique that is commonly used in CBT is that of exposure therapy. Exposure therapy is a treatment technique that exposes individuals to the objects or situations they fear in a safe environment. The goal is to gradually increase the exposure level and reduce their anxiety level and decrease avoidant behaviour (APA, 2017). In the case of dental phobia, examples of low-level exposure could be the therapist holding the drill close to the individual or simply becoming comfortable sitting in the dentist chair.

When it comes to effective techniques and strategies for preventing dental anxiety or phobia, there is considerably less literature available. However, it has been suggested that CBT may be helpful also

in the prevention of dental anxiety (Bienvenu & Ginsburg, 2007). One study notes the importance of establishing a trusting relationship between the patient and the dental personnel (Raadal S. M., 2013). Another study, which conducted a review looking at the effectiveness of child and adolescent anxiety prevention programmes, found that the programmes were generally effective (Fisak et al., 2011). An important caveat is that the long-term effectiveness was still unclear.

In recent years, several technology-based solutions have emerged as an alternative to traditional dental anxiety treatments. These include interventions such as virtual reality exposure therapy (Raghav Gujjar et al., 2018), audio-visual distraction (Shah & Bhatia, 2018) and various types of internet-based CTB like psychologist-guided (Shahnavaz et al., 2018) and self-helped CBT (Marshman et al., 2016). A study has also found that commercial dentist simulation games might effectively prevent dental anxiety in children when used before their first dental treatment (Meshki et al., 2018). A promising approach to mental health treatment and prevention, which has yet to be explored to a substantial degree in the specific case of dental anxiety, is that of serious games (Fleming et al., 2017). Such games have also been suggested to be effective in psychotherapy, both as a part of treatment and used independently outside treatment (Eichenberg & Schott, 2017). To better understand the appeal of a serious game for health, the following chapter will present the concept in more detail.

Chapter 3

Serious Games

This chapter presents an overview of and differing opinions on the serious game definition. It describes the characteristics of a serious game, which pertain to the engagement factors of games and the need for simulation to ensure transferability of knowledge from game to real-life situations. The chapter concludes with a short presentation of how serious games have been used for different health purposes.

3.1 Description of Serious Games

Although there are various specific definitions as to what constitutes a game, one common denominator is that games are regarded as a form of play with set rules and a defined outcome (Dörner et al., 2016). Games are also primarily regarded as pastime activities, where players are motivated to play because they expect to be entertained. Serious games are games that, in addition to entertain, are meant to educate and instruct (Zyda, 2005) .

Some researchers consider the pedagogical intention of the creator a decisive criterion to define a game as serious, regardless of whether or not the game succeeds in being instructional (Dörner et al., 2016). Other definitions of the term also encompass games that were not intentionally made for learning, defining the intention of the player to learn from the game as a sufficient criterion (Susi et al., 2007). However, this broad definition blurs the line between games meant for entertainment and games meant for learning, an essential and necessary distinction for game developers to be aware of. Besides, the way players may or may not choose to use a game is beyond the control of a game developer and thus irrelevant to the designing process. In this work, we therefore use the definition given by Dörner et al. (2016) and regard the instructional intention of the game creators as the distinguishing factor between serious games and other types of games.

There is broad consensus that serious games include both entertainment and learning, yet there are differing opinions as to which of the two elements is the most important one. Zyda (2005) considers

pedagogy to be subordinate to the entertaining game elements of story, art, and software. In other words, since entertainment is a driving force for playing casual games, the same is supposed to apply to serious games. However, like Michael and Chen (2006), others rate the intended learning objectives above entertainment and consider entertainment simply a positive addition. These two contradicting descriptions mirror the different perspectives of player and game creator: The creator's intention is to create a learning tool and facilitate the achievement of a specific learning objective. On the other hand, the player will expect any game to be entertaining because entertainment is generally the primary purpose of games, even if a game is used within an educational context and the player is aware of the game's purpose. At any rate, most researchers agree that a serious game should include entertainment as a way to make the player engage with the topic.

3.2 Elements of Engagement in Serious Games

Games that are fun are in themselves engaging, and this makes serious games excellent potential learning tools (Gee, 2006). Several models try to describe what contributes to fun, and thereby engagement in games. The common denominators of these models are the elements of play, storytelling, rules (and challenges), aesthetics, social factors, and learning (Mildner & Mueller, 2016). Games do not always include all the aforementioned elements of engagement, but rather a mixture where all or a certain number of elements are included to different degrees.

Play
Play, as opposed to a game, has no rules and restrictions and is in itself a voluntary, fun, and engaging activity. The opportunity to explore a game world without fear of negative consequences is an essential element of play in video games (Mildner & Mueller, 2016). Play is also a natural form of learning for a child, and playing games can therefore be an especially engaging learning method for children.

Storytelling
Storytelling, i.e. the use of narrative, can create engagement in several ways and is therefore frequently used in games. A story provides characters who have to overcome problems and with whom the player can empathize. It also has a well-known structure: a beginning, a middle, and an end, with causally linked events. The player partly knows what to expect and thus becomes curious about how the story will develop and how it may end. Storytelling also creates progression in the game, often in the form of different levels of scenes that need to be completed, which drives the player forward (Mildner & Mueller, 2016).

Rules and Challenges
Rules restrict the possible range of actions and thus force the player to reflect on which action to take. The rules of a game also affect its level of challenge (Mildner & Mueller, 2016). The right level of challenge – easy enough to be solvable but hard enough to require effort – can create an experience of *Flow* (Csikszentmihalyi, 2008, as cited in Mildner and Mueller, 2016). This sense of

flow is a strong motivator and engagement factor because overcoming challenges leads to a feeling of achievement and satisfaction. In this work, we first and foremost consider the aspect of challenge instead of the underlying rules.

Aesthetics
The game aesthetics are tightly linked to the experience of a story. Elaborate aesthetics are attractive and can add to the immersive qualities of the story. In addition, aesthetics can make the game world appear more authentic. Still, Warren and Jones (2017) claim that lack of aesthetic perfection will not necessarily lower the motivation to play a game. The human brain is both able and used to dealing with incomplete visual representation. As long as players are supplied with sufficient information to be able to imagine and fill in missing information about characters, places, and events, they will do so automatically.

Social Factors
Sharing a game experience with others creates a sense of community that helps to maintain player engagement. Many games involve multiplayer and team play, and large games like MMORPGs (Massively Multiplayer Online Role-Playing Games), exploit the social aspect of games extensively by allowing players to form teams, plan for quests and engage with each other in other ways. Many players like to discuss games outside the game context as well.

Learning
Learning can be an engaging activity in itself because mastering a new skill invigorates the learner, giving a feeling of joy and satisfaction and increased confidence. Even when playing pure entertainment games, we are constantly learning – finding out more about rules, elements, or levels, mastering new tasks, overcoming obstacles. Although designed for acquiring skills and knowledge that is transferable to real-life and practical situations, learning games may draw on the motivation generated by the player's mastering of gaming skills.

3.3 Serious Games and Simulation

Educational simulations are "instructional scenarios where the learner is placed in a 'world' defined by the teacher" (UNSW, 2018) and have long been used as (analogue) learning tools. Simulations offer the learner an active role in the learning process, and knowledge or skills that are transferable to real-life situations. Warren and Jones (2017) claim that one may borrow the act of simulating actions and use it to enrich another learning experience or improve transfer.

Serious games are usually played to provide the player with skills or knowledge transferable to real life. Therefore, a serious game must "[...] include a reasonable representation of the reality of anything we want students to be able to do out in the real world, or it offers no ability to move practice to real activity" (Warren and Jones, 2017, p.17). However, a serious game does not have to be a complete simulation product. The fidelity required to make it function according to purpose is dependent on what is being taught (Warren & Jones, 2017). Besides, it is important to find a

satisfying balance between simulation and game engagement factors to make sure one aspect does not overshadow and hinder the other.

3.4 Serious Games for Health Promotion and Education

Serious games for health promotion and education (also called health games) have become increasingly popular in recent years (Dörner et al., 2016). They have been used to promote physical and mental health, amongst other things to distract patients during procedures, and for rehabilitation purposes (Michael & Chen, 2006). They have also been used for self-management of diseases, like the game "Balance", which was developed to support self-management of adolescents with diabetes (Fuchslocher et al., 2011). Serious games have furthermore proven helpful for mental health treatment, such as phobia treatment, because people perceive and react to games the same way they would react in real life (Michael & Chen, 2006). As such, serious games can be especially suitable for exposure therapy, a technique in behaviour therapy to treat anxiety disorders. In order to overcome their fear, patients are forced to face the source of their fear in controlled environments. Studies have shown that using games in exposure theory can increase enthusiasm about the treatment in patients, especially in children (Szczesna et al., 2012). These aspects and findings make serious games a promising option for a digital solution to prevent dental anxiety.

Chapter 4

Related Work: A Systematic Literature Review

To answer the first research question and to find inspiration for our own design process and game solution, a systematic literature review was conducted. As it proved difficult to find any studies describing the design process of a digital solution for the treatment or prevention of dental anxiety, this review took a broader approach by including solutions intended for individuals of all ages and all anxiety disorders. However, special attention was paid to the game-based solutions. The review resulted in key takeaways, which were used to guide our design and development process.

4.1 Relevant Systematic Literature Reviews

Before initiating the systematic literature review, a total of nine searches were conducted in relevant databases to discover if there already existed one or more peer-reviewed literature reviews on digital solutions designed to treat anxiety or phobia. Several combinations of different queries were used. However, all of them contained the search terms: *literature review*, *anxiety*, *phobia*, and *digital*. Searches were carried out in Engineering Village (EV), Google Scholar, Scopus, and Web of Science (WoS). The search results were sorted by relevancy. Google Scholar returned a large number of search results, so the scan was limited to the first five pages (a total of 50 articles). After the search, the titles were manually scanned. If the title seemed relevant, the abstract was reviewed.

After conducting several searches, no literature review on digital solutions designed to treat anxiety or phobia was discovered. The study with the most similar objective and scope was *A systematic review of digital mental health interventions for depression and anxiety in young people* by Garrido et al. (2019). However, this study focused on the effectiveness of such digital solutions, not on design and development as is the focus of this review.

4.2 Objective

The objective of the SLR was to answer RQ1 (*What kinds of digital solutions for anxiety treatment are described in relevant literature?*) and find inspiration for a game-based solution. Thus, the review looked for the following aspects:

- Purpose of the solutions
- Target groups (disorder and age)
- Integrated treatment practices
- Game elements in solutions
- Other components
- Design approaches
- Evaluation methods
- User acceptability and efficiency of game-based solutions

4.3 Method

4.3.1 Databases and Search Terms

The papers included in this review were collected on November 11, 2020. In order to be able to identify relevant research, databases containing studies on computer science and technology were chosen. The databases chosen were ACM Digital Library, Engineering Village and Web of Science. Though there are many databases on medical health (e.g. PubMed), these were excluded because of the review's focus on the development, design, and evaluation of digital solutions. Before defining a search query, three main topical categories were defined: disorder, technology, and design. Using these categories as a starting point, a query was constructed and refined iteratively by applying different keywords and evaluating search results. The final search string keywords are presented in Table 4.1.

Disorder	**Technology**	**Design**
Anxiety, Phobia	Web, Mobile, App, Application, M-health, E-health, "Virtual reality", VR, "Augmented reality", AR	Design

Table 4.1: Search terms.

Based on these search terms, the following search string was constructed:

(phobia OR anxiety) AND (web OR mobile OR app OR application OR e-health OR m-health OR "virtual reality" OR VR OR "augmented reality" OR AR) AND (design)

To end up with a manageable number of studies and further refine the results, the following cat-

egories were applied to the search on Web of Science: Psychiatry, Health Care Sciences Services, Computer Science Theory Methods, Medical Informatics, Computer Science Information Systems, Computer Science Interdisciplinary Applications. It was not necessary to limit the search results from ACM or Engineering Village.

4.3.2 Selection Process

The first step of the selection process was a database search. A protocol consisting of the search string and a list of inclusion and exclusion criteria (see Table 4.2) was followed. This search returned a total of 1843 studies. After duplicates had been removed, the resulting set included 1584 titles. The screening of these articles was conducted in three stages:

1. Title screening
2. Abstract screening
3. Full-text screening

Inclusion Criteria (IC)	**Exclusion Criteria (EC)**
The study describes a digital solution for prevention or treatment of anxiety or phobias that has been empirically tested	The study is less than 4500 words (e.g. short papers, extended abstracts, and poster presentations)
The study describes how the solution was designed	The study is published earlier than the year 2000
The study is peer-reviewed	The study is non-English
	The study is a book, dissertation, or literature review
	The study is a duplicate

Table 4.2: Inclusion and exclusion criteria.

Title Screening

In the first screening step, any titles that did not describe a digital solution for anxiety and phobia treatment were removed. Studies that focused on other types of mental illnesses were also excluded. The same was the case for articles describing physical therapy. Finally, studies that focused solely on measuring the effectiveness of a pre-existing solution were excluded since our key interest was the design process. This screening was conducted individually by both researchers, and the selections were then compared. Any disagreements were resolved through discussion. If it was unclear whether an article met the inclusion criteria, a decision was made to err on the side of caution and allow it to pass the screening.

The number of studies remaining after title screening was 212. The excluded articles all fell into one of the following categories:

1. Anxiety detection or definitions of anxiety
2. Focusing solely on measuring the effectiveness
3. Physical, not mental therapy
4. Non-technical solutions
5. Duplicates

Abstract Screening
The second screening step concentrated on the abstracts of all the articles that had met the necessary criteria in screening one. The screening was once again conducted individually by both researchers. The number of studies remaining after the abstract screening was 71.

Full-text Screening
In the third and final stage of the screening process, the full text of the articles were considered. This time, in order to reduce workload, each researcher screened half of the articles. However, if any uncertainty arose, the article in question was discussed with the other researcher. Most of the articles (47) were excluded due to insufficient length, i.e. less than 4500 words. Three articles (Bossenbroek et al., 2020; Botella et al., 2010; Mohr et al., 2017) had no description or mention of the design and development of the described solution. A further three articles (Antle et al., 2019; Carlier et al., 2019; Liszio et al., 2020) were excluded because they presented the same projects as other articles already included. A final article (Wilansky et al., 2016) was excluded as it only described a planned design and development project.

The number of remaining studies after the full-text screening was 17. Figure 4.1 shows the selection process.

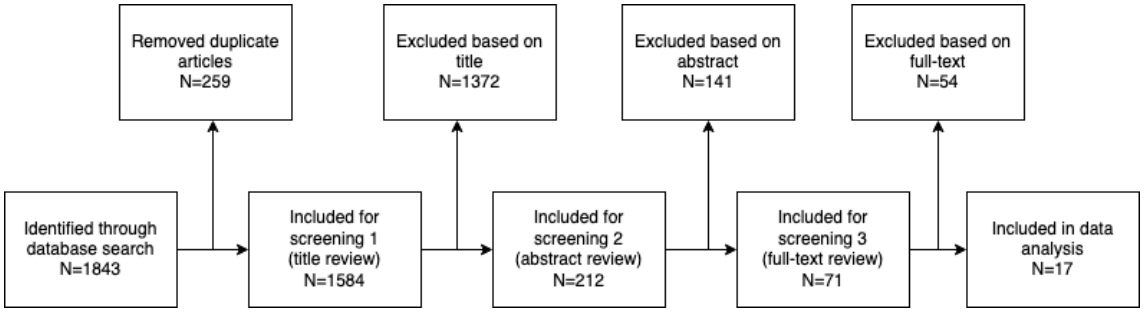

Figure 4.1: Flow chart illustrating the selection process.

4.3.3 Analysing Process

A total of 17 articles passed the final screening and was included in this review. The articles that passed full-text screening were categorised utilising an Excel sheet with a column for each aspect considered relevant to the review's aim. Each article was first categorised individually by one researcher before the other researcher reviewed the article to verify the categorisation.

4.4 Results

The SLR aimed to answer RQ1 ("*What kinds of digital solutions for anxiety treatment are described in relevant literature?*") and find inspiration for a game-based solution. Thus, the review looked for the following aspects:

- Purpose of the solutions
- Target groups (disorder and age)
- Integrated treatment practices
- Game elements in solutions
- Other components
- Design approaches
- Evaluation methods
- User acceptability and efficiency of game-based solutions

The relevant characteristics of these studies are presented in detail in Tables 4.3, 4.4 and 4.5. Table 4.3 provides an overview of the different solutions, containing information about the target group, the disorder it addresses, the type of solution, its purpose, and whether therapist involvement is needed to use the solution. Table 4.4 shows the incorporated treatment practices and components of each solution. Finally, Table 4.5 highlights the design and evaluation approach adapted by each study and shows whether the target group or domain experts have been involved in either of these processes. The remainder of this section will describe the results in more detail.

Table 4.3: Overview of solutions.

Study	Name of Solution	Type of Illness/Anxiety	Target Group	Type of Solution	Purpose of Solution	Therapist Involvement Needed
Antle et al. (2018)	Mind-Full	Anxiety as a result of complex trauma	Children who have suffered complex trauma and suffer from anxiety	Neurofeedback Brain-Computer Interface application (NF BCI)	Regulation and self-management	No
Báldy et al. (2020)	None	Social Anxiety Disorder (SAD)	University students	Unity game	Creating awareness about the disorder	No
Bray et al. (2020)	Xploro	Anxiety for medical procedures	Children undergoing medical procedures in a hospital	Web platform (Digital therapautic platform)	Reduction of anxiety	Yes
Carlier et al. (2020)	NewHorizon	Anxiety and stress (in children with ASD)	Children with autism suffering from anxiety and/or stress and their parents	2D mobile game	Empower children and patients, reduction of anxiety	No*
Costa et al. (2016)	EmotionCheck	Anxiety (unspecified)	Individuals who get anxious in stressful situations, people with anxiety disorders	Wearable device	Manage anxiety	No
Coyle et al. (2011)	gNats Island	Clinical anxiety disorders	Adolescents aged 10–15	3D computer game	Tool supporting therapy	Yes
Currie et al. (2010)	Feeling Better	Moderate depression, anxiety and stress	Post-secondary students with moderate depression, anxiety or stress	Web Platform (Online CBT programme)	Intervention	Yes

Continued on the next page.

** Requires parental support ** Requires someone to act as interventionist (e.g. parent or teacher)*

Table 4.3 – continued from the previous page.

Study	Name of Solution	Type of Illness/Anxiety	Target Group	Type of Solution	Purpose of Solution	Therapist Involvement Needed
De Sa and Carriço (2012)	None	Fear related disorders	Children (age 5-14) with fear related disorders	3 mobile apps (Fear therapy support)	Tool supporting therapy	Yes
Ferreira et al. (2020)	StopAnxiety	Anxiety (no specific disorder)	Students and teachers	Mobile application (mHealth)	Treatment	No
Ha and Kim (2020)	Spring	Depression and anxiety (Trait Anxiety)	Adults suffering from depression and anxiety, counsellors	Mobile application (Cognitive reappraisal)	Treatment	Yes
Hartanto et al. (2015)	Memphis system	Social phobia	Individuals with social phobia	Virtual reality exposure therapy (VRET) system with three applications	Treatment	Yes
Liszio and Mausch (2017)	None	Stress and anxiety connected to MRI examination	Children aged 8 to 15 years who await an MRI exam.	Virtual reality (VR) application	Reduction of anxiety	Yes
McEnery et al. (2019)	Embrace	Social anxiety disorder (SAD) (in people with psychosis)	Young people with first order psychosis (FEP) and SAD	Web platform (Moderated online intervention)	Moderated intervention	Yes
Pathwardhan et al. (2015)	None	Anxiety (unspeficified)	Children in 4th and 5th grade	Mobile application (mHealth)	Prevention and early intervention	No**
Ryu et al. (2020)	Yeonheebot	Anxiety, depression	Elderly with anxiety and/or depression	Mobile-based chatbot	Reduction of anxiety	Yes

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** Requires parental support ** Requires someone to act as interventionist (e.g. parent or teacher)*

Table 4.3 – continued from the previous page.

Study	Name of Solution	Type of Illness/Anxiety	Target Group	Type of Solution	Purpose of Solution	Therapist Involvement Needed
Shamekhi and Bickmore (2018)	Breathe Deep	Chronic health conditions, including pain, anxiety, and depression	Adults who feel anxious, individuals with chronic health conditions related to pain, anxiety or depression	Desktop application (Virtual meditation coach system)	Reduction of anxiety	No
Simm et al. (2016)	Snap	Anxiety (in people with autism)	Individuals diagnosed with autism and that has anxiety	Digital stretch wristband	Anxiety management	No

Table 4.4: Overview of treatment practices and components.

Study	Children Target Group	Treatment Practices	Components	Type of Solution	Gamification
Antle et al. (2018)	Yes (age unspeficied)	Brain-state self-regulation	Three simple games, where the only user-input is the child's brain wave activity, and the output was NF visually represented as something the child could recognise and easily understand.	Neurofeedback Brain-Computer Interface application (NF BCI))	Yes
Báldy et al. (2020)	No	CBT and exposure therapy	SAD-centric narrative, interaction with non-playable characters (NPCs), a conversation system	Unity game	Yes
Bray et al. (2020)	Yes (8 - 14)	Age appropriate information dissemination about hospital procedures, information about how to build coping strategies	Customisable avatar as a guide and chatbot, serious games with health themes, artificial intelligence, augmented reality	Web platform (Digital therapeutic platform)	Yes
Carlier et al. (2020)	Yes (5 - 12)	CBT (relaxation techniques: visualisation and focused breathing)	Serious games to teach relaxation techniques,, narrative, character, regular mini-games with no CBT techniques	2D mobile game	Yes
Costa (2016)	No	Relay false feedback on slow heartrate to help regulate anxiety	Wristband with a heart rate monitor that gives false feedback on heartrate	Wearable device	No
Coyle et al. (2011)	Yes (10 - 15)	CBT (identifying and challenging negative thoughts)	Game elements, narrative, narration through other characters, character based, 3D world, in-game notebook in which they answer characters' questions and record new ideas, personification of abstract concepts, character voiceovers, cartoon drawings, conversation with in-game characters	3D computer game	Yes

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Table 4.4 – continued from the previous page.

Study	Children Target Group	Treatment Practices	Components	Type of Solution	Gamification
Currie et al. (2010)	No	CBT (strategies to manage symptoms), assessment of symptoms	Interactive work-book with text examples and activities, mood rating scale, learning modules, gender-specific optional module for females	Web platform (Online CBT programme)	No
De Sa and Carriço (2012)	Yes (5-14)	Measurement of fear level	Quantifying of fear through a set of drawings and measures, each using a different metaphor (weight, strength, height)	3 mobile apps (Fear therapy support)	No
Ferreira et al. (2020)	No	Clinician-approved anxiety management techniques	Selection of technique, practice different techniques, feedback on technique through voice guide	Mobile application (mHealth)	No
Ha and Kim (2020)	No	Semi-crowdsourced counselling, immediate interventions from counselors, CBT therapy-based short commentary	A "chat" between users and multiple counselors, where users are prompted to publish posts following a CBT-pattern (emotion-situation-thought), gamification (Sprouts rewarded to counselors for helpful comments)	Mobile application (Cognitive reappraisal)	Yes
Hartanto et al. (2015)	No	Exposure therapy, interactive psycho-education	Virtual health agent (coach) which acts as a substitute for therapist, virtual scenarios reflecting anxiety inducing situations, word recognition and speech detection technology, a therapist application where a therapist can monitor and interact with patients.	Virtual reality exposure therapy (VRET) system	No
Liszio and Mausch (2017)	Yes (8 - 15)	Play-therapy (with exposure therapy)	Realistic virtual MRI scanner in the VR environment, virtual preparation room, sounds recorded from a real MRI scanner, narrative elements (a protagonist, a virtual doctor, a story, interactive objects), gamification of MRI procedure	Virtual reality (VR) application	Yes

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Table 4.4 – continued from the previous page.

Study	Children Target Group	Treatment Practices	Components	Type of Solution	Gamification
McEnery et al. (2019)	No	CBT-based treatment models for SAD	Web platform that offers independent online modules (steps). Each module include 1) a brief psycho-educational description of each therapeutic concept 2) unique therapeutic comics designed to maximize engagement with the pathway 3) discrete behavioral experiments and 4) an interactive discussion forum	Web platform (Moderated online intervention)	No
Patwardhan et al. (2015)	Yes (5 - 12)	REACH (early intervention program targeting anxiety in youth) school-based cognitive behavioural protocol	Game based strategies (rewards as motivation), animated motivational avatar (Bob the blob), motivational rewards in the form of Bob learning new tricks), graphics and language for children	Mobile application (mHealth)	Yes
Ryu et al. (2020)	No	Conversational interactions	A chatbot, games to prevent dementia (serious games), gamification to motivate use (stamps as rewards for using the bot, quizzes related to health articles)	Mobile-based chatbot	Yes
Shamekhi et al. (2018)	No	Mindfullness	Interactive meditation coach (VR) as conversational agent which talks the user through meditation practices, calming background music, input from respiration sensor and feedback.	Desktop application (Virtual meditation coach system)	No
Simm et al. (2020)	No	Interaction recording for later reflection	A digital stretch wristband that records interaction	Digital stretch wristband	No

Table 4.5: Overview of design and evaluation approaches.

Study	Design Approach	End-users Involved in Design Process	Experts Involved in Design Process	Evaluation Method(s)	Evaluated with End-users
Antle et al. (2018)	Expert review, user-centred fieldwork, iterative cycles of design and techincal experiments	Yes	Yes	Technical experiments, usability tests, field experiment	Yes
Báldy et al. (2020)	Co-design with chief psychiatrist	No	Yes	Pilot-testing	Yes
Bray et al. (2020)	User-centered design or person-based approach, information pull-design	Yes	No	Before and after evaluation, mixed methods design	Yes
Carlier et al. (2020)	Iterative, multidiscplinary, and user-centered	No	Yes	Usability studies, analysis of game elements	Yes
Costa et al. (2016)	Literature based design*	No	No	Laboratory experiment	Yes (only effectiveness)
Coyle et al. (2011)	Framework for the design and evaluation of complex health interventions and learner-centred design	No	No	Clinical study, acceptability testing	Yes
Currie et al. (2010)	Iterative qualitative approach	Yes	Yes	Iterative qualititative usability testing approach	Yes
De Sa and Carriço (2012)	User-centered and iterative design process	Yes	Yes	Usability tests, exploratory clinical study	Yes
Ferreira et al. (2020)	Multidisciplinary user-centred approach	Yes	Yes	Brainstorming session, heuristic evaluation, user testing	Yes

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** Category assigned by authors of this work ** Currently being tested, will be published in another study*

Table 4.5 – continued from the previous page.

Study	Design Approach	End-users Involved in Design Process	Experts Involved in Design Process	Evaluation Method(s)	Evaluated with End-users
Ha and Kim (2020)	Literature based design*	Yes	Yes	Randomized Control Trial/-Experiment (UX testing and clinical testing in one)	Yes
Hartanto et al. (2015)	Design in collaboration with psychologists*	No	Yes	Usability evaluation in pilot study	Yes
Liszio and Mausch (2017)	Iterative child-centered design process	Yes	Yes	Focus group testing, clinical testing	Yes
McEnery et al. (2019)	User-centered intervention design and multidiscplinary, collaborative development approach to design therapy comics	Yes	Yes	8-week single group design	Yes**
Pathwardhan et al. (2015)	Multidiscplinary, collaborative design process inspired by user-centered leveraging	No	Yes	Usability study	Yes
Ryu et al. (2020)	Exploratory research using mixed methods	Yes	Yes	User testing	Yes
Shamekhi and Bickmore (2018)	Literature based design*	Yes	No	Formative pilot study, sensor validation study, comparative evaluation study	Yes
Simm et al. (2016)	Participative approach and user centered	Yes	No	User testing	Yes

** Category assigned by authors of this work ** Currently being tested, will be published in another study*

4.4.1 Purpose of the Solutions

Although the solutions described were all tied to anxiety, they had been designed to serve different purposes. Only three studies presented solutions specifically aimed at treating some type of anxiety (Ferreira et al., 2020; Ha & Kim, 2020; Hartanto et al., 2015). Six of the studies (Bray et al., 2020; Carlier et al., 2020; Liszio & Masuch, 2017; Ryu et al., 2020; Shamekhi & Bickmore, 2018) stated that their solution aimed at the reduction or mitigation of anxiety in their target group. Two of the studies designed solutions that were supposed to act as a supporting tool for therapy (Coyle et al., 2011; De Sa & Carriço, 2012). For example, De Sa and Carriço (2012) developed an interactive mobile application for measuring the fear level of children in therapy. The remaining five studies described solutions with the purpose of anxiety management (Antle et al., 2018; Costa et al., 2016; Simm et al., 2016), anxiety prevention and early intervention (Patwardhan et al., 2015) and creating awareness of a specific disorder (Báldy et al., 2020). The latter aimed to design and evaluate a serious game that could raise awareness of cognitive behavioural therapy (CBT) skills used in treating social anxiety disorder.

4.4.2 Target Groups

Five of the 17 studies proposed solutions that targeted individuals with general anxiety (Costa et al., 2016; Currie et al., 2010; Ferreira et al., 2020; Patwardhan et al., 2015; Shamekhi & Bickmore, 2018). Three studies presented solutions meant for individuals with fear-related disorders or phobias (Bray et al., 2020; De Sa & Carriço, 2012; Hartanto et al., 2015), while four studies described solutions designed for people with anxiety and an additional diagnosis (Carlier et al., 2020; Ha & Kim, 2020; McEnery et al., 2019; Simm et al., 2016). Simm et al. (2016) and Carlier et al. (2020) focused on anxiety in individuals with autism, Ha and Kim (2020) targeted individuals suffering from depression and anxiety, and McEnery et al. (2019) considered patients with first-order psychosis and Social Anxiety Disorder (SAD). The two remaining studies concentrated on children with anxiety tied to a particular event: Liszio and Masuch (2017) focused on anxiety in children awaiting an MRI exam. Similarly, Bray et al. (2020) targeted anxiety related to hospital visits and the anticipation of an upcoming procedure.

The age of the target groups of the different solutions varied as well. Slightly more than half of the solutions focused on children or adolescents aged between five and 18. Five studies targeted adults, making them the second commonest target group (Costa et al., 2016; Ha & Kim, 2020; Hartanto et al., 2015; Shamekhi & Bickmore, 2018; Simm et al., 2016). Young adults (McEnery et al., 2019) and university-age students were the target group of four solutions (Báldy et al., 2020; Currie et al., 2010; Ferreira et al., 2020). McEnery et al. (2019) specified their target group to ages 18–25, while the age range of the university students was not mentioned. Ryu et al. (2020) is the only study that explicitly targets only older adults, making elderly persons the least common target group.

4.4.3 Integrated Treatment Practices

Seven out of seventeen articles explicitly stated that the solution presented incorporates practices from cognitive behavioural therapy (CBT), such as treatment models (McEnery et al., 2019), cognitive behavioural protocols (Patwardhan et al., 2015), relaxation techniques (Carlier et al., 2020), short commentary counselling based on CBT (Ha & Kim, 2020), and strategies for identifying and challenging negative thoughts (Báldy et al., 2020; Coyle et al., 2011; Currie et al., 2010). Two solutions use exposure therapy to treat specific phobias and anxiety-inducing situations (Hartanto et al., 2015; Liszio & Masuch, 2017). Meditation is used as a treatment in one solution (Shamekhi & Bickmore, 2018), evaluation of and reaction to various sensory feedback in three (Antle et al., 2018; Costa et al., 2016; Ferreira et al., 2020). One solution focuses on providing information to help build coping strategies (Bray et al., 2020), another one on conversational interaction to combat depression and anxiety (Ryu et al., 2020). Finally, one solution was meant to assist anxiety self-management (Simm et al., 2016) and one supported traditional anxiety treatment by offering digital alternatives to paper-based artefacts used during treatment (De Sa & Carriço, 2012).

4.4.4 Game Elements in Solutions

Nine of the solutions incorporated various degrees of gaming and gamification. Bray et al. (2020) used a customisable avatar as a chatbot and health information provider and shorter serious games with health themes. Carlier et al. (2020) created an exploration game where the players follow a character, Jimmy, who travels across the universe in a spaceship. On his journey, Jimmy lands on planets where he has to complete a mini-game. There are four mini-games in total, two that teach relaxation techniques and two that are just regular games meant for entertainment. Coyle et al. (2011) used a 3D world and incorporated game elements such as a narrative of a character fighting against gNats (a personification of negative thoughts). The game also delivered information on health concepts through non-playable characters. Báldy et al. (2020) created a serious game with interactive dialogue as the primary form of interaction. They used dialogues as a tool in different scenarios that might be challenging for persons suffering from social anxiety disorder (SAD). The game follows an underlying narrative that introduces and explains CBT skills to the player through a non-playable character.

The health application described by Patwardhan et al. (2015), a digital implementation of a program for early intervention in childhood anxiety disorders (REACH), uses notifications to improve compliance with training and corrective feedback based on user data. To enhance motivation to use the app, the user can develop the skills of his or her avatar. Besides, information was presented in a fun way through graphics. Ha and Kim (2020) and Ryu et al. (2020) used gamification to reward the users and thereby increase their motivation to use the application. Ha and Kim (2020) incorporated gamification into a chat functionality that enabled users to contact counsellors with posts that followed a CBT pattern. Users would be able to give rewards, called sprouts, to comments given by counsellors. Ryu et al. (2020) used dementia prevention games and coupons to reward frequent use

of the application. In addition, the application used a chatbot feature to provide counselling, and it provided health articles and health-related quizzes.

Liszio and Masuch (2017) used VR technology for play therapy. The VR application consists of a narrative that includes several characters, a virtual preparation room and a realistic MRI scanner, with sounds recorded from an actual MRI scanner. All the narrative and informational elements are presented orally and in a language that is easy to understand. Antle et al. (2018) created a brain-computer interface (BCI) application containing three games where neurofeedback served as the game controls. One game was designed for relaxation, whereas the other two were supposed to increase attention. Each game was based on a familiar and culturally relevant activity. For example, in the game designed for relaxation, the designers used the activity of blowing on a pinwheel as their concept since this was a familiar activity for Nepalese children.

4.4.5 Other Components in Solutions

Shamekhi and Bickmore (2018) used an embodied 3D generated conversational agent that responds to a respiratory sensor's feedback. They also incorporated calming background music. Costa et al. (2016) designed a wearable device that emits vibrations in response to heart rate, whereas the wearable solution by Simm et al. (2016) was an interaction-recording wristband. McEnery et al. (2019) used therapeutic comics to increase motivation and an interactive discussion forum to allow users to discuss content. Hartanto et al. (2015) created a virtual health agent providing psychoeducation and virtual social scenarios where the user could initiate a dialogue with virtual patients. The system dialogue was generated using word recognition and speech detection technology. Currie et al. (2010) created an interactive workbook based on principles and strategies from cognitive behavioural therapy, with text information and activities to practice the strategies they had learned. The solution described by Ferreira et al. (2020) offers the user a choice between different techniques to learn; it visualises the procedures for the users and provides guidance. De Sa and Carriço (2012) created a solution that allowed the users to express their level of fear using visual metaphors (e.g. the height of a building would visualise the users' level of fear).

4.4.6 Design Approaches

Table 4.5 summarises the design approaches and evaluation methods used in the studies included in this review. The column "Experts Involved in the Design Process" indicates whether health professionals such as psychologists, therapists or other relevant stakeholders working with the specified anxiety disorder were involved in the design process. The column "End-users Involved in Design Process" indicates whether representatives of the target group were involved in the design process. End-users are considered as involved in the design process if feedback from the target group was used to improve the solution during the development process described in the article. The column "Evaluated with End-users" indicates whether end-users evaluated the solution at any point.

The keywords most frequently mentioned in the studies were user-centred (8), iterative (5), multidisciplinary (3) and collaborative (2). User-centred design is a broad term to describe design processes where end-users influence how a design takes shape (Abras et al., 2004). These design processes can take many forms, but the key to the concept is that users are involved in one way or another (Abras et al., 2004). Eight articles described their approach as user-centred, yet a whole 11 of the studies included their end-users in the design and development process. A total of 12 studies involved experts (e.g. therapists, CBT counsellors or clinical psychologists) in the design process. Experts were thus the most common stakeholders involved, followed by end-users.

A few of the articles described their design approach as collaborative, participative, or as a kind of co-design. Simm et al. (2016), for example, co-developed their solution with adults diagnosed with High-Functioning Autism. Patwardhan et al. (2015) stated that they employed a collaborative design process; however, they ended up relying upon subject matter experts as proxies for end-users in their design process. Coyle et al. (2011) combined a framework for the design and evaluation of complex health interventions with Learner Centred Design in the design of their solution.

Despite describing their design process, four articles did not name a specific design approach (Costa et al., 2016; Ha & Kim, 2020; Hartanto et al., 2015; Shamekhi & Bickmore, 2018). Therefore, for the sake of classification, a design category based on each articles' description of their design process was created. Three of the studies based their design on findings from psychology and previous digital solutions. For example, Costa et al. (2016) stated that they "... used theories and findings from psychology to design a mobile intervention" (p. 767). Shamekhi and Bickmore (2018), on the other hand, based their design of a virtual meditation coach on previous work on embodied conversational agents representing health coaches, as well as on other healthcare applications. These approaches were therefore classified as "literature-based design". The final article, by Hartanto et al. (2015), described a concept and design based on reviews and discussions with psychologists. This article was therefore classified as "design in collaboration with psychologists".

4.4.7 Evaluation Methods

All the studies had evaluated or were currently evaluating their product with end-users. Only one study tested only the effectiveness of the solution and not its usability (Costa et al., 2016)[1]. There were, however, other research groups that tested both effectiveness through a clinical study and usability through other forms of evaluation (e.g. Antle et al., 2018; Coyle et al., 2011; De Sa and Carriço, 2012; Liszio and Masuch, 2017). In fact, most of the studies carried out two or more types of evaluation. However, usability was by far the most common aspect tested. Six research groups specified that they had performed usability studies, whereas three others stated they had carried out user testing (see Ferreira et al., 2020; Ryu et al., 2020; Simm et al., 2016). Two more, Antle et al. (2018) and Shamekhi and Bickmore (2018), had carried out pilot testing to test usability. In the case of Ferreira et al. (2020), the solution also underwent a heuristic evaluation of the usability of the

[1]Note that while Costa et al. (2016) only evaluated the effectiveness of a solution, it also described the design process. It therefore still met the inclusion criteria of this review.

user interface. Ha and Kim (2020) looked at the user experience through an evaluation with users. Similarly, Báldy et al. (2020) evaluated how engaged their users were with the game when pilot testing their solution.

Next to usability, effectiveness was the most commonly evaluated aspect. This element was measured in various ways, such as pilot-testing (Carlier et al., 2020), laboratory experiments (Costa et al., 2016), clinical studies (Coyle et al., 2011; De Sa & Carriço, 2012), and field studies (Liszio & Masuch, 2017). The studies conducted by Báldy et al. (2020) and Bray et al. (2020) were the only ones to test the learning outcome of their solution. The former aimed to spread awareness of SAD, and the latter contained information for patients about a medical procedure. The study by Carlier et al. (2020) was the only study to test its game quality by analysing game elements, using guidelines by game experts. Coyle et al. (2011), on the other hand, performed acceptability testing of their solution.

4.4.8 User Acceptability of Game-Based Solutions

We were particularly interested in learning more about whether the users and health professionals accepted the game-based solutions. By game-based solutions we refer to all the solutions that included at least some element of gamification (e.g. motivational rewards, progressing levels).

All game-based applications generally scored well on usability evaluations with target users. Antle et al. (2018) identified no usability challenges in their evaluations. They found that all the children were able to successfully interact with the application, modify their actions based on feedback and earn tokens already in the first session. The brain-computer interface (BCI) application they had developed contained games based on a familiar and culturally relevant activity, and the researchers noted that "with very little prompting, children knew how to move or be in their bodies, and understood the resulting feedback through game activities" (p. 38).

Carlier et al. (2020) also carried out a usability study testing their space exploration game. The results showed that although the children were distracted by getting their own smartphone, they enjoyed playing the games and would even play them voluntarily after school. The most popular game in the application was the memory game. In contrast, the mini-game designed to teach the children to breathe deeply and calmly was seen as "too boring or difficult to play spontaneously" (p. 31). However, it should be noted that these findings are based on user testing with only three children.

Coyle et al. (2011), who developed a game about CBT strategies that included the personification of abstract concepts, tested their application in therapy. The researchers found that many of the children adopted the language of the game, frequently referring by name to gNats (personification of negative thoughts) who had stung them. Bray et al. (2020) concluded that the games in their application were very popular, based on the number of children who chose to play them when preparing for a medical procedure. They found that the children particularly enjoyed the customisable avatar and the chatbot.

Liszio and Masuch (2017) also found that the children participating in the study enjoyed their VR game. Focus group testings showed that children enjoyed the story and its protagonist (a penguin visiting the hospital to get an MRI). Ryu et al. (2020), whose target group were elderly Koreans, discovered that several users reacted positively to the suggestion of cognition-enhancing games. Even older adults with no interest in games changed their attitude when they realised the games could help them prevent dementia.

Some of the studies looked into measuring specific aspects of usability. Báldy et al. (2020), for example, reported based on user feedback that their 3D computer game creating awareness about social anxiety disorder was successful in terms of focused attention, aesthetic appeal and narrative understanding. They hypothesised that emotional engagement, and thereby the user experience, could be further improved through further in-game personalisation. In another study, Patwardhan et al. (2015) found that REACH, an early intervention app for children, was highly rated by most users for system ease of use, quality of support information, system ease of learning and system satisfaction. They conclude that the results suggest overall satisfaction, ease of use and increased motivation.

While an app must be liked by its intended users, it should also be accepted by health professionals who will potentially use the application in their practice. Ha and Kim (2020), who had designed a mobile app that allowed counsellors to connect with individuals seeking help, conducted a satisfaction survey. Clients reported that they were satisfied with the app, rating it 73 out of 100. Counsellors gave the app a slightly lower average rating of 66.1 out of 100. Based on two clinical studies and one professional survey, Coyle et al. (2011) present strong evidence that their application is acceptable to young people and mental health professionals. Around 97% of the 216 professionals questioned agreed that the game would be quite (15.3%), very (39.8%) or extremely (41.8%) helpful in their clinical work. Health professionals especially liked that the game was engaging, appealing to young people and interactive. On the other hand, testing also revealed that the graphics might not quite meet the expectations of adolescents and that the information given to the users sometimes was too extensive or in too complex language. In the case of Liszio and Masuch (2017), the application received strong support from medical professionals.

4.4.9 The Efficiency of Game-Based Solutions

While user acceptability is important to evaluate, it is no less important to consider the efficiency of the game-based solutions and to find out if they successfully reduced anxiety levels. Most of the applications described in our literary review did lead to at least some level of anxiety reduction. For example, Antle et al. (2018) found that the children in the intervention group improved significantly across most measures, compared to the waitlist control group. The children also showed an improved ability to self-regulate in classroom settings. In another study (Carlier et al., 2020), they found that the children did indicate reduced stress and anxiety levels after the study. However, none of the children played the games during the pilot-testing period while feeling anxious. The authors note that to create a game that is both engaging and effective, it might be necessary to also include children with ASD (their target group) in the design process.

In their study, Liszio and Masuch (2017) found that the children thought the game could reduce fear of the MRI exam. Results, albeit non-significant, also showed that tendencies indicated a drop in the anxiety level after using the application. Ha and Kim (2020) found that only depression levels were reduced significantly after using the chat app. Anxiety levels remained stable. This result could be due to the two weeks of testing was not enough to produce changes in the trait-anxiety index they employed in the study. In Ryu et al. (2020), however, their application did decrease the levels of both anxiety and depression by 36% and 18%, respectively. However, it should be noted that games were only a minor part of this application, mainly acting as a motivator for use.

Báldy et al. (2020) did not evaluate efficiency in terms of anxiety reduction, nor was this a goal of the game, but rather how much information participants could recall from the game a week later. The participants had on average less than 50 per cent correct answers, which was a lower accuracy score than the authors expected. They note that this score could be improved with better game design focusing on the specific information that should be retained. Bray et al. (2020) found that the intervention benefited the children by giving them information about the procedure while still at home. The authors noted that playing at home allowed them to prepare in a safe environment.

4.5 Observations

Technology has the potential to make anxiety treatment more accessible, interactive and entertaining for patients. This systematic review set out to discover what types of digital solutions have been described and tested in academia. Game-based solutions were of particular interest. Since the review took a design and development perspective, it focused on how the studies had implemented anxiety treatment practices in their solutions and what kind of methodology had been employed in the design and evaluation of the solution. The screening process revealed that most of the existing literature focused on the effectiveness and not so much on the design and development process of solutions. After we had carried out three screenings, 17 articles remained. This section presents some observations and reflections based on the findings from this review.

A gap in research on the design of digital applications for dental anxiety

Despite extensive searches, no articles on solutions for dental anxiety could be included in the final review. This lack of results indicates that there is a gap in the literature on this area. Although this does not mean that there do not exist any studies on digital solutions on dental anxiety, it is possible to conclude that there are no peer-reviewed studies focusing on the design and development of digital solutions for the prevention or treatment of dental anxiety. It can therefore be said that there is a need for further research on this area.

Varied involvement of end-users in the design process

All the studies we analysed had either evaluated their solutions with end-users or were currently doing so. Most had tested the usability of the solution. However, the degree of involvement of end-

users in the design process varied greatly. Six studies did not make changes to the solution based on feedback from the target groups(s). In other words, the involvement of the target group in designing these solutions can be considered as relatively limited. The remaining 11 studies used feedback from the end-users to improve design, but the degree of involvement varied in these cases as well. Most of the studies involved users through various types of usability testing, and one study mentioned collaborating with potential users to specify requirements (Ferreira et al., 2020). None of the studies involved users in co-designing the solutions, yet four of the studies collaborated with domain experts in the design of the solution. In summary, user-centred practices were used by many. However, there is still a potential for even more end-user involvement in designing digital solutions to prevent and treat anxieties and phobias.

Inclusion of health professionals in the design process

Many of the studies involved health professionals (e.g. therapists, psychologists), likely because of the vulnerable target groups consisting of adults and children with diagnosed anxieties or phobias, and because domain expertise was needed to create a solution that could prove helpful to this group of patients. Potential benefits of the inclusion of health professionals encompass ensuring that the solution is safe to use and that evidence-based treatment techniques for the specific disorder are included.

Gamification and game-based strategies can act as a motivator for users

Gamification and game-based strategies were elements in many solutions. The type of game elements and to which degree each solution applied them varied greatly, but it was frequently used as a motivator to make the user more interested in complying with treatment activities or in using the solution itself. An example of using gamification to motivate is the animated motivational avatar "Blob" created by Patwardhan et al. (2015). Whenever the children completed a task from the treatment program in the mobile application, they were rewarded with new skills for Blob. This avatar was one of their strategies to combat limited compliance among children when using a paper-and-pencil based anxiety treatment protocol. Others, such as Báldy et al. (2020), used a game-based strategy in the form of a serious game where players learn about CBT techniques and need to apply them in different anxiety-inducing situations. Gamification and game-based strategies were techniques used for both adults, elderly, and children, but the most common target group was children.

Game-based solutions are generally well-received by users

Usability evaluations carried out by the studies found that game-based solutions were generally well-liked by the users and that they enjoyed playing them. Some of the components in the game-based solutions were narrative, characters, or avatar as "guide", presentation of information, the personification of concepts and realistic depiction of environments or scenarios that can be anxiety-inducing. Evaluations found that users particularly enjoyed the story aspect of game-based solutions. Their enjoyment of this aspect might be due to these solutions being centred around a narrative and a protagonist the player followed.

While not so many studies looked into whether mental health professionals found the applications acceptable, one study demonstrated that therapists found their game helpful in their clinical work. It should also be mentioned that mental health professionals were consulted during the design and development process in most of the studies, thereby indicating that they supported the content in the applications. The evidence on the effectiveness of the game-based solutions presented in this review is less clear, mainly because this aspect was outside the scope of the review. However, it is still interesting to note that the studies that measured efficiency mostly found that their solutions reduced anxiety levels. Based on this, it seems fair to conclude that game-based solutions offer a promising avenue for digital treatment and prevention solutions.

Simulations are suitable for exposure therapy

Exposure therapy involves exposure to the source of one's fear. Digital exposure therapy should therefore implement authentic representations of the element(s) of fear. Simulations seem to be especially suitable for exposure therapy. Because anxiety can be situational, e.g. social anxiety or related to hospital visits, using narratives representing these situations is a suitable device for digital exposure. An example is the exposure therapy game by Liszio and Masuch (2017), which uses the narrative of a penguin preparing for an MRI exam as a way to expose the player to the anxiety-inducing situation. The same solution also used a recording of an MRI machine as a part of the exposure therapy in their MRI simulation. Another is the VRET described bye Hartanto et al. (2015), where players with social phobia are exposed to anxiety inducing scenarios.

Anxiety prevention and treatment solutions targeted at children

Solutions targeted at children need to include content suitable for their cognitive abilities and their interests. As per Liszio and Masuch (2017), the narrative and informative elements are represented in an easy-to-understand language and given orally. As both De Sa and Carriço (2012) and Coyle et al. (2011) show, using metaphors for abstract concepts related to anxiety and anxiety treatment can be effective when designing for children when working with children. De Sa and Carriço (2012) used metaphors of height to communicate about degrees of anxiety with children, which proved to be effective. Coyle et al. (2011)used visual representations of the concept of negative thoughts as an "enemy" in their therapy game.

Incorporating evidence-based treatment into digital solutions

As the review shows, technology allows for many ways to implement anxiety and phobia treatment, and there does not seem to be any one solution that is the most suitable for treatment. In addition to the multitude of technologies, there are also numerous treatment practices to choose from when creating solutions for treatment and management of anxiety. A widespread treatment practice to incorporate in digital solutions seems to be cognitive behavioural therapy. CBT is a well-tested and acknowledged treatment method and appears to be applicable to many different kinds of technologies (e.g. Unity game as in Báldy et al. (2020); mobile game as in Carlier et al. (2020); online programme as in Currie et al. (2010)). Another well-grounded technique is exposure therapy. This technique lends itself particularly well to VR as the technology allows for deep immersion into a

virtual world (see, for example, Hartanto et al. (2015) or Liszio and Masuch (2017)).

As the primary goal of these solutions is to treat or reduce anxiety disorders, it makes sense that so many incorporate evidence-based treatment practices in their solution. CBT, exposure therapy, and psychotherapy have been proven to work in the traditional treatment of anxiety disorders (Choy et al., 2007; Roth & Fonagy, 2005). This review shows that this type of treatment also can be incorporated into digital solutions.

4.6 Study Limitations

As explained in Subsection 4.3.1, Databases and Search Terms, the search was limited to only technical databases. The reason for excluding medical databases such as PubMed was that our focus was on the design and development of a solution and not merely its effectiveness. Nonetheless, we may have excluded studies that, while primarily concerned with measuring effectiveness, also contained a detailed description of the design and development of the solution. Therefore, it is important to stress that this review by no means provides a complete overview of all the studies about digital solutions in the literature.

4.7 Summary and Key Takeaways

The searches for literature on technological solutions and anxiety treatment showed there are many studies on this topic. However, after the screening process, only 17 articles remained that met the inclusion criteria. This result shows that few studies describe how they developed a digital solution for anxiety treatment. Therefore, there is limited literature to guide developers and designers who wish to develop similar solutions. In addition, none of the articles described the design of a solution intended for dental anxiety or dental phobia treatment. Despite this, the concepts presented in the various studies were still considered to be relevant for this thesis, as they all focused on anxiety disorders.

Based on this review, a few takeaways were formulated which will be used to guide the design and development process of this work:

- Aim to include professionals in the design process, as they are important stakeholders, and their expertise is likely to be essential to the solution's effectiveness.
- Aim to include elements of CBT, such as psychoeducation and coping mechanisms.
- Aim to use simulations and narratives are suitable for exposure therapy.
- For anxiety treatment of prevention solutions intended for children, aim to use concrete representations of abstract concepts in solutions and ensure that the solution is usable in a safe environment, e.g. at home.

Chapter 5

Case: The TBiT Service

This project was a case study of the psychotherapeutic treatment service provided by Trygge Barn i Tannbehandling (TBiT) aimed at exploring how an interactive solution could support the service, and the design and testing of a functional prototype of such a solution. This chapter provides a description of the service and a presentation of the treatment trajectory.

TBiT offers psychotherapeutic treatment to children and adolescents aged eight to 18 who suffer from severe dental anxiety and dental phobia. It is offered by the Center for Oral Health Services and Research (Tannhelsetjenestens kompetansesenter), which is a part of the Norwegian National Public Health Service. There are six regional centres for oral health services in Norway, but the TBiT service is currently only offered in one region; Trøndelag County.

The TBiT team is multidisciplinary, consisting of specialised psychologists, dentists, and dental assistants. Children are generally referred to the service by their personal dentist based on the dentist's assessment of the child's need for psychological treatment. Treatment at TBiT is organised into several sessions, each led by a specialised psychologist. The psychotherapeutic treatment is based on exposure therapy, a treatment where individuals are gradually exposed to the objects or situations they fear in a safe environment (APA, 2017), and cognitive behavioural therapy, a method involving teaching patients how to identify and change destructive thought patterns (Hofmann et al., 2012). The ultimate goal of the treatment is to make it possible for the patient to receive regular dental treatment at their local clinic.

The service can be divided into four phases: Before Treatment, Start of Treatment, During Treatment and End of Treatment, as seen in Figure 5.1.

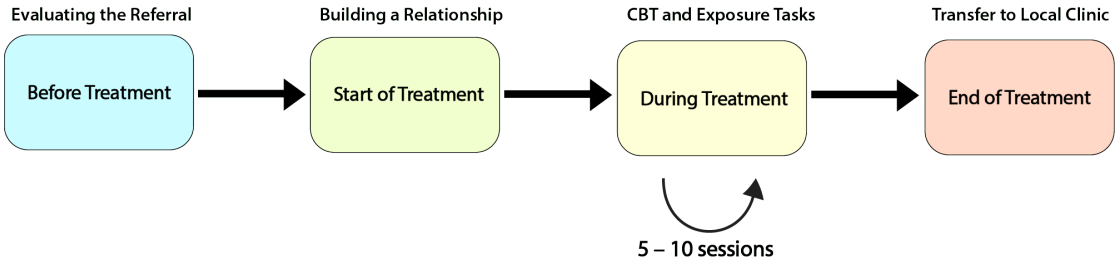


Figure 5.1: Overview of the TBiT treatment trajectory.

1. **Before Treatment: Evaluating the Referral**
   The children are typically referred to TBiT by their local dentist. Upon receiving the referral, a team of experts at TBiT evaluates it. If the application is accepted, the child is most likely placed on a waiting list.

2. **Start of Treatment: Building a Relationship**
   The patients have an initial talk with a psychologist from TBiT to build trust and help the psychologist evaluate their need for treatment. In this talk, the psychologist and the patients evaluate the patients' degree of fear, create a treatment plan, decide on a stop signal (a sign to use when the patients becomes too anxious and want to pause a treatment), and decide what to do next session. An important goal of this talk is to give the patients a sense of control during the treatment. The psychologist will also often incorporate some psychoeducation in this session, which includes teaching the patients about their body's natural reaction to fear. Psychoeducation typically involves providing patients with psychiatric disorders with the skills and necessary knowledge to handle their illnesses (Medical Dictionary, 2009).

3. **During Treatment: Practicing What the Child Is Scared Of**
   The treatment consists of five to 10 sessions at 45 min each. How many sessions are needed depends on the severity of each patient's anxiety and how quickly progress can be seen. There is often a couple of weeks between each session. The anxiety treatment is mainly conducted at a dental office. The treatment aims to be predictable and structured. Each session typically consists of the following activities:

   - *Check-in:* The session plan is reviewed and possibly revised if the patients want to.
   - *Tour of the dental office:* The patients are allowed to see and feel the instruments (only in the first session).
   - *Exposure therapy:* The patients practice exposure tasks, using the stop signal if they get too anxious. The tasks are adapted to the severity of their fear and include gradual exposure. e.g. first putting together a syringe, then touching a syringe, then having the syringe next to their chin.
   - *Check-out:* The session is summarised and the psychologist and patient agree on a plan for the next session.

4. **End of Treatment: Transfer to Local Clinic**

> In the final session, the entire treatment is summarised, and the patients recount what they have done during the treatment and what they have achieved. A proficiency plan ("mestrings-plan") is then created, which is sent to the patients' local dentist. This plan contains information about what the patients have done and achieved during the treatment, and considerations that the local clinic should follow when treating the patients, e.g. using a stop signal. Finally, representatives from the local clinic, the patients' psychologist and the patients meet to complete the transfer back to the local clinic. The patients will then receive a notice for dental treatment from his or her local clinic. If the treatment has been successful, the patients are now able to receive regular dental treatment.

Concerning the TBiT service, there is currently an ongoing research project called Innovasjonsprosjektet for Trygge Barn i Tannbehandling (T-TBiT) (Service Innovation for Children in Dental Care). The project was initiated in 2019 and is a collaboration between the Center for Oral Health Services and Research and SINTEF. The project aims to develop a digital toolbox for children, parents and dental professionals that can contribute to the prevention and treatment of dental anxiety in children and teenagers. Digital tools could make this type of prevention and treatment more accessible to a larger audience beyond Trøndelag County. To better understand how professionals who treat dental anxiety in children view the possibilities of a digital solution for dental anxiety prevention (RQ2), we conducted a preliminary study on the TBiT service. This preliminary study is described in detail in Chapter 7.

Chapter 6

Research Design

This chapter presents the research method and data gathering methods used in the project.

6.1 User-Centred Design

User-centred design is the process of putting the needs of the end-users and stakeholders at the forefront of every step of the design process of a system. The idea behind user-centred design is that designers need a deep understanding of the needs of the end-users and other stakeholders to be able to design solutions that are accessible and effective for the users. A user-centred design process can improve human-centred qualities, such as usability, accessibility, user experience and ensuring that the system does not cause any harm to its users (International Organization for Standardization [ISO], 2019). The user-centred design process is outlined by the standard ISO 924-210:2019 and describes four main activities of design and development: understanding and specifying the context of use, specifying the user requirements based on a deep understanding of the user, producing design solutions that meet the defined requirements and evaluating the solutions against the requirements.

6.1.1 Implementing a User-centred Design Process

The user-centred design (UCD) process followed in this project can be seen illustrated in Figure 6.1. Details on the activities in each phase are described in the subsections below.

6.1.2 Planning the Process

As described in ISO9241-210, a project which aims to be user-centred needs to plan and allocate time for how user-centred activities should be incorporated in the overall project plan.

Initially, the general project constraints were identified to get an overview of the project timescale,

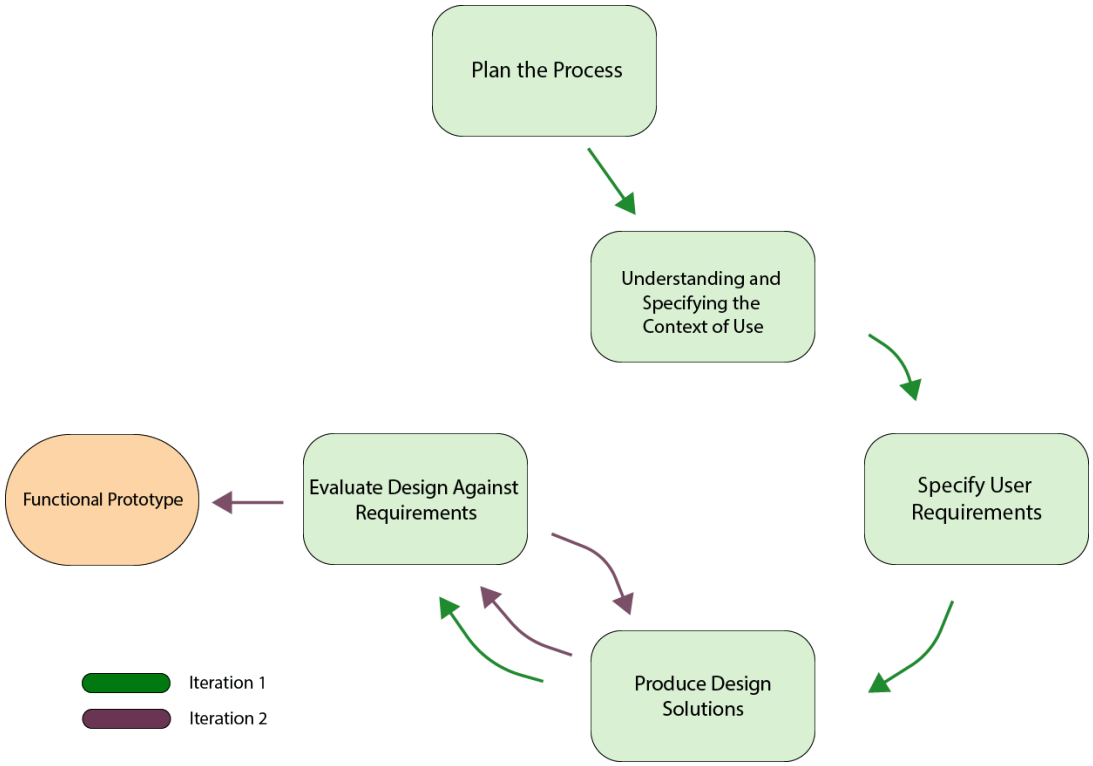


Figure 6.1: The user-centred design method.

which resources were available, and how and when it would be possible to incorporate users in the process. The project had a fixed timescale limited by the deadline for submission in June. Because of the ongoing Covid-19 pandemic and strict limitations on close contact between people from different cohorts, it became necessary to consider the type of user-centred activities that would be possible to conduct. As new restrictions could be implemented at any time by the government, a contingency plan in the case of a complete lockdown was created. Luckily, the most drastic contingency plans were never needed but the user evaluations had to be conducted remotely, and within a more limited time period than initially planned.

6.1.3 Understanding and Specifying Context of Use

Context of use is the cross-section between users, tasks, goals, resources, and environment (ISO, 2019). In other words, the context of use is defined by the users and stakeholders involved, their tasks and goals when interacting with the system, the environment where the system is situated and the available resources (ISO, 2019).

The background for this thesis was the case of the TBiT service, and the research questions were related to how an interactive solution, and serious games in particular, could support the service. The TBiT service thus determined the context of use for this study. To get an understanding of the TBiT service, a preliminary study was conducted. The preliminary study and resulting context of use are described in Chapter 7.

6.1.4 Defining User Requirements

In a user-centred design process, the needs and goals of the users and stakeholders are the basis for design choices and evaluation (ISO, 2019). These needs are often condensed into specific user requirements, which can be used to evaluate the solution and as a way to get feedback from stakeholders. In a user-centred design process, user requirements are related to and restricted by the intended context of use (ISO, 2019).

The user requirements for the serious game were created based on information acquired through the preliminary study and the context of use description. The user requirements are presented in Section 7.6.

6.1.5 Producing Design Solutions: Iterative Development and User Evaluation

A design solution is designed based on, amongst other things, the solution's context of use, the design of established applications in the domain and design and usability guidelines and experience and knowledge of the development team (ISO, 2019). Producing design solutions includes making design solutions concrete by using prototypes and evaluating these prototypes based on user-centred evaluations (ISO, 2019). User-centred evaluation, or, i.e. evaluation based on users' perspective, is a required and crucial activity in user centred-design (ISO, 2019). User-centred evaluation can be used to collect information about user needs, get feedback on the design, assess whether requirements have been met, or establish baselines. Ideally, user-centred evaluation should be included from the very start of the design process. However, this might not always be feasible. In this case, the ISO standard recommends evaluating design solutions in other ways.

As it is time-consuming to plan and conduct user evaluations, it was decided to first evaluate and refine the initial concept with health professionals. Following this, two iterations of user evaluations were conducted. In the first iteration, a prototype of a serious game was created and evaluated to get feedback on the concept and uncover usability issues. The user evaluation included observation, a semi-structured interview, and a questionnaire. The data from each source was summarised and compared in order to create a list of improvements. Next, a functional prototype was created and presented to stakeholders for input and feedback before the second round of user evaluation. The same data collection methods were employed as in the previous round. The iterative development process is described in Chapters 9 and 10.

6.2 Data Collection Methods

A user-centred design process is centred around the needs of the stakeholders, especially the end-users. These needs are used during the design process to specify requirements and get feedback for design improvement. Data gathering is essential for both (Sharp et al., 2019). Naturally, then,

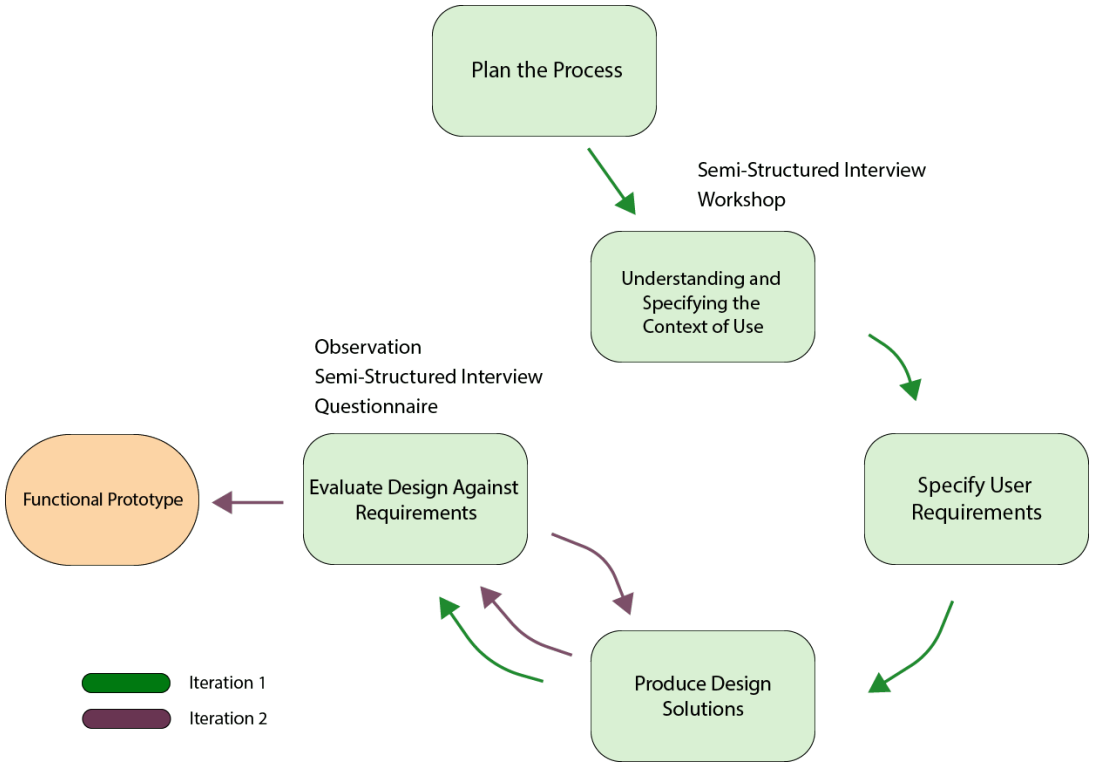


Figure 6.2: The design process with data collection methods.

a user-centred design process needs to include evaluation of and feedback from the intended end-users (ISO, 2019). It is common to employ interviews, questionnaires, and observation to gather this kind of data from end-users. (Sharp et al., 2019). The advantage of using multiple data gathering methods and data sources, also called triangulation, is that it combines multiple perspectives and can lay the grounds for a more comprehensive understanding of a problem (Salkind, 2010). Depending on the data gathered, it can be evaluated both quantitatively and qualitatively based on the project's needs, but it is common to use a combination of both (Sharp et al., 2019).

This study employed the following data collection methods to define requirements for the serious game and evaluate the developed prototype: workshop, interviews, observation, and questionnaires. As stated in Chapter 1, the contribution of this research is a set of emerging design guidelines for the design of serious games for the prevention of anxiety disorders. The use of data triangulation provides a better basis for identifying and defining valuable guidelines.

To gather data from the TBiT team, semi-structured interviews and a workshop were conducted. This data was used to answer RQ2 ("*How do professionals involved in dental anxiety treatment view the use of a digital solution to prevent dental anxiety in children?*"). To answer RQ3 ("*How do children experience the functional prototype of a serious game for such a purpose?*"), three different methods were utilised: observation, a semi-structured interview for qualitative data and a questionnaire for quantitative data. The methods are described below. Figure 6.2 shows where different methods were employed in the UCD process.

Observation

Observation is a widely used method where data is collected through observing the user in a situation. In the case of user-centred design, it is typical to observe the user interacting with a product to uncover any usability issues. The Nielsen Group recommends that the observer takes as many notes as possible. These notes can be, for example, user mistakes, system errors, strategies, quotes, or any other aspect with the system that the user overlooks or misunderstands (Farrell, 2016). A benefit of observation in user evaluations is that it has been found to identify a higher number of usability issues than other methods (Hasan, 2014). When utilising observation in the user testing of games, it is advisable to create an observation checklist based on the functionalities of the game (Diah et al., 2010).

Semi-Structured Interview

An interview is a common qualitative data collection method where the interviewer attempts to elicit information from another person by asking questions (Longhurst, 2016). In a semi-structured interview, the interviewer prepares a list of questions in advance but still leaves room for open-ended exploration (Wilson, 2014). The semi-structured interview can be used to explore any topic, but in the case of user-centred design, the interview typically is centred around the users' needs or experience with a system after carrying out a user test. A benefit of the semi-structured interview is that it allows for uncovering previously unknown issues while ensuring particular points are covered in each interview (Wilson, 2014).

Questionnaire

Questionnaires, also called surveys, are standard methods of data gathering in user-centred research (Lazar et al., 2017). Questionnaires are suitable to get data from many respondents, get feedback on user experience, and measure attitudes (Lazar et al., 2017). Depending on the data gathered, questionnaires can be evaluated both quantitatively and qualitatively. A frequently used questionnaire within the field of user-centred design is the System Usability Scale (SUS). A SUS questionnaire is a quick and reliable way of measuring the usability of a digital system (Sauro, 2011). It consists of ten statements with one of five possible responses, ranging from "Strongly Agree" to "Strongly Disagree". As the SUS questionnaire is created for adults, it has been suggested to adapt the language when utilised for children (Putnam et al., 2020).

Workshop

A workshop refers to an "arrangement whereby a group of people learn, acquire new knowledge, perform creative problem-solving, or innovate in relation to a domain-specific issue" (Ørngreen and Levinsen, 2017, p. 71). The objective of a workshop is to produce reliable and valid data about the specific domain (Ørngreen & Levinsen, 2017).

Chapter 7

Preliminary Study

To gain understanding of the context of use, a preliminary study of the TBiT service was conducted. The study focused on understanding the team's needs and challenges and exploring how a digital solution and a serious game could serve as a supporting tool for the service. The study included an initial semi-structured interview with a psychologist (ID-A), a workshop with the same psychologist specialist, a second psychologist (ID-B) and a dental hygienist (ID-C), and another semi-structured interview with ID-A. The study resulted in a description of the TBiT treatment trajectory, a description of the context of use, requirements for a serious game and a set of persona and scenarios used throughout the design process. This chapter describes the results of the preliminary study.

7.1 Identified Challenges Experienced by the TBiT Service

This section describes the main challenges experienced by the TBiT team. The main challenges were derived from a description of the TBiT treatment, which included an overview of challenges faced by each stakeholder during the treatment phases. This description resulted from reviewing the transcripts and notes from interviews with one of the psychologists (ID-A) and the workshop with the TBiT team. The description was analysed to find shared commonalities between the challenges and categorised accordingly. The complete description can be found in Appendix A. This section presents what we consider to be the main identified challenges.

The main challenges experienced by the TBiT service are:

1. Children's motivation
2. Children's maturity level
3. Practical challenges

These categories are detailed below while Table 7.1 shows an overview of the key challenges.

Motivation

The biggest perceived challenge in treating children with dental anxiety is the lack of motivation for attending and receiving treatment. The psychologists believe that a lack of motivation is tied to children not seeing or understanding the need for treatment, or the lack of information about why they have been sent to receive treatment. The lack of motivation is often most prominent at the start of the therapy and decreases as long as the children continue to receive treatment. Tied to a lack of motivation, the psychologists often experience that children lose focus during a treatment session because the tasks are difficult or make them uncomfortable. Tasks involving exposure to objects or situations that are frightening are by their very nature uncomfortable and requires that the child has intrinsic motivation to push themselves beyond what feels safe. As a result, a child's motivation to do these kinds of tasks is tied to the success of the treatment method.

Children's Maturity Level

Another major challenge for psychologists is the children's maturity level. Children do not have the same cognitive abilities as adults and have a limited ability to self-reflect and relate to abstract ideas. Children may have difficulties expressing themselves and controlling and organising their thoughts, which is an essential element of cognitive behavioural therapy. For example, children often say "I don't know" during the treatment because they are unable to express their thoughts and feelings. They also often overestimate or underestimate their feelings, especially their fear. This makes it difficult for psychologists to develop an effective treatment procedure that fits the children's needs.

Practical Challenges

The TBiT service also faces practical challenges in the form of a lack of time and resources. Currently, there is only one active psychologist at TBiT, and children might have to wait an entire year before being offered treatment. This can have severe consequences for children in urgent need of dental treatment, as untreated dental problems only continue to deteriorate. Furthermore, when these children finally receive treatment, the experts at TBiT are also under pressure to achieve positive treatment results quickly, which is not always feasible because of the previously mentioned challenges.

Category	Challenges
Motivation	• The child is scared of receiving treatment and the different exposure tasks used in the treatment • The psychologists have difficulties motivating the child to receive or continue treatment. • The child does not see the need for treatment.
Maturity level	• The child quickly becomes unfocused, distracted and/or tired. • The child has difficulties challenging themselves to do treatment assignments. It is difficult and uncomfortable. • The child struggles with categorising and sorting thoughts and do not know how to manage negative thoughts. • Children have difficulties expressing themselves, which makes it challenging to discuss difficult topics such as feelings.
Practical challenges	• TBiT has long waiting lists. • Too much time passes between each session. • Patient needs to travel far to receive treatment.

Table 7.1: Key challenges.

7.2 The Possibilities of a Digital Solution as a Support Tool for TBiT

To uncover the possibilities of a digital solution, we reviewed the transcriptions from the workshop and interviews. From the review, three benefits of a digital solution in the context of the TBiT treatment could be identified:

1. Provide information about dental health and dental procedures to all children to prevent dental anxiety
2. Low-threshold solution for those that do not need extensive treatment
3. Interactivity

Provide information about dental health and dental procedures to all children to prevent dental anxiety

The psychologists and the dental hygienist believed that providing information about dental procedures and dental health could be a way to increase a child's experience of control during dental treatments. As one psychologist noted, "It can give information, a sense of predictability and provide the child with a feeling of control" (ID-A). They also mentioned that this was especially suitable for younger children because this age group often asked for information about "what was going to

happen". The participants provided many suggestions for what type of information a digital solution could include. ID-A commented that "it needs to contain psychoeducation so they understand what it means to be scared, what happens when you're scared". The dental hygienist (ID-C) suggested including "examples of adjustments one can make at the dentist office to feel more in control, like for example looking in a mirror, counting, getting an explanation from the dentist". They all mentioned that there should be information about the different instruments and procedures.

To provide this information to the public, they described the possibilities of a "self-help toolbox" providing information about dental health and dental treatments through videos and other media. The toolbox could also possibly include learning modules that could teach children about dental treatments and dental instruments through various tasks. One psychologist (ID-A) commented that this toolbox for anxiety prevention could support the service by being easily accessible to all Norwegian children and thereby reduce the general need for treatment.

A digital solution can be a lower-threshold option for those who do not need extensive treatment

The psychologists think that some on the waiting list do not require a complete treatment. Instead, it might be sufficient with a lower-threshold digital solution for children with mild anxiety. For them, it "might be enough with an understanding of what is going to happen during a dental treatment" (ID-A). A digital solution that includes information on the topics described in the previous point could, in other words, be a satisfactory "treatment" for many children. Such a digital solution could solve the problems with long waiting lists at TBiT and shorten the waiting time for the children who urgently need treatment.

Digital solutions can be highly interactive, which makes them entertaining and motivational

A digital solution allows for many interactive and entertaining learning methods, which can be useful tools when working with children. As mentioned in the list of challenges in Table 7.1, psychologists sometimes find it difficult to motivate children during treatment, and that children often lose focus and are easily distracted. Children's ability to challenge themselves is also tied to their motivation to complete treatment tasks, which can often be difficult or scary. A fun, interactive solution could be used as a tool during treatment to make and help keep children more engaged and thus more open to receive treatment.

What a Digital Solution Cannot Do

Understanding what a digital solution can do involves understanding its possible limitations. According to the psychologists at TBiT, the kind of extensive exposure therapy that people with dental anxiety or odontophobia need would require guidance from psychologists and access to an actual dental office. In other words, this form of exposure therapy has "little value in a digital format" (ID-A). However, simpler forms of exposure, such as exposure to sounds from and interacting with dental instruments, can be achieved by a digital solution. Studies included in the SLR have shown that VR solutions can be suitable for exposure therapy (Hartanto et al., 2015; Liszio & Masuch, 2017), but this would require considerable resources and was outside the scope of the project. The experts

at TBiT also noted that a digital version of the complete TBiT treatment without any involvement from a psychologist would be challenging to develop because psychological treatment often relies on a well-established relationship between patient and psychologist to be successful. Designing and testing such a solution was also beyond the scope of this thesis.

7.3 The Possibilities of a Serious Game for Dental Anxiety Prevention and Treatment

The TBiT team proposed that teaching children about dental treatments, dental health and dental anxiety will make them feel more comfortable in dental situations, which could have a preventive effect on the development of dental anxiety. A serious game designed to teach children about the aforementioned topics can be effective, as there is a chance that many children do not find the subject of dental health and dental treatment very engaging in itself. A serious game can provide an entertaining way of learning about this topic and foster engagement and learning.

During the workshop, the experts at TBiT suggested many different activities for children to learn about dental procedures and dental health. One psychologist suggested a cavity game: "It would be useful to have a game where you, for example, fix a cavity. You could add drilling sounds, the actual sounds when do you it. This could be a type of exposure, which is often scary for kids. This would be possible with many elements at the dentist» (ID-B). The dental hygienist added: "You could also have a game where you handle the sedation or a puzzle where you need to assemble the sedative syringe" (ID-C). It was also suggested that a game could include a simulation of the waiting rooms and dental office or be used to practice the stop-signal. They especially highlighted the possibility of games and interactive simulation as suitable solutions for teaching children about dental health and dental treatment through fun and play.

Additionally to positive engagement, serious games can provide extrinsic motivation to learn about topics where a person does not have any intrinsic motivation or personal drive for learning (Mildner & Mueller, 2016). This advantage can make a serious game suitable within the context of dental anxiety treatment for children, as children who receive treatment often struggle with motivation. In other words, a serious game can be a tool for dental anxiety prevention in children because it is an entertaining way of learning and because it can motivate them to learn about dental health.

7.4 Description of the Context of Use

The context of use was defined based on the findings from the workshops and interviews presented in Sections 7.1-7.2. The context of use is the cross-section between users, tasks and goals, resources, and environment (ISO, 2019) and provides the basis for defining the requirements of a solution in a user-centred design process.

The age of the target group and potential users of the serious game was determined by the users of the TBiT service, which are children aged eight to 18 years. For this project, the age segment was narrowed further to the ages 8–12, which according to one of the psychologists at TBiT is a time when many children develop anxiety: "I think this is a good target group. It is common to become more anxious between the ages eight and 10" (ID-A). As the design intention of the solution was the prevention of dental anxiety, the target group were children without dental anxiety. The serious game should also be usable by children without the need for supervision from psychologists, as it is intended for children both receiving and not receiving treatment. The goal of the serious game is for children to learn more about dental treatment and how to handle related anxiety as a method of providing children with a feeling of control in the dental office.

7.5 Personas and Scenarios

Personas are archetypes of the intended users (Benyon, 2014). To better understand the target group, we conducted a semi-structured interview with a parent and two children aged 10 and 12. This resulted in the description of two personas. Because the experts at TBiT are important stakeholders, a persona of a TBiT psychologist was also created to represent their needs concerning the solution. Scenario descriptions were also formulated to contextualise the personas and to describe the intended use cases of the serious game. Scenarios are short descriptions of how designers envision how the personas will use the solution as a tool to reach their goals (Sharp et al., 2019). The personas and scenarios can be found in Appendix B.

7.6 Identified Requirements

The user requirements were based on the context of use as described in Section 7.4. User requirements are representations of the needs of the users and other stakeholders within the intended context of use and are used to guide the user-centred design process (ISO, 2019). The requirements were evaluated by the TBiT team and revised based on their feedback.

- The serious game must provide information about TBiT concepts that the TBiT team believes can have preventive effects (e.g. information on dental treatment(s), stop signal).
- The serious game should not require involvement from professionals.
- The serious game must present information suitable for children aged 8–12.
- The serious game must be engaging.
- The serious game must be playable on an iPad.

Chapter 8

A Point-and-Click Game for the Prevention of Dental Anxiety

This chapter describes the serious game concept developed and tested in this study. The first section presents the learning objectives of the game, formulated to mirror the pedagogical intention of the domain experts from TBiT. Then, the point-and-click game concept, the simulations and activities included in the game are outlined. The last section presents the aspects and elements of the game that are supposed to create and maintain engagement.

8.1 Learning Objectives

Games designed for learning have clearly defined learning objectives that the learners are meant to achieve as they play (Warren & Jones, 2017). Learning objectives are measurable statements of what the players are supposed to know or be able to do after playing the game. Warren and Jones (2017) suggests that a learning objective should start with the expression “The learner will . . . ”, e.g, "The learner will be able to explain five major differences between bacteria and viruses". We decided to express the learning objectives of our game as recommended by Warren, but since the target group in the context of a user-centred design process is most often referred to as users, we exchanged the term “learner” with “user”.

The learning objectives define the “serious” part of the game, i.e. the knowledge that the domain experts contribute to the game. This concern makes it essential to include domain experts when formulating these objectives. A first version of the learning objectives of the game were derived based on findings on how a digital solution may contribute to the prevention of dental anxiety and from the user requirements, all described in Chapter 7. This version was then reformulated based on feedback from the TBiT team, and the final version of the learning objectives of the game concept described in this study were as follows:

- The user will know how a cavity treatment is conducted.
- The user will know the use of the instruments needed for a cavity treatment.
- The user will know how to ease nerves before a dental appointment.
- The user will know what to do to feel more control during a dental treatment.

8.2 Point-and-Click Concept

For the concept, we decided on a point-and-click adventure game. Point-and-click adventure games are primarily defined by their main interaction method of clicking on objects in the game in order to interact with them. They are often story-driven and usually in the form of a role-playing game (RPG), where the player plays as a character and needs to collect objects and solve puzzles to progress through the story (AG Staff, 2020). Point-and-click games also often rely on elaborate aesthetics to create an immersive gaming experience. The point-and-click game type was chosen for several reasons. First, the primary interaction method of clicking would make the game suitable for tablets, which was a requirement. Second, the interaction method made the game accessible and easy to use for children, as tablets have become a commonality at Norwegian primary schools. Third, point-and-click games are well-suited for story-driven games, and fourth, can be quickly developed by using stock illustrations.

8.3 Game Simulation

As Warren and Jones (2017) states, the reality presented in a simulation can differ from absolute reality and still be able to communicate what the player is supposed to learn. The important thing is that the information given in the simulation is correct and sufficient to teach the right skills and knowledge (Susi et al., 2007). Our game was supposed to teach the learning objectives, and the game content, therefore, had to ensure that the information provided to the player was transferable to a real-life cavity treatment situation. The following simulations were included in the concept:

1. *A realistic story*. Like in Liszio and Masuch (2017), the story represents a situation (cavity treatment) that can be anxiety-inducing to some children. It tells accurately how a child can handle anxiety before and during a cavity treatment, the former by talking to a parent or calling the dentist, the latter by using a stop-signal). The narrative was created in collaboration with TBiT professionals to ensure it was realistic and pedagogical. The story centres on a girl, Mari, who is anxious before a cavity treatment.
2. *Authentic instruments and instrument audios*. Realistic and authentic instruments and instrument audios were included, so the children would learn what they look like, how they sound and what they are used for. Liszio and Masuch (2017) also used realistic sounds as a form of exposure in their solution .
3. *Realistic, but simplified cavity procedure*. The cavity procedure used in the game is a simplified

version of a real procedure. The procedure used in the game was reviewed by the TBiT experts to ensure it was still an accurate simulation.

4. *Realistic game environments*. The game environment was represented using cartoon-style 2D graphics. The dental office was a realistic representation, according to the TBiT professionals.
5. *Butterfly metaphor for anxiety*. To convey the concept of anxiety, the metaphor of having “stomach butterflies”, visualised as small butterflies, was used. The TBiT professionals had advised us to avoid negatively connotated words such as "anxiety" and "fear" because they might reinforce existing feelings of dental anxiety in children playing the game or create an unwanted connection between anxiety and dental treatment in children who did not suffer from dental anxiety in the first place. "Stomach butterflies" is not only a metaphor, but also a euphemism, as butterflies are usually considered beautiful to the eye and harmless. One important function of euphemisms is to make difficult feelings or events easier to bear, and we therefore considered the butterfly metaphor especially helpful in the context of our game.

8.4 Game Activities

The game activities included were based on what TBiT considered to have effect as preventive measures against dental anxiety, and relevant findings from the SLR articles. The activities, along with a description and their reason for inclusion, are presented in Table 8.1.

Game Activity	Activity Description	Reason for Inclusion
Preparing Mari for dental treatment through different tasks	The task involves asking Mari's mother to call the dentist and to watch a video of the procedure. Progression through the task is visualised by using the butterflies symbolising Mari's anxiety. They disappear whenever the player makes the correct choice.	A way to teach the player how to prepare for cavity treatment and teach them how to handle related anxiety.
Collecting instruments	The player needs to search for and collect dental instruments in the dental office. When an instrument is found, the player is given information about the instrument and its use.	To get the feeling of exploring and becoming familiar with a dental office, and to repeat the information about the instruments introduced in the video.
Gamification of dental procedure (acting as a dentist)	The player acts as the dentist and has to carry out the procedure, using the instruments in the correct sequence.	To test and enforce what the player remembers about the cavity procedure and the instruments from the previous scenes.
Answering questions during the procedure	During the procedure, the player (dentist) asks Mari (patient) questions about what they are doing and has to answer correctly to avoid Mari getting anxious. The number of butterflies will increase if the answer is wrong, and after the third incorrect answer Mari will give a stop sign which will force the dentist to wait.	Aims to force the player to reflect on the procedure and to show how a stop sign can be used during treatment. The stop sign was included because it is a common technique to teach children with dental anxiety.

Table 8.1: The game activities.

8.5 Elements of Engagement

As described in more detail in Chapter 3, Mildner and Mueller (2016) assessed different models trying to define what game mechanisms provide fun and engagement and found that the elements all models had in common were play, storytelling, rules, aesthetics, learning and social factors. This section describes in what way these elements were included in our concept of a narrative-focused point-and-click game for dental anxiety prevention. (Note that social factors were excluded as it was outside the scope of this study to implement them.)

Play

Freedom to act without rules is essential to play, and one way to grant the player a feeling of freedom in a game is through the opportunity of exploration. Our game was intended to give the children the chance to explore and experience a dental situation in a way they would not be able to otherwise. A second type of play element in our game was role-playing. It forces the player to adopt a role or behaviour. For example, the game allowed the player to act as a dentist by conducting a cavity treatment.

Storytelling

Storytelling has the ability to create engagement, not least because stories stir curiosity to find out the ending. Our concept was centred on the story of a girl who is anxious about receiving a cavity treatment. The game consisted of different scenes that act like chapters in a narrative, and the activity in each scene was tied to that narrative. The activities were meant to add a sense of control over the narrative and thus potentially create increased engagement in it. The game also included a voice-over of dialogue and text to increase immersion in the story.

Rules and Challenges

Rules in a game are related to the challenges. The overall challenge of our game was to complete the story, but each scene contained its own challenge(s) as well. For example, in scene 1, the player needed to calm Mari, the main character. In order to do so, the player had to click around the room to trigger the actions that would calm Mari down. In scene 2, the player was supposed to find all the instruments needed for the procedure. This challenge required clicking around the dental office in order to discover the instruments, which were hidden. The challenge in scene 3 was two-fold: using the instruments in the right order while also correctly answering Mari's questions to the dentist to avoid her becoming too stressed.

Aesthetics

Aesthetics and graphics are an essential part of the gaming experience, and the graphics must be suitable for the target group. As the target group of this game concept was children aged 8–12, it was especially important to find graphics that were not too childish as this might be perceived as condescending, but not so realistic as to detract from a fun experience either. It was also crucial that the different elements in the dental office scenes, like instruments and machines, were representative of actual instruments and machines. The game, therefore, used 2D cartoon graphics.

Learning

Learning can be engaging in itself. As children usually visit the dentist only for yearly check-ups, they have most probably little knowledge of dental equipment and procedures. According to TBiT, many children who receive treatment are curious and are interested in the different dental instruments and tools. It can therefore be assumed that the topics covered in the game were potentially engaging in themselves.

Chapter 9

Iteration 1: Designing and Testing the First Prototype

This chapter describes the first design solution and its evaluation by end-users.

9.1 Prototyping Tool

The first prototype was designed in Figma, a design and prototyping tool used by user experience and user interface designers to develop and test new system designs. The general setup of Figma is to create frames and connect them in a way that simulates the intended navigation within a system. Figma also offers a set of features that allows designers to create visual interactivity and feedback to user navigation, such as adding animation to transitions to simulate feedback from a button click. However, Figma has limits as a tool for game development because interaction with the prototype is limited to click-and-drag actions. Figma also lacks the functionality to save state, which is important when choices made by the player are supposed to affect the course of a game. These limitations make it difficult, though not impossible, to simulate actual use. As the goals of our first testing were to get feedback on the concept and the methods of interaction in the game were clicking and dragging, we still considered a Figma prototype to be suitable. Figma prototypes are also easily distributable and therefore ideal for remote user testing, a requirement because of Covid-19 restrictions.

9.2 Prototype Description

The prototype was a point-and-click style game aimed at instructing players in how to reduce anxiety before a dental appointment and teaching them about cavity treatments and related dental equipment. The game concept comprised three scenes representing three points in the underlying narrative, and the prototype included simplified versions of these three game scenes. In scene 1, the player

had to prepare the game character Mari for her cavity treatment. In scene 2, the player had to help the dentist collect all the instruments he needed for a cavity treatment. In scene 3, the player was to take the place of the dentist to complete a cavity treatment. The scenes are described in more detail below, and an overview of the scenes can be seen in Figure 9.1.

The prototype was designed for being used on an iPad. The background graphics and dental instruments were taken from Adobe Stock, and the characters were created using the Figma plugin Blush [1]. Using stock illustrations reduced the time and resources necessary to create the prototype. The illustrations were chosen based on their perceived entertainment value for the target group and because they provided accurate representations of a living room and a dental office.

1. Introduction to scene 1
2. Scene 1 – The Living Room
3. Scene 2 – Intro to scene 2
4. Scene 2 – The Dentist's Office
5. Scene 3 – The Cavity Treatment Procedure
6. End Screen

Figure 9.1: Overview of game scenes in the prototype.

Scene 1: The Living Room

In scene 1, the player is in Mari's home, in the living room. Present in the scene are Mari herself and her mother. There are also several pieces of furniture and objects placed in the room. A box with information about the player's current task (infobox) is shown in the top left corner of the screen. In Figure 9.2, the red circles indicate the clickable objects in the scene. Three butterflies in the top right corner indicate how anxious Mari is at any moment (more butterflies indicate a higher level of anxiousness). The butterflies disappear one by one for every task that is completed, their disappearance symbolising the decrease of Mari's anxiety as the player progresses through the story. A mobile phone appears behind Mari once she has talked to her mother and they have decided call the dentist to learn more about dental treatment. The scene is completed when all the butterflies are gone.

[1]The illustrations from Adobe Stock had a standard license, while the illustrations from Blush had a free license.

Figure 9.2: Screenshot of scene 1: Mari's living room with clickable elements.

Scene 2: The Dentist's Office

In scene 2, Figure 9.3, Mari is at the dentist's office. At the beginning of the scene, the dentist is missing his syringe. The player has to look through the room to find the syringe. In the scene, the player can find three instruments. Whenever an instrument is found, a pop-up is shown with a picture of the instrument and some information about it. Once the syringe is found, the player is told by the dentist that he is ready for the procedure and that Mari can go to the treatment chair.

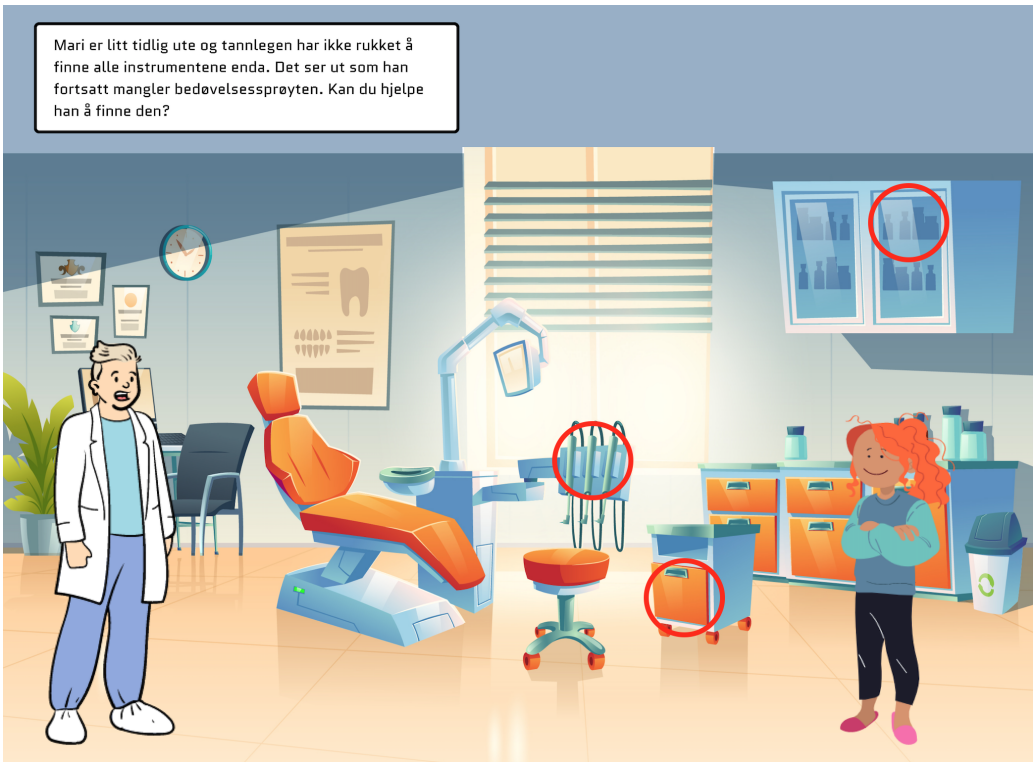


Figure 9.3: Screenshot of scene 2: The dental office with clickable elements.

Scene 3: The Cavity Treatment

In the last scene (see Figure 9.4) the player has to perform the cavity treatment by picking five dentist's instruments in the correct order and dragging them to the cavity. The player may already know three instruments from Scene 2. Two instruments, however, are new to them. If the player applies the correct instrument, the instructions in the infobox will change. If the choice of instrument is incorrect, the instrument will not be possible to drag. Once the player has finished the procedure, the game is completed.

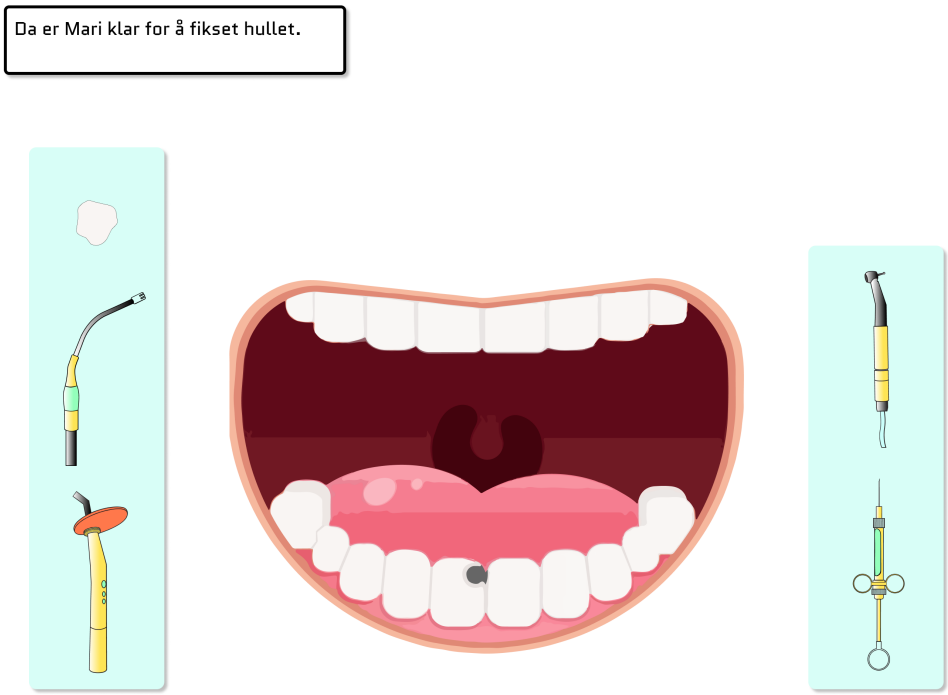


Figure 9.4: Screenshot of scene 3: The cavity procedure.

9.3 User Evaluation

Purpose

The primary purpose of the first user evaluation was to see how concept was received by the target group. We also wanted to uncover any usability issues. Based on these two overall evaluation questions, four evaluation goals were formulated:

1. *Usability*: To evaluate the usability of the game.
2. *Story*: To get feedback on whether the story was easy to understand.
3. *Suitable information*: To test whether the information presented in the game was understandable and acceptable to the users.
4. *Enjoyment*: To get feedback on how enjoyable the game concept.

Participants

The prototype was evaluated by 10 fifth-grade students (aged 10–11) at Sky skole in Larvik, Norway. User testing and evaluation was limited to one school grade because of Covid-19 restrictions, and 5th grade was chosen because this grade represented the middle of our target group in terms of age. Five of the students were boys, five were girls. None of the children suffered from dental anxiety, and none had any problems receiving regular dental treatment. All had been to the dentist before, but none had had any cavity treatments. All were familiar with iPads through schoolwork, and most played games on tablet, smartphone or PlayStation in their spare time. The teachers at the school selected the children based on their perceived maturity, although this was not a specified requirement

for participation from our side. The children's guardians had signed a form of consent in advance. Each participant was assigned an ID using the following format: 1.X. The first number represents the user evaluation round and the second number ("X") indicates each participant's place in the order of evaluation.

Preparation
As a preparation, a pilot test was conducted together with two teachers. Two days before the user evaluations, the teachers received the procedure in writing so they could use the document to explain the procedure to the children and as a checklist during each session.

Procedure and Setup
The user evaluations were conducted from February 1 to February 3, 2021, during school hours. Due to Covid-19 restrictions, the evaluations were conducted remotely using Zoom and Zoom Screen Share. Each session lasted approximately 30 minutes, and there was a teacher present during the sessions. The teacher was responsible for the zoom video call, restarting the prototype between each session, and accessing the questionnaire. The teacher also recorded each participant's interaction with the prototype for later review by the test leaders.

Each evaluation consisted of the following steps:

1. *Introduction*: Brief introduction to the evaluation.
2. *Introductory interview*: Three warm-up questions.
3. *Playing the game*: The participant try the prototype.
4. *Post-test interview*: Follow-up questions.
5. *Questionnaire*: The participant completes an online questionnaire.
6. *Wrap-up*: Information about the next round of evaluations.

The complete interview guide can be found in Appendix C. The first three user evaluations were conducted with an iPad placed horizontally on a stand. During these three sessions, the Figma prototype became increasingly unstable. To ensure we would get relevant feedback from the evaluations, the iPad was exchanged with a PC with a wired mouse for the remaining seven sessions. We considered it more important to get feedback on the game content and the game mechanics than on how the prototype worked specifically on an iPad.

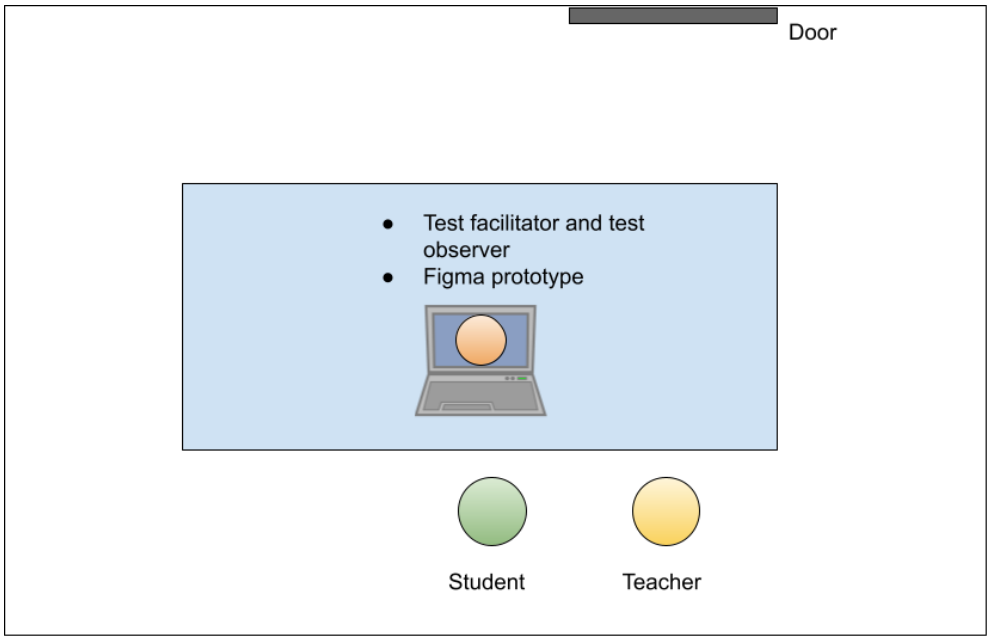


Figure 9.5: The test environment

Evaluation Tasks

Previous work has shown that if one wants to detect usability issues, one should let children play freely when testing a computer game (see Barendregt and Bekker, 2003). Instruction on what the player is meant to do at any time is supposed to be found in the game, and an essential part of the game experience is to figure out what to do and how to solve challenges on one's own. The participants were thus told to play freely.

9.4 Data Collection

Three data gathering methods were employed in this user evaluation: observation for qualitative and quantitative data, semi-structured interview for qualitative data and questionnaire for quantitative data.

Observation

Observation was used to find out how the participants interacted with the game while playing freely, and to uncover possible problematic aspects of the design. We made use of an observation form to evaluate the difficulty of each of the game tasks the player was supposed to solve in order to progress through the game. Each task was rated from 1 to 3:

1 – Task solved without any issues

2 – Task solved, but with some difficulty

3 – Task solved only with great difficulty, or not at all

Other challenges observed were also noted, as well as comments from the participants. The form was filled out during the evaluation session and the notes were later double-checked against the recording of the session. The complete form can be seen in Appendix D.

Semi-Structured Interview
During the introductory interview, the participants were asked about game preferences and about their attitude to dental treatment in general. After playing, a semi-structured interview was conducted in order to gain more in-depth information on how the participants had experienced the game.

Questionnaire
At the end of each session, the participant was asked to fill out an anonymous questionnaire. The first part of the questionnaire was taken from the System Usability Scale (SUS) form to assess the usability of the game. The questions used were taken from a child-adapted SUS questionnaire (Putnam et al., 2020) which we had translated into Norwegian. Three questions from the original SUS were deemed irrelevant to the evaluation and removed from the questionnaire. Research has shown that statements can be removed from the SUS questionnaire without affecting the score as long as the calculation is amended accordingly (Lewis & Sauro, 2017). In addition to the usability questions, the questionnaire included five questions about the children's experience of the game concept. These questions were excluded from the SUS score calculation. The complete questionnaire can be found in Appendix F.

9.5 Results

This section presents the results of the user testing in two parts: (1) the usability of the prototype and (2) the achievement of the defined objectives.

9.5.1 Usability

We reviewed our data from the observation forms, the recordings of the user evaluations, the transcriptions of the interviews and the questionnaires to get an overview of usability issues. The issues were categorised based on similarities, as seen in Table 9.1. Four categories of issues were detected:

1. Uncertainty about what to do
2. Uncertainty about where to click
3. Some trouble reading the in-game text
4. Prototype bugs

Issue	Challenge	Category
1	Participants did not understand what they were supposed to do at the start of scene 1 and answered the question orally instead of exploring the game.	Uncertainty about what to do
2	Participants needed help to understand that they were supposed to look for a mobile.	
3	Participants did not understand that they had to click on the pop-up to read the rest of the introduction.	Uncertainty about where to click
4	Participants did not understand how to advance in the dialogue with the dentist.	
5	Participants had to lean forward to read and mispronounced during reading.	Some trouble reading the in-game text
6	Participants had issues dragging the instruments during the cavity treatment.	Prototype bugs

Table 9.1: Usability issues.

1. Uncertainty about what to do

The first issue observed was that many were uncertain about what to do in scene 1. This task also got a score of 1.5 in the observation form, which makes it the most problematic of all tasks. Four of the children were unsure of what they were supposed to do at the start of scene 1, and instead of exploring the game, they answered the starting question orally. The in-game instruction in the infobox was as follows: "Mari has to go to the dentist, but she is a bit anxious and has butterflies. What can she do to get rid of the butterflies?", Figure 9.6. After the first four user evaluations, we changed the instruction to clarify that the task was meant to be solved within the game. The new instruction was as follows: "Explore the room to find out what Mari can do to get rid of the butterflies." Only one of the remaining six children who participated in the evaluation still answered the question aloud after this change. The fact that the evaluation sessions took place at the school the children were attending, with a teacher sitting next to them, is another possible reason why the children answered the question orally instead of starting to play. Still, it was clear that the in-game instruction was not necessarily intuitive and could be interpreted differently, based on the context of use.

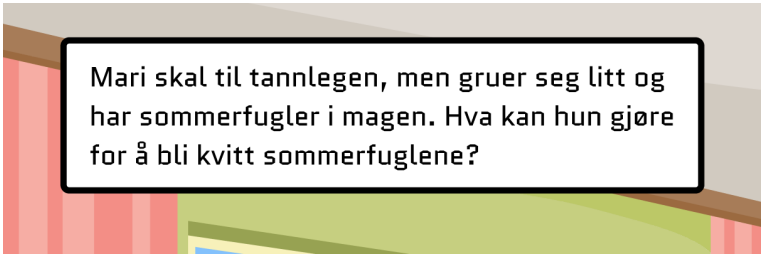


Figure 9.6: Infobox with instruction in the top left corner of the screen.

The results from the questionnaire revealed that the children seemed to find the game a bit confusing at times. The average score of the statement "I was confused many times when I was playing the game" was 2.4, with 5 indicating complete agreement and 1 indicating complete disagreement. Some were also at times a bit unsure of what they were supposed to do. The statement "I always knew what I was supposed to do in the game" got an average score of 3.7 out of 5, with 5 indicating complete agreement.

2. Uncertainty about where to click

At times, the children were uncertain about where to click to proceed. This applied mainly to the introduction pop-up and to the dialogue with the dentist, as shown in Figure 9.7. Six of the children were uncertain about where to click to read the second paragraph of the text in the introduction pop-up. In the first three user evaluations, a bug in Figma showed the entire introduction. It was therefore impossible to know whether these three children would have known how to continue or not. One child mentioned in the interview that he did not understand that he had to click on the screen to continue.

Figure 9.7: Pop-up with the introduction. The first paragraph.

Figure 9.8: Pop-up with the introduction. The second paragraph after clicking anywhere on the pop-up.

The same problem seemed to occur in the dialogue with the dentist, which was designed in the same way. In this scene, the pop-up was placed in the middle, Mari's mother was placed to the left of the pop-up and the dentist to the right. Speech bubbles would appear one at a time until the pop-up was full and then emptied to make space for new speech bubbles. The participants could click anywhere in the pop-up to see the next speech bubble, but there was no visible button or clickable cue to guide them. Seven participants knew where to click this time, but three participants were still unsure what to do. In scene 2, all the participants had learned to click on the pop-up to proceed.

3. Some trouble reading the in-game text

The game included several textboxes and textual information. The participants would read the text aloud during the test, and we could hear that they had difficulties pronouncing certain words or were stumbling across sentences. The teachers who were present in the testing room also commented that many of the children had to lean closer to read.

The children themselves, however, did not seem to consider this very problematic. Regarding the amount of text in the game, one child even said: "There wasn't that much text, and that might be good for those who are not good at reading" (ID1.9).

4. Prototype bugs

Most children had difficulties dragging the instruments when trying to perform the cavity treatment in scene 3. It took time to make the instruments move, and sometimes they would snap back to their original position, which made the children unsure whether or not they had managed to apply them. Apparently this was a bug in Figma which had not been detected during pilot testing of the game.

Other Issues

We also discovered some issues that were not design-related. One such issue was that three children had difficulties using a computer mouse. After pressing down on the mouse, they would drag the mouse off the clickable element and then release, thus invalidating the click. In the interview, one child specifically mentioned that she was not comfortable using a mouse and that she was more used to a touchpad.

9.5.2 Achievement of Objectives

The Story
When questioned after testing the prototype, all the children could retell the story in great detail. They all knew that the story was about going to the dentist and about what happens there. Most of them, though not all, mentioned that the character was a bit anxious to visit the dentist and what one could do to become less anxious.

The participants described the story as "good" or "fun", but none of them said they could personally relate to the story, as they were not afraid of going to the dentist themselves. However, three believed that a friend or a brother might relate more to the story. One tester commented that "it sounded like the text told a real story, that it had actually happened in real life" (ID1.10).

Presentation of Information in the Game
One of the objectives of this user test was to check if the information presented in-game was understandable and suitable for the target group. As mentioned in the previous section on usability, several children struggled with reading some words in the game instructions. More importantly, however, they reported that they did not experience that they struggled. The children seemed to agree that there was a suitable amount of text per page.

All the children either "Agreed" or "Strongly Agreed" with the statement "After having played this game, I now know more about what happens at the dentist's." The same was true for the statement "I have learned something about drilling which I did not know." These results indicate that the children found the key information in the game understandable. The fact that the children were able to retell the story of the game in great detail supports this assumption.

Enjoyment of the Game
Based on the questionnaire, the participants either "Agreed" or "Strongly Agreed" with the statement "This was a fun way to learn more about the dentist." Throughout the user evaluation sessions, we also observed that the children would laugh spontaneously or utter exclamations. This observation seems to support the answers given by the children.

There were especially two features that seemed to contribute notably to the enjoyment of the game: exploring the rooms and learning about the instruments. The children reported they enjoyed looking for objects and learning more about what the instruments are used for. When questioned about what would make the game more fun to play, most of them had no suggestions. One of the children, however, wanted tasks that would allow the player to move around more in the different scenes.

One user also stated: "The times I've been to the dentist, I've always received a toy. Therefore, I would like to have a look inside the toy drawer first" (ID1.8). Another user shared: "Maybe taking pictures of the teeth or something, and then they have forgotten to plug in the machine, and you have to find the plug or something" (ID1.10). Many mentioned that they found the instruments interesting and would like to learn more about them.

For some children, the game seemed to be too easy, which possibly detracted from the overall game experience. Five children mentioned that they didn't find the game particularly difficult. One said that "there wasn't much that was difficult" (ID1.2) and another thought the difficulty level was intended for younger children (ID1.10). Another mentioned that the instructions gave too much information, which made the game too easy (ID1.5).

9.5.3 Summary

Despite the usability issues, we assessed the overall usability to be acceptable. The results from the observation form show that the participants had little to no trouble to complete most tasks in the game. Most of the tasks had an average score between 1.0 ("The task was solved without any difficulties") and 1.2. The SUS score from the questionnaire was 73 (out of 100)[1], which is above average and is deemed as "Good". It should be noted that this score is not directly transferable to other systems because of the changes made to the SUS questionnaire, as described in Section 9.4. This score is mainly intended to give an idea about the usability of the game and to measure potential differences between the two iterations in this study. Although usability was satisfying, there was still room for improvement.

All the children had understood the main points of the story, and they seemed to enjoy the game concept. Two factors particularly contributing to their enjoyment were the possibility of exploring the rooms and learning about the instruments. For a few participants, a factor detracting from the game's overall enjoyment was that they found it a bit too easy.

[1]Only the questions regarding system usability in the questionnaire were included in the calculation. To account for the removal of three questions from the original SUS questionnaire, the multiplying factor in the standard SUS formula was adjusted from 2.5 to 100/28 (approx. 3.5). This adjustment followed the one suggested in Lewis and Sauro (2017).

Chapter 10

Iteration 2: Designing and Testing the Functional Prototype

This chapter describes the second design solution and its evaluation by end-users. As part of this iteration, the usability issues discovered during the first round of user testing were addressed. In addition, new features were added to further develop the design.

10.1 Prototyping Tools

Unity

Unity is a well-established game development engine used to develop both 2D and 3D games. Unity also makes it simple to create games for iPad, and it easily deploys the game to TestFlight. The functional prototype was built using the Unity game engine.

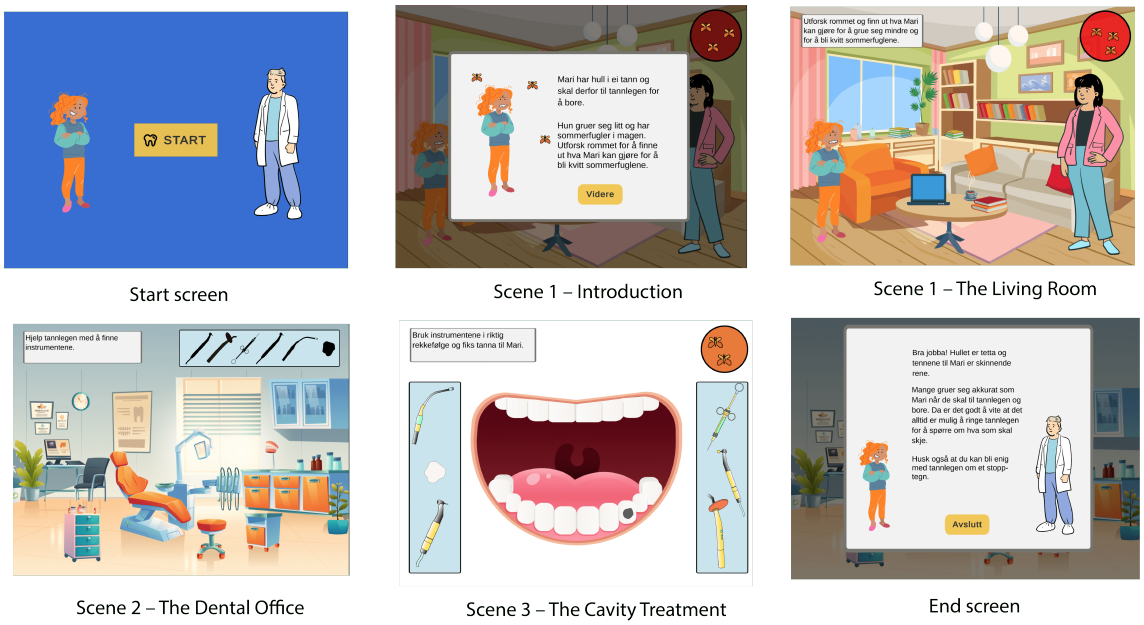
TestFlight

TestFlight is an online service offered by Apple to carry out user testing on applications on iOS devices. The application to be tested can be distributed to any device with the TestFlight app installed, and TestFlight allows for immediate updates to new releases. TestFlight was used to distribute the game to the participants.

10.2 Prototype Description

In the second prototype, the usability issues detected in iteration 1 were addressed, and new features were added to the game scenes. In addition, a start scene and an end scene were added to offer a more complete game and story experience. An overview of the game scenes can be seen in Figure

10.1.



Start screen | Scene 1 – Introduction | Scene 1 – The Living Room

Scene 2 – The Dental Office | Scene 3 – The Cavity Treatment | End screen

Figure 10.1: Overview of the game scenes in the functional prototype.

10.2.1 Usability Improvements Based on Results from Iteration 1

The following improvements on the design were made, based on the usability issues described in Table 9.1:

- *Issue 1*: Insufficient start instructions. This issue was already resolved during the previous user evaluation by reformulating the task description in the infobox in scene 1.
- *Issue 2*: The in-game instruction was reformulated to clarify that the children needed to look for a mobile phone.
- *Issue 3 and 4*: A button was added to the scene introductions and to the dialogue with the dentist to make sure the children understood how to proceed with the game.
- *Issue 5*: The font size was increased to make the in-game text easier to read.
- *Issue 6*: As the second prototype was made with proper game development software, it was expected that drag functionality would be greatly improved.

10.2.2 New Features

Some features that had been excluded from the first prototype because they were not essential to the evaluation goals, were now included into the functional prototype, such as game sound, a video animation on how cavities in teeth are repaired, better feedback and gameplay. It was expected that these features would improve the general usability of the game.

Scene 1: The Living Room

Feature: A video animation of a cavity procedure was added. The video describes a cavity procedure and is meant to teach the player how a cavity treatment is conducted and how the instruments are used. The cavity procedure in scene 3 was a simplified version of this procedure. The video was provided by TBiT. A screenshot of the video can be seen in Figure 10.2.

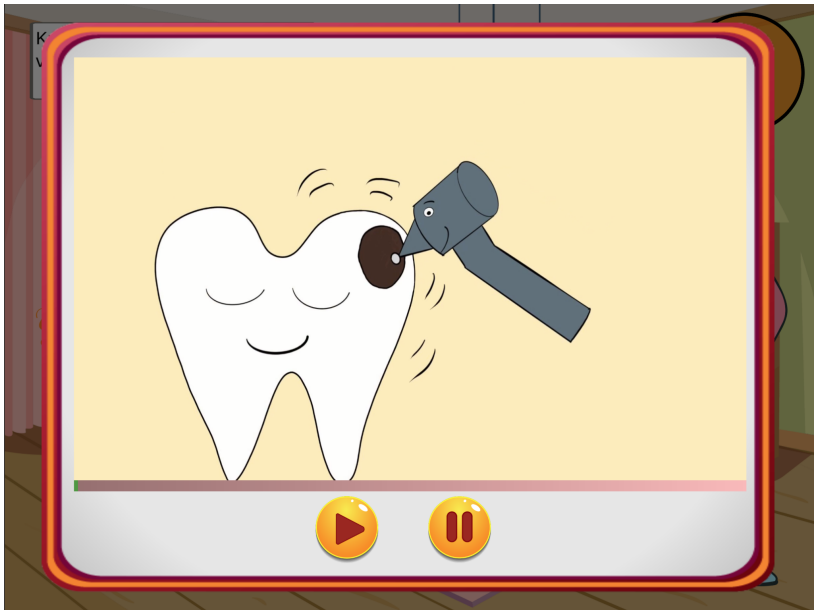


Figure 10.2: Screenshot of the cavity procedure video.

Scene 2: The Dentist's Office

Feature: The number of instruments to be collected was increased, and a panel to show the collected instruments was added. The instruments were presented in the video, and all except one were also used in the cavity procedure in scene 3 (Figure 10.3).

Feature: Dental instruments not needed for the cavity procedure itself were added to increase the experience of learning and exploring the room. These instruments did not have to be collected, but they too included descriptions, just like the other instruments.

Feature: More office elements were made clickable to make the office more explorable: clickable bin, computer, and cupboards (Figure 10.3).

Feature: Voice-overs of the instrument descriptions and audio recordings of the instruments were added (Figure 10.4).

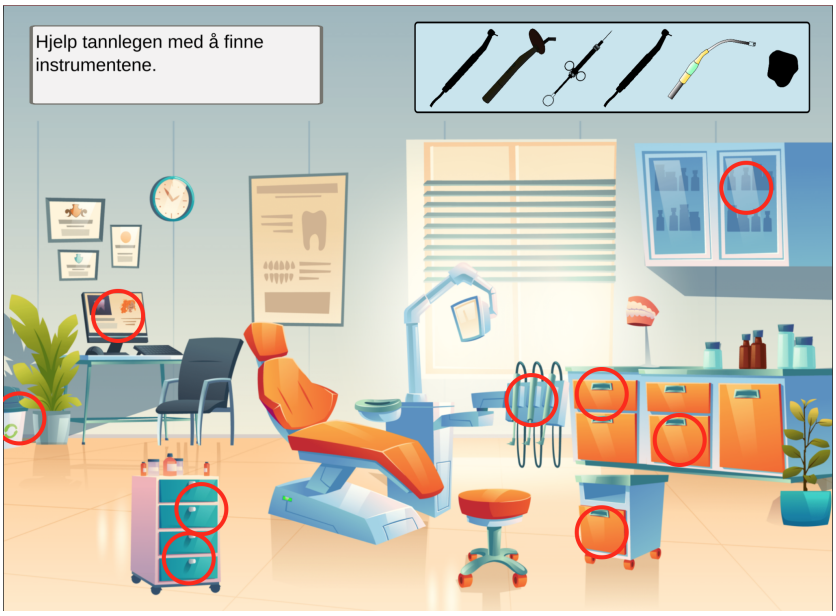


Figure 10.3: The dentist's office: The clickable elements in the second prototype.

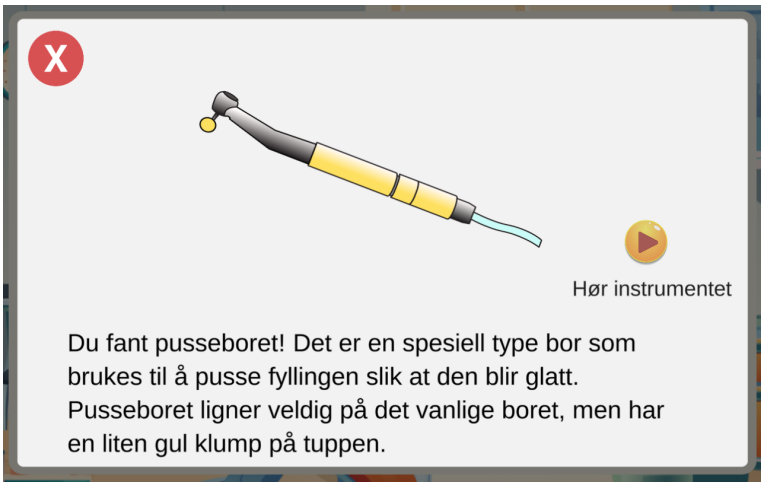


Figure 10.4: Instrument description with audio and voice-over.

Scene 3: The Cavity Procedure

Feature: More instruments were added to the procedure to reflect the cavity procedure presented in the video (Figure 10.5).

Feature: Authentic instrument sounds were added to the game, both to enhance the game feeling and to make the game experience more realistic. According to experts from TBiT, including exposure elements such as real-life sounds may have a preventive effect even in a target group that does not suffer from dental anxiety or phobia.

Feature: Multiple-choice questions that pop up during the cavity procedure were added. The questions, such as "What are you going to do now?", are "asked" by Mari, and the player, acting as the dentist in the scene, answers them (Figure 10.6).

Feature: A stop signal was added. Its function was to appear if too many questions were answered incorrectly. Every wrong answer would increase the number of butterflies representing Mari's anxiety by one. If the number of butterflies reached three, the stop-sign would appear and force the player to wait for five seconds before s/he could continue with the procedure (Figure 10.7).

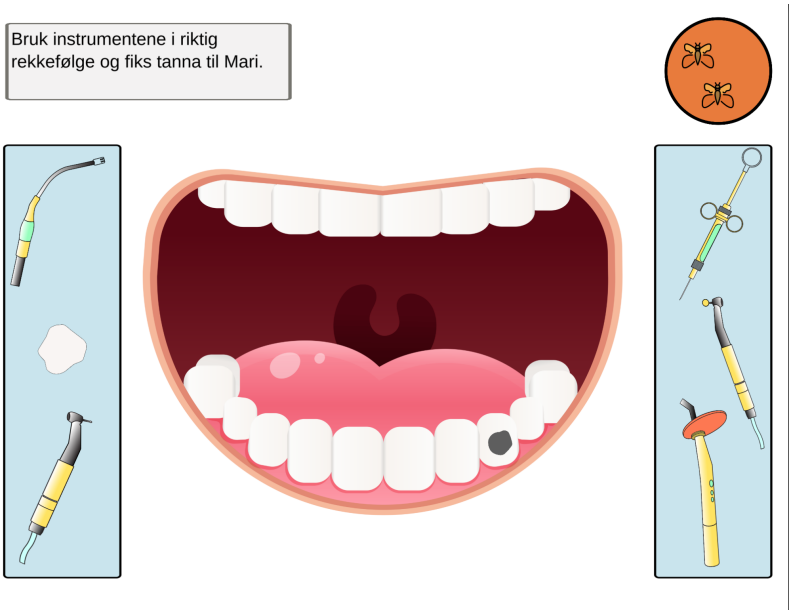


Figure 10.5: The instruments, and the butterflies to indicate the level of anxiety.

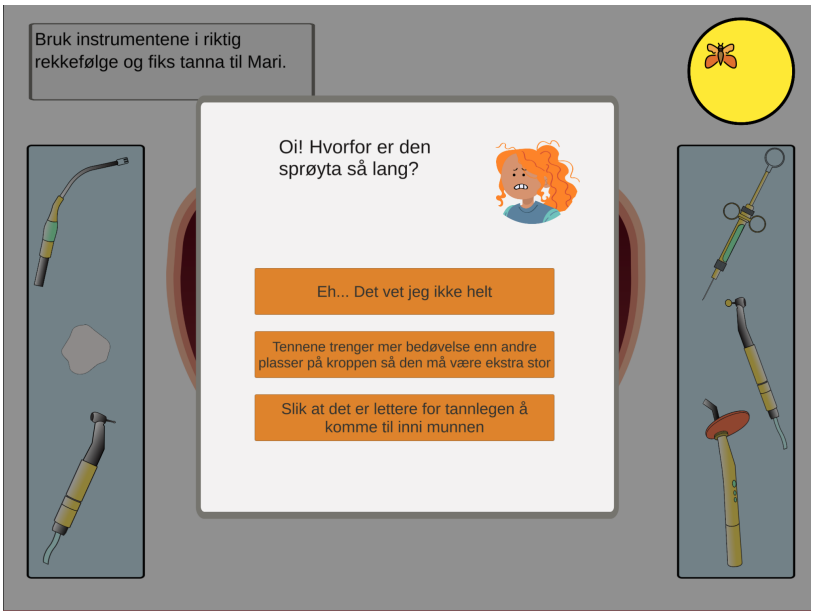


Figure 10.6: A multiple choice question.

Figure 10.7: The stop signal.

10.3 User Evaluation

Purpose

The aim of the second user evaluation was to assess whether the users achieved the learning objectives, and how the children perceived the elements of engagement. The learning objectives were as follows:

- The user will know how a cavity treatment is conducted.
- The user will know what some of the instruments at the dentist's office are used for.
- The user will know how to ease nerves before a dental appointment.
- The user will know what to do to feel more in control during a dental treatment.

Test Participants

The second prototype was also evaluated by school children from Sky skole in Larvik. This time the prototype was evaluated by 16 children in 5th grade (aged 10–11). Out of these, nine had participated in the first round as well. None of the participants in evaluation round two suffered from dental anxiety, and none had problems with going to the dentist. Each participant was given an ID in the following format: 2.X, the first number indicating the second round of testing and the second number ("X") the participant's order in the user testing.

Preparation

TestFlight was used to install the prototype on the iPad used by all the participants. The entire procedure and setup were tested in a pilot test with the teachers.

Procedure and Setup

The evaluation sessions were conducted in a meeting room at the school on 18, 19 and 22 March, 2021. The iPad with the prototype was placed upright on a table by means of a small stand. The child would sit at the table, and a teacher would sit a bit further back in the room during testing. During the session, the teacher would record the iPad screen and the child's hands as the child interacted with the prototype. Zoom with video enabled was used by the test leaders to communicate with the teacher and the child.

Before starting the game, the participants shared their screen, making it possible for the testers to see how they navigated through the game. Both audio and video were recorded in Zoom from the moment the children shared their screen and to the end of the session.

Each test lasted approximately 30–40 minutes and consisted of most of the same steps as the previous user testing:

- *Introduction*: Warm-up questions for new participants.
- *Evaluation*: Playtesting the prototype.
- *Follow-up questions*: Semi-structured interview about the user experience.
- *Questionnaire*: Online questionnaire to be completed without aid.
- *Wrap-up*: Thanking the child for participating and asking for concluding remarks.

10.4 Data Collection

The same data collection methods as in iteration 1 were used: observation, semi-structured interview, and a questionnaire. The observation form and the questionnaire were slightly altered to account for the new features in the game. Questions were added to the interview to account for changes in the prototype and to assess whether the learning objectives of the game had been achieved. Both the observation form and the questionnaire used can be found in Appendices E and G.

10.5 Results

This section briefly summarises the usability results and the results pertaining to the learning objectives and the elements of engagement of the serious game concept.

10.5.1 Usability

Judging by the SUS score, the level of usability improved from a score of 73 to a score of 83. This score equals a rating of "Excellent" and indicates that usability has improved from the previous iteration.

Furthermore, most of the game tasks were carried out without any significant issues. The testers did observe that some of the participants struggled with selecting the correct instruments during the cavity treatment; however, this was not deemed a usability issue but rather a game challenge.

10.5.2 Learning Objectives

This section presents the combined results from interviews, observation notes and questionnaire pertaining to the learning objectives.

Learning Objective 1: The user will know how a cavity treatment is conducted

When playing the game, nearly all the children had some difficulties with the correct order of the instruments. However, during the interview, eight children could recount the procedure correctly and the rest could recount it with only a few errors. Seven children forgot one or two instruments, but still remembered the correct sequence. One forgot three instruments, but had the correct sequence. Most of the children recounted the sequence as it was demonstrated in the play treatment, but many also remembered details only given in the cavity treatment video in scene 1. For example, eight of the children mentioned removing bacteria, and two mentioned glue. One child also remembered that the syringe is meant as a "sleeping medicine" (ID2.11), which was a term only used in the video.

In the questionnaire, the statement "After having played this game, I can explain to a friend how the dentist conducts a cavity treatment" got an average score of 4.2 out of 5, which shows some uncertainty, but is overall a satisfactory score. The children also stated that they knew more about what happens at the dentist after playing the game (avg. 4.6). This was also reflected in the answers to the interview question "Do you feel that you have learned something that you didn't know before?" All children stated that they had learned something, and many specified that they had learned about the cavity treatment. One child mentioned that before playing the game "I didn't even know what they did. I didn't know about the water and that they polish it (the tooth)" (ID2.16). Another also mentioned that s/he had no idea about the procedure before ("I thought they only drilled and put in some white stuff and that was it" (ID2.12)). Another mentioned, "I've learned that they remove bacteria. I didn't know that" (ID2.15). Many mentioned that they had learned the correct sequence of the treatment ("The sequence and what the dentist is going to do" (ID2.4)).

Learning Objective 2: The user will know the use of the instruments needed for a cavity treatment

In the interview, the participants were shown pictures of three instruments (the dental curing light, the polishing drill and the water suction device) and asked if they remembered the names of the instruments and what they were used for. These instruments were selected because they were expected to be the least familiar ones to the children. Syringe and drill were omitted as we considered these two instruments to be generally known.

When recounting how a dental treatment is conducted, many remembered what the instruments did,

but were uncertain about their names. 13 out of 16 participants remembered various aspects of the dental curing light. Most remembered what it was used for, but not the proper name ("It makes that thing you put on your tooth firm" (ID2.1), "An instrument that showed a blue light. Don't remember the name. To dry things." (ID2.12), "I don't remember the name, but it dried the filling" (ID2.4)). One child even remembered the actual name ("Herdelys! That's a doctor name" (ID2.9)).

When asked about the "water suction instrument", nine out of 15 remembered what it was used for (one participant had to leave the session midway), four remembered it had something to do with water, and two did not remember using it. Finally, 11 out of 15 participants remembered what the last instrument (the polishing drill) was used for. When describing the instruments, many seemed to remember how the instrument had been used in the play treatment in scene 3 ("Is that what they used at the end?" (ID2.2), "It made it dry quickly after you had added the cotton thing" (ID2.12)). One possible reason for this might be that the pictures of the instruments the participants were shown were identical to the ones used in the play treatment scene. However, two participants also mentioned information that had been only presented in the video ("In the video they talked about one [instrument] that sucks up mucus" (ID2.1), "I don't remember what it's called. Tooth dryer, or something like that" (ID2.8).

The statement "I know more about the instruments the dentist uses now than what I did previously" got an average score of 4.6 (where five indicates "I agree completely"), which suggests that most children felt they actually did know more about the instruments after playing the game than they had done before, even if they did not always remember the names of the instruments. One participant mentioned, "I only thought they used sedation and drill" (ID2.10). Another said, "(I didn't know) that there was something to polish, or that thing that makes it hard" (ID2.14). A third commented, "I wouldn't have known any of this if I hadn't played the game" (ID2.16).

Learning Objective 3: The user will know how to calm nerves before a dental appointment

In the interview, the participants were asked what kind of advice they would give a friend who was scared to go to the dentist. 11 mentioned advice that is presented explicitly in the game: Eight suggested that their friend should talk to the dentist to find out more about the treatment ("Talk to the dentist, or ask your mom to do it" (ID2.8)), and three suggested the use of a stop sign ("[...] and then give a stop sign to the dentist if you want him to stop" (ID2.8). In addition, three participants gave advice deduced from information gained in the game, naming sedation as a reason not to be scared ("you will be sedated and then it won't hurt" (ID2.7)). One participant was unable to mention any advice.

Learning Objective 4: The user will know what to do to feel more in control during dental treatment

When asked about methods for handling anxiety during dental treatment, only one participant mentioned two methods: The possibility of asking the dentist for information if one is getting anxious during treatment, and the possibility of asking him or her to stop treatment. Seven participants mentioned only the possibility of asking the dentist to stop, three mentioned only asking the dent-

ist questions during treatment (“Maybe ask ‘what are you doing now?’ or ‘why’, to be less scared” (ID2.15), “One can ask what they are doing” (ID2.7)).

One participant suggested more generally that it might help to think of what the dentist had explained in the conversation with Mari’s mother in scene 1 of the game. One participant expressed uncertainty, one mentioned closing one’s eyes and one suggested holding hands. In total, 11 out of 15 remembered at least one of the specific strategies presented in the game.

10.5.3 Elements of Engagement

The recordings, interview transcriptions and questionnaire were reviewed to identify how the participants perceived the different elements of engagement. This section also includes relevant results from the first iteration, since the two iterations partly focused on different aspects of the game concept.

Play

When testing the game, several children clicked on many of the elements in the room while looking for the instruments, such as the bin and the computer. In the interviews seven children mentioned specifically that it was fun to look for objects in the dental office, and three children stated that they would like to be able to move around even more in the office. Nine of the children mentioned they enjoyed conducting the cavity treatment. Their enjoyment of this part of the game may possibly be ascribed not only to the game mechanics, but also to the additional element of role play that allowed the children to act as the dentist and be in charge of the situation.

Storytelling

Three children described the story as fun. One participant thought the story sounded authentic ("like a real story"), and he liked how it was written. A few seemed to find specific dialogue parts funny, such as the option of asking the mother for a dog. Two of the children thought it fun that the dentist had forgotten the instruments, and they liked to be able to read books. Two laughed at the name of the dentist’s office, “Null Hull Tannlegekontor” (Zero Cavity Dental Clinic). Overall, we observed that many seemed to engage with the story while playing, commenting on tasks and actions: “Does she have to find it?” (ID2.5) when the mother has to find the phone, “Is she getting a sedation first?” (ID2.3) and “It was strange that the phone was behind the pillow. She could have had it in her pocket” (ID2.16), “Eeh, where is the dentist?” (ID2.1) in the dentist’s office.

All children could retell large parts of the story, which indicates that it was memorable, even though none of the children had experienced similar problems as the main character in the story before.

Challenges

The children seemed to enjoy different aspects of the game. Five specifically mentioned that they liked the challenge of having to find objects (“It is fun to have to find things myself” (ID2.7)). Six

also explicitly mentioned that they enjoyed the cavity procedure, even though no child knew the correct sequence of all the instruments during the procedure ("Oh my god! I completely forgot the sequence" (ID2.12). Two specifically mentioned that they enjoyed the multiple-choice questions that appeared during the cavity procedure because they forced them to pay attention. Another child especially enjoyed getting the correct answer and exclaimed "Yes!" (ID2.3) when he answered the first question correctly.

Opinions were differing as to the degree of challenge in the game. Five children did not find the game particularly difficult ("I don't think many will think this is difficult" (ID2.3)). One of them also mentioned that he thought it would be difficult for younger children (ID2.9). Two children estimated the difficulty level as suitable ("It can't be too easy either" (ID2.16)). Seven children commented that it was challenging to find the instruments, but we also observed that this difficulty did not seem to detract from their engagement, on the contrary: The children seemed to become extra engaged when they faced some struggles looking for the instruments, making comments such as "Where could it be?" (ID1.2) and "I thought it would be in the cupboard!" (ID1.6), and exclaiming "Ah!" (ID1.8) when finding the correct instrument. Two children reported that despite some difficulty finding the instruments, they liked that they had to work for the result ("I think it is better to have to look around a bit than to find everything immediately" (ID2.2). Commenting on the game in general, one stated: "It was difficult, but I thought that was good because then you had to pay attention" (ID2.1). Two children also remarked that they would have liked the game to be longer and suggested that the game should include more tasks.

Aesthetics

Most of the children did not comment on the graphics, but one mentioned that he thought they "fit him" and that he had read books and schoolbooks with similar drawings (ID1.10). Two children pointed out that they liked that the instruments looked real ("The pictures [of the instruments] are practically the real thing" (ID2.15), and that they enjoyed the animations and cartoons in the video. One child, however, characterised one of the instruments as a bit scary-looking because of its "pinprick" eyes.

Learning

Our impression from observing the participants play was that many enjoyed learning about the instruments and the cavity procedure. Six children reported they enjoyed learning about the instruments, and four of them mentioned explicitly that they would like to know even more about them. When asked about what they would like to see more of in the game, two answered they would like to explore the dental office in more detail. Learning about dental treatments and instruments might be especially interesting. It should be mentioned that none of the children participating in the evaluations had had a cavity treatment before, and most of them had not been to the dentist for a year or more, a fact that may have added to their interest in activities at a dentist office.

Overall, the participants seemed to enjoy the game. After playing, seven participants explicitly said they thought it was "fun", "good", or "nice". The results from questionnaire supported these com-

ments, as the statement: “I thought this was a fun way to learn about the dentist” got an average score of 4.8 out of 5 (5 being “Strongly Agree”).

10.6 Evaluation of Requirements

A vital step of the evaluation in a user-centred design approach is to assess whether the prototype met the specified requirements. Based on the data collected, this section evaluates whether the requirements derived from the preliminary study and the learning objectives for the game were met.

10.6.1 Requirements

Requirement	Satisfied
The serious game must provide information about TBiT concepts that the TBiT team believes can have preventive effects (e.g. information on dental treatment(s), stop signal).	Yes
The serious game should not require involvement from professionals.	Yes
The serious game must present information suitable for children aged 8–12.	Partly
The serious game must be engaging.	Yes
The serious game must be playable on an iPad.	Yes

Table 10.1: Evaluation of requirements.

Requirement 1: The serious game must provide information about TBiT concepts that the TBiT team believes can have preventive effects (e.g. information on dental treatment(s), stop-signal).
The prototype contains information about how one can handle anxiety both before going to the dentist and during one’s visit. It also contains information about the drilling procedure and the different instruments used in this procedure. The underlying story in the game and all the related details were assumed by TBiT to have a potentially preventive effect on dental anxiety in children. This requirement is therefore met.

Requirement 2: The serious game should not require involvement from professionals.
The game was designed in such a way that no professional involvement is needed. Furthermore, the children were confident that they could play the game without any adult help or supervision. The statement "I would need help from an adult to continue to play the game" received an average rating of 1.4, 1 being Strongly Disagree. The children were also able to complete the game by themselves during the user evaluations where there were no professionals present. This requirement is therefore met.

Requirement 3: The serious game must present information suitable for children aged 8–12.

The information presented appeared suitable for the participants. However, all our test participants were aged 10–11, and since not all ages of our chosen target group were represented in the testing, it is not possible to draw a general conclusion on the age suitability of the game for ages 8–12. This requirement is therefore only partly met.

Requirement 4: The serious game must be engaging.
As our observations and interviews show, the children seemed to enjoy the game and were engaged with the story and the game challenges. Furthermore, the results from the questionnaire indicate that the participants in the second round considered the game a fun way to learn about the dentist. The fact that some of the participants suggested the game should be extended and the level of challenge increased, may therefore reasonably be interpreted as a wish to prolong an already engaging gaming experience. This requirement is therefore considered to be satisfied.

Requirement 5: The serious game must be playable on an iPad.
All 16 participants tested the prototype on an iPad, without experiencing any bugs. This requirement is therefore also met.

10.6.2 Learning Objectives

A serious game has clearly defined learning objectives which the user is meant to achieve by playing the game. The game concept was based on four learning objectives, each defining specific knowledge or skills. For a more comprehensive evaluation of whether the participants in the user evaluations had acquired these objectives, the results from the second user evaluation were combined with relevant results from the first user evaluation presented in Section 9.5.

Requirement	Satisfied
The user will know how a cavity treatment is conducted.	Yes
The user will know what different instruments at the dentist's office are used for.	Partly
The user will know how to ease nerves before a dental appointment.	Partly
The user will know what to do to feel more in control during a dental treatment.	Partly

Table 10.2: Evaluation of learning objectives.

Objective 1: The user will know how a cavity treatment is conducted
All the children who had participated in the evaluation were able to retell how the procedure was performed. Eight of the participants remembered the procedure completely correctly, the remaining seven with minor errors. This learning outcome indicates that the game facilitates the achievement of objective 1 satisfactorily.

Objective 2: The user will know the use of the instruments needed for a cavity treatment
All children remembered the use of at least one instrument that is needed for a cavity treatment,

four remembered the use of all three. Still, the number of children remembering all the instruments is low, and the achievement of objective 2 must therefore be considered as partly met.

Objective 3: The user will know how to ease nerves before a dental appointment
Eleven of the participating children were able to mention a calming strategy that had been presented directly in the game. Three others suggested a calming strategy not presented explicitly in the game, yet most likely based on information gained by playing it (the possibility of using sedation). In other words, 14 out of 15 participants had acquired a strategy how to calm down before a dental appointment. We therefore consider this learning objective partly achieved.

Objective 4: The user will know how to get more control during a dental treatment
11 out of 15 participants were able to name a specific strategy suggested in the game (stop sign or asking the dentist what is happening) that they could use if getting anxious during a dental treatment. One child referred more generally to information provided in the phone call to the dentist in scene 1 of the game, whereas three children did not mention or recall any of the strategies suggested. Based on these results, we consider objective 4 to be only partly achieved.

10.6.3 Summary

Requirements

Five out of six requirements are considered satisfied, whereas the final requirement is only partly satisfied because the participants in the evaluation did not represent the complete age-range of our target group (ages 8–12), only ages 10–11. The prototype should also be evaluated by both younger and older children in order to assert whether this requirement is met.

Learning Objectives

As the results show, most of the learning objectives were only partly met. Ideally, every child should achieve the learning objectives of the game. However, because the children only played the game once, it is not realistic to assume that they would be able to remember everything. Some of the information in the game, like the names of the instruments, would most likely require further repetition to remember properly, as is common when learning new terms. However, all the children had acquired at least some new knowledge from the game. Furthermore, the number of children who remembered specifics, such as the uses of instruments, the course of the dental procedure, the stop-signal and treatment preparation methods, can still be considered as comparatively high. These results show that the current game concept is already useful and has the potential to facilitate the desired learning outcomes.

Chapter 11

Discussion

This chapter first discusses the learning effectiveness of the game, then how the functional prototype can fit into the TBiT treatment. The third section considers the children's experience of the serious game and reflects upon the different elements of engagement. The last section discusses in which ways the digital solution presented in this work can be considered a novel approach to the prevention of dental anxiety.

11.1 Learning Effectiveness of the Game

The learning objectives of the game were directly tied to the core information presented in the game, which included (1) the course of a cavity procedure, (2) the names and uses of five dental instruments used in the procedure and (3) three strategies how to avoid developing anxiety before and during a dental treatment: (a) talking to a parent, (b) seeking information about the treatment, e.g. by calling the dentist, and (c) agreeing on a stop sign with the dentist so that the treatment can be paused or stopped if the patient starts feeling anxious. The results from the evaluation sessions show that some of the information presented in the game was remembered better than other. When asked in the interview, for example, all test participants were able to tell the course of the cavity procedure more or less correctly. Most of them remembered what the different instruments were used for during the treatment, but they did not remember the names of these instruments. Also, the calming strategy of using a stop sign was remembered by more participants than talking to a parent or seeking information beforehand. This raises the question of what may be the reasons for these differences.

The Cavity Procedure

The cavity procedure was first demonstrated in an animated video in scene 1. In scene 2, the participants had to look for dental instruments in the dentist's office and were thus reminded of the instruments used in the procedure. Still, they struggled with the correct sequence of instruments where they were asked to take the role of the dentist and perform the cavity procedure themselves

in scene 3 of the game. When interviewed after playing, however, they could retell the entire course of the dental procedure, either completely correctly or with only a few errors. It is therefore not unreasonable to assume that the participants may have benefited more from actively trying out their knowledge in a simulated "real life" situation than from merely watching a video showing the same procedure and situation, or from looking for and finding instruments.

The Instruments

The five dental instruments used in a cavity procedure were part of all three scenes in the game. In the animated video of the procedure in scene 1 and in the pop-ups in scene 2 both the name of the instruments and their use was explained. In scene 3, when acting as a dentist, the participants only had to remember how the instruments were used. The reason why the participants had difficulties remembering the names of the instruments, is probably twofold: Firstly, three of the instruments had been unknown to the participants before they played the game, and secondly, the the participants did not need to know the names of the instruments to use them actively in the game and to complete the game successfully. Knowing the name of these instruments makes it easier to refer to them outside the game context. Therefore, adding activities that support learning the names of the instruments might be a relevant option for a further development of the game.

The Calming Strategies

All three calming strategies we wanted the users to remember were introduced in scene 1 of the game. Two of them were mentioned explicitly by the dentist when Mari's mother called to ask for advice, namely learning more about the dental procedure and using a stop sign. The third strategy, asking an adult, was presented implicitly in the opening of the story: Having been informed that Mari was nervous because of her upcoming dental treatment, the users had to reflect on several options of what she could do to find help. The correct choice of option was asking her mother.

A strategy we especially intended the participants to learn, was agreeing on a stop sign with the dentist. The stop sign was therefore also included in scene 3. When acting as the dentist and performing a cavity treatment on Mari, the users had to answer questions from Mari, and the stop sign would pop up if too many questions were answered incorrectly. However, the participants answered most of the questions correctly, so none of them encountered the stop sign again in the cavity procedure. Therefore all three strategies were spoken of or used only once in the game. When asked in the interview following the game, eight of the participants mentioned the stop sign as a possible strategy, whereas talking to a parent and learning more about the dental procedure were mentioned by only a few. This difference may possibly be explained by the fact that agreeing on a stop sign may be an especially appealing strategy to a child since it gives an instant feeling of being in charge of the situation. Still, we were not completely satisfied with the learning outcomes shown by the participants, but we assume that explicit presentation, repetition of information and active use of the provided information in game activities could contribute to a better learning outcome.

General reflections

The fact that three out of four learning objectives were only partly achieved by the participants indicates that the information given in the game was not repeated often enough to help the player remember properly. Probably, the children would need to replay the game to gain enough repetition for learning; however, game replayability was not considered during the game designing process, and the current concept therefore does not offer alternative ways of playing the game. Playing the game one more time would therefore not be challenging, as the story and challenges would be identical and now easy to solve, making the game less engaging. Further development should therefore also consider adding further game elements to increase replayability, such as alternative story lines which can lead to different endings, or a score system.

11.2 Professionals' View on Utilising Interactive Technology for the Prevention of Dental Anxiety

From the interviews and workshop with the TBiT professionals, it was clear that there were many possibilities for how interactive solutions could support the work of TBiT. Our analysis of the data gathered from interviews and workshop revealed three ways an interactive solution could be helpful to the service: (1) different ways of information dissemination (2), interactivity for entertainment and motivation, and (3) low threshold solutions for those on the waiting list. From the analysis, it was also clear that it would be challenging to create an interactive solution that would replicate the entire treatment plan offered by TBiT, especially traditional exposure therapy.

Feedback from the professionals on both the concept and the prototype was positive. Commenting on the concept description, they noted that a serious game fulfilling the proposed learning objectives could be used in numerous ways. From their feedback on the functional prototype, we summarised three ways the TBiT professionals considered the prototype has the potential to work within the context of TBiT and one way the game can be used by dental practitioners with possible preventive effect:

(1) The game could be a low-threshold tool they could send to children on the waiting list who have been referred to treatment inaccurately.

As revealed in the preliminary study, the experts at TBiT believe that some of the children on the waiting list do not have severe dental anxiety and that a low-threshold informative solution would be sufficient. The functional prototype could be one such solution as it can be easily downloaded on an iPad and does not involve the involvement of psychologists to play and learn.

(2) As a way to prepare for a cavity treatment to prevent the child from developing dental anxiety.

One psychologist commented that children could use it to prepare for dental treatments to help them feel more in control during the treatment. She added that they believed it would have preventive value "[. . .] because it gives information and potentially an increased feeling of control in the dental

situation. That they (the children) know what's going to happen" (ID-A). Another commented that because the dental situation is unfamiliar to many children, there is a possibility that knowing more about the instruments can make them feel safer and feel comfortable enough to ask questions and explore the situation. The dental hygienist commented that "I think it would be a good idea to give an introduction early, because it is a lot of information the child needs to digest" (ID-B). In contrast, another TBiT representative commented that she believed the game could be used as preparation right before treatment, e.g. in the waiting room. Data from the user evaluation was gathered right after playing, which makes it difficult to ascertain how much the children would remember after two weeks since playing. The results from the achievement of the learning objectives can indicate that the game would be best suited for play closer to the time of treatment.

(3) The game could be a part of a larger toolbox for dental health information and dental anxiety prevention.

As mentioned in the introduction of TBiT, a part of T-TBiT's vision is to create a digital "toolbox" for children, parents and professionals which can contribute to the prevention of dental anxiety. The toolbox is meant to include tools for self-help that can be accessible to the public. The current prototype has limits in this regard, as it only focuses on one aspect of dental treatment: cavity treatments and related anxiety. As the anxiety-inducing elements can be different from person to person, where some react specifically to syringes and others more to the anticipation of pain, the current prototype might not have a preventive effect for all children. Still, the concept can be replicated to include other aspects of dental treatment, and the functional prototype can be one of the "tools" in the toolbox.

(4) The game could be used as a talking point during treatment.

Additionally, the serious game could also be used as a talking point between the children and the psychologists and dentists to help them discuss the procedure. As noted in the preliminary studies, a part of the treatment procedure at TBiT involves evaluating the child's fear level and creating a treatment plan fit for their level. In this case, the game could be used as a talking point to figure out what part of the cavity procedure invokes anxiety in the child.

Overall, the TBiT representatives considered the game to be the most pedagogical game about dental treatments they had seen, and the potential uses described above shows that the game can be a useful asset to the TBiT service in several ways.

11.3 Children's Experience of a Serious Game about Dental Treatment

A serious game is intended both for learning and for entertainment. For the user, fun and engagement are an integral part of the serious game experience. Games involve different elements that are fun and engaging, such as play, storytelling, aesthetics, learning and rules and challenges. This section discusses how the children perceived these elements in the current game concept.

Play

Play in the game involved exploring a dental office and acting as a dentist conducting a cavity treatment. However, the possibilities for exploration were arguably limited in the game. There were only three playable scenes in the game, and only two of them involved searching and exploring the game world. The interactive elements were also limited compared to commercial games, and mostly related to the main plot line. During the user evaluation, many children seemed eager to click around and look for elements, but they would often get little feedback, especially in the living room scene. Though the children seemed to enjoy exploring, particularly the dental office, the game could have benefited from expanded exploration possibilities.

The game also included a type of roleplay, the player acting out a cavity treatment and reassuring the main character if she got anxious during the procedure. Many children said they enjoyed this procedure and "fixing the teeth". The special appeal of this part of the game might lie in letting the player take a role that s/he would not be able to take in real life, and in letting the player be the person in charge.

Storytelling

The children seemed engaged in the story while playing the game, both laughing at funny moments and commenting on and referring to their own experiences when commenting aspects of the story (e.g. one participant commented that it was strange that Mari's mom had put her phone between the cushions on the couch because this was an unusual place to put a phone). The children also managed to retell large parts of the story. All in all, it can therefore be assumed that the story was suitable for the target group.

Aesthetics

Based on the data gathered, it is difficult to generalise what the children thought of the graphics. Because they generally seemed very engaged with the game, however, one can assume that the graphics did not detract from the gaming experience. The graphics were chosen based on other media targeted at children of the same age. One child stated spontaneously that he thought the aesthetics in the game looked like illustrations from other books he had read. When we observed the children interacting with the game and discussing it, it was evident that they had no trouble perceiving the game content as genuine and that they especially enjoyed the realistic instruments.

Learning

The children considered the game to be a fun way to learn about the dentist. They seemed to particularly enjoy the parts of the game related to the dental office, e.g. exploring the office, learning more about the instruments, and acting as a dentist and conducting the cavity treatment. Some even commented that they would like to explore the scenes even more. It is also possible that the children found the game fun because they have some, though not much, previous knowledge of dental treatments and are therefore curious to learn more.

Challenge

There were differing opinions on the level of challenge in the functional prototype. Some children reported that the game was suitably difficult, some found only specific tasks difficult, and some found the overall game a bit easy. During the user evaluations, however, we observed that all the participants completed the game without any significant difficulties, except that all struggled to some extent with applying the instruments in the correct order in scene 3. Yet not even those who mentioned that they found certain tasks difficult seemed to perceive these difficulties as an issue.

The fact that five of the children did not find the game difficult, and that two others would have liked the game to be longer, can indicate that making the game a bit more challenging might increase engagement and ensure a stronger sense of flow. As the game was tested on children aged 10 to 11, it is also reasonable to assume that the concept as is might not be challenging enough for older children. At the same time, care must be taken that the challenges are suitable also for younger children.

To summarise, the children seemed engaged in the game and especially enjoyed exploring the rooms, the challenge of finding instruments and the fun elements of the story. They also enjoyed learning about dental treatments, of which they had little previous knowledge. Still, the game has potential to become even more engaging by adding more explorative activities, especially in the dentist's office, and by providing more challenging tasks.

11.4 A Novel Approach to the Prevention of Dental Anxiety?

While there are several other interactive solutions related to anxiety disorders described in the literature, the solution presented in this study differs from these in several ways. The first aspect that distinguishes the solution is that of the domain. None of the solutions identified in the SLR targeted dental anxiety. However, it is worth noting that the exclusion criteria applied in the review might have excluded some solutions. Furthermore, the experts at TBiT were not aware of any similar solutions existing in Norway.

A second distinguishing factor is the solution's focus on prevention. Out of the 17 interactive solutions described in the SLR, only one (see Patwardhan et al., 2015) specified its purpose as prevention. The amount of literature on prevention is considerably smaller than that of treatment, which may explain this considerable difference. What is clear, however, is that the potential of interactive solutions for dental anxiety prevention has not yet been explored to a satisfying degree.

A third aspect of the solution which distinguished it from many solutions in the review is how it can be used independently of any therapeutic service. The obvious benefit of this is that the game can be made available to all children as an educational tool for cavity treatments and dental anxiety. The game would still need to be distributed by either a service, an educational institution, or another actor, but this would be effortless. As the game has not yet been tested on children with dental

anxiety, it is currently impossible to say whether the game could have any potentially harmful effects on children with severe anxiety. The game contains only minimal exposure, so this is unlikely yet cannot be entirely excluded.

The idea of a serious game for health for children is certainly not novel. In fact, it is a popular choice when designing for children as it can be both engaging and motivating if done well. For the serious game presented in this work a 2D point-and-click style game that has not been tested in the domain of dental anxiety was chosen. Though a 2D point-and click-style game often relies on elaborate graphics, they can be quick to make using stock images and can thus be potentially cheaper to create than 3D or VR games.

The various aspects presented above of the serious game concept presented in this work are by no means unique in themselves. Nonetheless, the solution presented in this work can still be considered significant due to the domain (dental anxiety), the nature of the intervention (preventive), its potentially wide accessibility, and the 2D point-and-click concept. Furthermore, this work contributes by providing a detailed description of a serious game where children are exposed to and learn about the dental experience.

Chapter 12

Design Guidelines

Design guidelines are design tools intended to help designers create positive user experiences within a specific context of use (The Interaction Design Foundation, 2012). They make it easier for a designer to create a solution that will be accepted by the intended users. As shown in the structured literature review, there is currently not much guidance for designers and developers wishing to develop a serious game aimed at children with anxiety. Based on the design and evaluation of our functional prototype and on results from similar projects, we suggest five emerging design guidelines that we hope can be of interest to others who set out to create a serious game for the prevention of an anxiety disorder. Each section contains a brief discussion providing the background for the guideline. Following the background, a brief rationale for the guideline is presented. Examples of how the guideline can be implemented are also included, along with some strategies for implementing the guideline. This format was inspired by the design guideline structure proposed in Isbister and Mueller (2015).

The following guidelines will be presented: (1) Include voice-over of in-game text and dialogue, (2) Repeat information to increase the probability of achieving learning objectives, (3) Keep the story and anxiety-inducing elements realistic, (4) Provide freedom to explore, and (5) Use metaphors to visualize and simplify complex concepts.

12.1 Design Guideline 1: Include voice-over of in-game text and dialogue

According to the Norwegian Directorate for Education and Training (Utdanningsdirektoratet), children aged 9–10 should be able to "read texts with fluency and understanding" (Utdanningsdirektoratet [Udir], 2021). However, results from the yearly national tests for reading show significant differences in children's reading capabilities within this age segment (Folkehelseinstituttet [FHI], 2015). Any interactive solution targeted at this age group needs to consider this. A common way for interactive systems to adapt to different user needs is to include options for voice-over. In games,

voice-over narration or voice actors voicing characters is a common feature (e.g. Assassin's Creed and Civilization), and it often increases immersion in the game world. Realistic voice acting can therefore also be a useful tool in a serious game to increase children's perception of the content as a simulation.

During the second round of user evaluation, all children reported that they liked hearing the text read aloud in the game, and they mentioned various reasons. One child said that he enjoyed the voice-over "because then I didn't have to read so much. It made it a bit easier to follow the story" (ID2.11). In fact, the majority of children preferred that voice-over was included ("I didn't have to read it myself and it was easier to understand what they were saying" ID2.15). A few children mentioned that they generally preferred to read the texts themselves. Although all the participants claimed that they had no difficulty reading the text parts of the game, we observed that several struggled a bit when reading. The teachers present in the meeting room during the user evaluations confirmed our observations and supported the addition of voice-over. Some of the children also pointed out that they liked the voice-overs because they sounded realistic. As one child mentioned, "I think that it feels a bit more real [when there is a voice-over] than when you have to read it yourself. I think you get more real feelings from it." (ID2.9).

Rationale

The user evaluation of our game showed that the participants appreciated the voice-over and that they liked that it sounded realistic. We also observed that some participants overestimated their reading abilities and pronounced words and sentences incorrectly. Considering that learning is an essential goal of a serious game, a voice-over should be included to ensure that all children understand all the information presented in the game. Besides, the voice-over should be as natural sounding as possible to provide a more immersive game experience for the users.

Example: Virtual MRI Liszio and Masuch (2017). In their Virtual Reality MRI application meant to prepare children for MRI exams, the player follows the narrative of a penguin girl who is preparing for an exam. The game uses a natural-sounding voice-over for story elements (like a talking doctor) and informational elements (e.g. information about instruments).

Strategies for Designers

- If the game is based on a story: Invest time in formulating dialogue that sounds natural, and consider spending some extra resources on good voice acting since it adds to the immersive qualities of the game and can increase children's experience of the game world as realistic.
- Do not prioritise adding a voice-over for the first prototypes. It is not necessary for getting feedback on the concept, and the dialogue and text in the game will likely undergo several changes during the design process.

12.2 Design Guideline 2: Repeat information to increase the probability of achieving the learning objectives

Activities in a serious game should support the achievement of the specified learning objectives (Warren & Jones, 2017). However, since serious games are also meant to be entertaining, there is a risk that the entertainment elements overshadow what an activity is supposed to teach. In the user evaluations, we experienced that some children did not read the informational text about the various dental instruments because they were more interested in the playful task of collecting the instruments to prepare for the cavity treatment. For example, one child did not wait to listen to any of the voice-overs telling about the instruments, which was a clear sign that he did not read the descriptions either. However, the post-test interview revealed that the children remembered some information about the instruments anyway. This information must have been gathered from other sources in the game, such as the informative video in scene 1 and the cavity procedure in scene 3. Essential information should therefore be repeated throughout the game as a way to increase the user's chances of achieving the learning objectives.

Rationale

When playing serious games, there is a danger that the player gets too caught up in the entertainment at the cost of intended learning, or that specific learning activities fail to work as intended. This is a risk especially when the players are children who might not be mature enough to understand what they are meant to learn by playing the game. A way to address this issue is to ensure that crucial information is repeated throughout the game and in various ways, and that every repetition has a purpose within the game.

Example: Game creating awareness of social anxiety disorder (Báldy et al., 2020). In the game, a character introduces CBT skills through dialogue. Following this dialogue, the player needs to utilise the newly learned skills in three different gameplay scenarios. The game ends with a recap of the CBT skills learned in the game.

Strategies for Designers

- Ensure that the information given has a function within the game.
- Ensure repetition of information to support learning.
- Include information in various ways, e.g. through both informative videos and in-game dialogue between characters.

12.3 Design Guideline 3: Keep the story and anxiety-inducing elements realistic

Warren and Jones (2017) notes the importance of simulation in a learning game to ensure the transferability of in-game knowledge to real-life situations. A serious game does not have to represent reality perfectly, e.g. through a hyper-realistic virtual environment, to ensure transferability of knowledge. Serious games can vary in simulation fidelity as long as the real-life activities simulated in the game make it possible for a player to recognize them as such (Warren & Jones, 2017). Games targeted at children often include cartoon graphics to make them more age-appropriate and entertaining. We used cartoon graphics to create the living room and the dental office shown in the game, but these rooms still resembled reality. We especially ensured that the narrative described a scenario that the player could experience as realistic and that was based on a possible real-life situation.

The dental anxiety treatment provided by the experts on dental anxiety treatment who we had consulted includes exposure therapy, i.e. exposing a person his or her sources of fear in a controlled manner in order to overcome this fear. Even though the game was aimed at children without dental anxiety, the experts recommended that the game should be realistic and introduce the children to both the dental procedure and the instruments used to potentially achieve a mild similar effect for preventive purposes. Therefore the instruments were realistically presented in the game, and the procedure was simplified, but accurate. Additionally, we utilised authentic sound effects for the instruments. We experienced that the cartoon drawings did not detract from the children perceiving the in-game narrative and elements as realistic. Rather, the children perceived the story as real and even compared the story to their own experiences. Many also noticed that they enjoyed that the instruments looked realistic.

Rationale
To ensure that the game teaches the right skills, the in-game simulation has to be a realistic representation. In the context of anxiety prevention, the presentation of common sources of fear and the underlying narrative should be kept as realistic as possible. However, simplifications or a cartoon context can be used to increase the entertainment value of the game.

Example: Virtual Reality MRI. In Liszio and Masuch (2017)'s solution, which aims to reduce children's fear of MRI exams, the characters in the game are penguins. The story is intended to be relatable to the player and is an accurate representation of a situation (protagonist scared of taking an MRI). The potentially anxiety-inducing aspects (the look and sound of an MRI machine) are depicted accurately.

Strategies for Designers

- Identify the children's sources of fear in the context of relevant treatment practices, preferably in collaboration with domain experts.
- Collaborate with domain experts to formulate a realistic narrative.
- Collaborate with designers to ensure the graphics fit the target group, and with domain experts

to ensure they are authentic.
- Ask domain experts for pictures, videos, sound clips or other material to ensure the anxiety-inducing objects or procedures are portrayed accurately.

12.4 Design Guideline 4: Provide freedom to explore

The game concept described in this paper included the exploration of two rooms, a living room and a dental office. The living room was used in the first scene to set up the story about Mari and her up-coming visit to the dentist. Exploring the dental office allowed the children to learn more about the dental experience, become familiar with the environment and to get used to being exposed to dental instruments. Exploration is a form of engagement, and the user evaluations in this project show that the children greatly enjoyed this type of game activity. They also seemed to enjoy finding random game elements while exploring. As one of them commented: "It was fun that one could read books" (ID1.10). Others would look for instruments in the bin and laugh about the pop-up telling them that a bin might be a strange place to store an instrument. During the user evaluations, children said they would like to explore both the dentist's office and the living room more. One specifically mentioned wanting to learn more about the various dental machines. Coyle et al. (2011) observed something similar: The children liked to continue exploring the game world after completing the game activities.

Some children expressed a wish to do other tasks in the game as well. As one of them commented during the interview: "I would like some tasks that are just fun and don't have anything to do with the dentist. Like maybe a mini-game that is not directly tied to the game. Because then I would be like, 'Why is this here?'" (ID2.1). Another said: "I wish there were more things to do in the living room, and that there were more butterflies [that have to be removed]" (ID2.3). Including other tasks can help foster engagement and motivation to play.

Rationale
Motivating and keeping children engaged during therapy is a key challenge for psychologists, and serious games can be great tools for motivation. To ensure engagement in the game, the designer should consider activities that allow for extensive exploration of the game world. This includes tasks that are meant purely for entertainment.

Example: Carlier et al. (2020)'s New Horizon solution included four mini-games in their application for children: two which incorporated CBT relaxation techniques, and two games that were purely for fun.

Strategies for Designers

- Include some elements that are intended purely for play.
- Consider the story and decide where you might be able to incorporate fun tasks that still fit within the game world.

12.5 Design Guideline 5: Use metaphors to visualize and simplify complex concepts

One of the challenges the experts at TBiT face is children's maturity level. Children can struggle with categorising and sorting their thoughts and do not always know how to manage negative thoughts. Children also often have difficulties expressing themselves, making it challenging to discuss complex topics such as feelings. Such discussions are vital to psychological treatment, and not being able to assess a child's feelings can make it difficult for psychologists to develop a suitable treatment trajectory. One way to remedy this problem is to provide children with tools that can help them express their feelings, such as metaphors. Metaphors are valuable tools in cognitive behavioural therapy with children because they turn abstract concepts into something visible and more easily relatable (Friedberg & Wilt, 2010).

Instead of relying on a textual description of anxiety in our game, the main character's fear was visualised as butterflies in her stomach. The dental anxiety treatment experts at TBiT suggested it would be better to use a metaphor than adjectives such as "afraid" or "scared", which have negative connotations. The metaphor "butterflies in the stomach" was chosen both because it is a euphemism and because it is well-known and thus self-explanatory. The children understood that the character was anxious and actively used the metaphor while describing the story. Five of the children also made explicit references to the butterflies, and one participant commented that it was "fun to see the stomach butterflies that disappeared" (ID2.12).

Rationale
Children often struggle to express their feelings verbally. Including metaphorical representations of abstract concepts can help them vocalise their feelings. Metaphors may also help making difficult issues or problems less frightening to talk about.

Example: gNats Island (Coyle et al., 2011). In the 3D game gNats Island, the player has to fights against gNats (personifications of negative thoughts). For example, being stung by a Black and White gNat can cause you to only think in extremes. The researchers observed that many of the children adopted the language of the game, referring by name to gNats who had stung them. The game also used metaphors for the strategies for identifying and challenging negative thoughts.

Example: In De Sa and Carriço (2012)'s software catalogue meant for supporting fear therapy, height, weight and strength are used as optional metaphors for the level of fear, e.g. drawings of buildings of different heights to indicate different fear levels.

Strategies for Designers:

- Collaborate with domain experts (psychologists and educators) to find suitable metaphors.
- Test the metaphor on the children in the target group to ensure they understand it and can relate to it.

Chapter 13

Limitations

The results and subsequent discussion presented in the previous chapters should be seen in the light of some limitations.

The first limitation is that the solution is only a prototype and not a complete game. As a consequence of this, any evaluation will also be incomplete. Due to limited resources and time constraints, designing and developing a fully complete game was not feasible. Furthermore, the aim was primarily to test how the game concept was received. It was therefore not necessary to design a complete game in order to measure this. Consequently, adding professional voice-overs was not prioritised, and the procedure in the game was slightly simplified. That being said, the final prototype was wholly functional and contained no bugs or incomplete features. Furthermore, none of the participants commented on the prototype appearing "unfinished" during the second round of user testing. For a more complete evaluation result, it is recommended that the prototype is further refined based on the feedback from the second round of user testing.

A second limitation concerns the participants of the user testing. One of the requirements for the prototype was that it should be suitable for children aged eight to 12. However, because of Covid-19 restrictions at the school, representation from all ages was not possible to acquire. As a result, the prototype was only evaluated by children aged 10-11. As the maturity level, cognitive abilities and interests of children can vary greatly; this potentially reduces the generalisability of the findings in this study to other ages included in the target group. In the case of further testing, it would be advisable to test on all the ages in the target group, both younger and older, to see if the game is still suitably challenging and well-perceived.

The third limitation is the lack of evidence on the preventive health effect of the developed prototype. While the game contains low-level elements of exposure therapy and information about dental treatment, which the TBiT team believes can have a preventive effect, this was not evaluated in this study. It is therefore not yet possible to prove or disprove any preventive effect of the solution. Inlay of effect, our research instead focused on exploring how end-users received the prototype. This choice was motivated by two factors. Firstly, no similar solutions for dental anxiety prevention were

found during the literature review. It, therefore, made sense first to establish that the serious game concept had potential, both in the eyes of domain experts and end-users. Secondly, the authors of this thesis were not domain experts on dental anxiety and did not have the required expertise to measure the preventive effect. Such an evaluation would have required more involvement from psychologists than was possible in this study. It would also have required recruiting participants with existing dental anxiety.

Chapter 14

Summary and Conclusion

The aim of this thesis was to explore the potential of a serious game concept in the prevention of dental anxiety in children. To do this, we conducted a structured literature review searching for existing solutions, consulted professionals working with dental anxiety treatment, and developed a functional prototype that was evaluated by children. We followed an explorative, user-centred, iterative approach to design the prototype of a serious game. The game concept was a point-and-click game that follows the narrative of a child with a mild degree of dental anxiety and who is going to the dentist for a cavity treatment. The game design was based on principles and techniques used in the treatment of dental anxiety in children, but as a way to achieve a preventive effect.

The thesis sought to answer three research questions. The questions and key findings are summarised below.

RQ1: What kinds of digital solutions for anxiety treatment are described in relevant literature?

The review showed that there is so far little literature available on the design of digital solutions for anxiety prevention or treatment. The studies addressed several types of anxiety disorders, but none of the solutions described targeted dental anxiety. The kind of solutions chosen and the treatment methods applied varied significantly, too. We found that domain experts were frequently involved in the design process, which indicates they were supportive of the endeavour. All of the solutions had been evaluated by end-users, and the technological solutions generally seemed to have been well-received. These findings show there is great potential for interactive solutions for the prevention of anxiety disorders.

RQ2: How do professionals involved in dental anxiety treatment view the use of a digital solution to prevent dental anxiety in children?

According to professionals at TBiT, it would be challenging to create an interactive solution that could provide standard dental anxiety treatment. Yet, there are ways in which an interactive solution can be helpful as a supportive tool within a standard treatment, or as a low-threshold solution for children who are anxious, but who do not need standard anxiety treatment. As a supporting tool,

an interactive solution, e.g. a serious game, might make the treatment experience less stressful for children and help them feel more comfortable and confident in a dental situation. A low-threshold interactive solution can also make information about dental treatments accessible to many children. The TBiT professionals consider the functional prototype presented in this thesis a promising concept for a tool and suggest that it can be included in a digital toolbox for dental anxiety prevention and treatment.

RQ3: How do children experience the functional prototype of a serious game for such a purpose?

The concept was positively received by the children. They were especially engaged with the game challenges of finding hidden items and instruments and of conducting a treatment. Most children had little knowledge about dental procedures or instruments before playing the game, and all stated they had learned something new after playing, especially about the dental instruments and about the cavity treatment procedure. However, the fact that not all the learning objectives were met suggests that the prototype should be extended with additional activities to ensure that all players retain the desired information. Overall, the concept appears suitable for the target group and has the potential to motivate children to learn about a topic they might not usually think of in everyday life.

Based on the research conducted, this thesis suggests a set of emerging design guidelines for the design of serious games for the prevention of anxiety disorders targeting children:

- Include voice-over of in-game text and dialogue.
- Repeat information to increase the probability of achieving the learning objectives.
- Keep the story and the anxiety-inducing elements realistic.
- Provide freedom to explore.
- Use metaphors to visualize and simplify complex concepts.

This thesis concludes that a serious game concept has the potential to become a valuable tool in prevention of dental anxiety in children. A logical next step would be to evaluate the effectiveness of the game concept as a preventive solution.

Looking forward, the concept could be used to create new games that focus on other aspects of dental anxiety and dental treatment. A collection of such games could be valuable for health professionals as tools for dental anxiety prevention.

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Appendix A

Overview of TBiT Treatment Stages and Associated Challenges

Phase	Before treatment	Start of treatment	During treatment 5 - 10 sessions (45 min x session) - Often a couple of weeks between each session	End of treatment	After treatment
Treatment activities	• Dentist writes referral to Tbit • TBiT Team receives and evaluates the referral • Child is placed on waiting list	• Initial talk with therapist • Therapist creates an anxiety ladder to evaluate their level of fear • Create a plan for treatment • Decide on a stop-signal • Decide what to do next meeting • Psycho-education: What does it mean to be afraid • Discussing the treatment	**Activities with children:** • Check-in: Ask how the child is feeling today and ask them if the agenda is okay or if they want to change anything • Tour of the dental office: See/feel the instruments (only in the first session) • Check with the children if their own evaluation of their fear is correct through exposure • Exposure therapy: e.g. with a "health check" (Friskhetskontroll), putting together a syringe, being able to touch the syringe, etc. • Check-out: Summary of the session • Utsjekk: oppsummering av økten **Psychologists:** • Breaking an activity into smaller, more manageable steps • Ask questions during the session • Give encouragement and praise for completing activities • Has to be flexible and be able to make both small and big changes to the activities should the child need it • Make sure the child feels safe (e.g. praise them if they use the stop-signal)	• Summary of treatment: recap of what they have done during the treatment and what they have achieved • Create a plan of mastery (mestringsplan): an overview which is sent to the child's dentist • Transfer meeting with the local clinic if possible	• Child receives a notice to get dental treatment
Stakeholders	• The child • The child's dentist • Parents • Team at Tbit	• Dental treatment team • Psychologist/(behandler?) • Child • Parent (sometimes)	• Dental treatment team • Psychologist • Child • Parents (usually)	• Dental Treatment Team • Child • Parents • Local clinic	• Child • Parents • Local clinic
Challenges	• Long waiting lists for treatment • Team receives limited info regarding the child's mental challenges • Not all dental clinics are aware of the treatment offered at Tbit (usually the same dentists who refer children to treatment, or dentists who know of the treatment) • The treatment is not known to parents and children	• The child is scared • The child doesn't see the need, or they don't understand why they are there • The child lacks motivation • The degree to which parents are able to follow up the treatment varies greatly	**Psychologists:** • Too long between each session (the treatment is at its most effective right after treatment) • Difficult to motivate the child • The child is often in dire need of dental treatment, which creates pressure on the psychologists/therapists to achieve improvements quickly • The child's experience of mastery can be tied to a specific therapist • Limited amount of resources. Too little capacity for treatment **Parents:** • It varies how good they are at following up the treatment • The parent's themselves have anxiety which affects the children • Need to travel far and get time off work • Parents can be a distraction during the treatment if they themselves are anxious or are unable to provide proper care • The parents have little knowledge of the treatment. They don't see the point of the treatment and some may even become impatient during the treatment. **Child:** • Child doesn't go to the treatment • Many have to travel far • The child easily lose focus during sessions • Children have difficulties sorting through thoughts and difficulties articulating how they feel and difficulties regulating their feelings • The child and/or parent don't see the point of the treatment • If the child has any other mental diagnoses in addition to dental anxiety, the treatment may be more complex and need to be extended • Too many other things are happening in their life • The children have difficulties challenging themselves	• The local clinic or the child needs Tbit to participate at the transfer meeting, but is too far away to be practical	• That too much time passes between end of treatment and the child's dental treatment, which may cause the child to develop anxiety.

Appendix B

Personas and Scenarios

Susanne Bjørkli

Personal Information

Name: Susanne Bjørkli

Age: 9 years

Nationality: Norwegian

City: Oslo

Interests: Tik Tok, watch videos on Youtube, play handball, draw and pain

Normal activities: School, homework, handball practice, read cartoons, be with friends

Favourite apps: TikTok

Technology: Uses iPad for homework and mobile for TikTok and games

Relation to the dentist: Susanne has never had any problems going to the dentist before, but now she is going to get a cavity treatment for the first time. She is not really nervous, but she is curious about what it is like. She has also become interested in learning more about the different instruments the dentist uses.

🗓️ Susannes' dental treatment goal

- To complete a cavity treatment without any problems

❌ Fears

- None

✅ Needs

- That the dentist explains what she is doing and why
- To be able to touch and hold the instruments
- To learn more about dental treatment in general

Scenario

Susanne has been scheduled for a cavity treatment in two weeks. Her mother has told her that she doesn't like getting cavity treatments, but Susanne is more curious than anxious. Instead, she thinks the instruments the dentist uses seem interesting and would like to know more about them. She downloads the game because she thinks it will teach her more about the dentist. After playing, she feels she knows exactly what the dentist does during a cavity procedure and what each of the instruments do. When she talks to her friends afterwards who are curious about what she did at the dentist, she explains what the dentist did and that removing a cavity is no problem.

Tobias Kielland

Personal Information

Name: Tobias Kielland

Age: 11 years

Nationality: Norwegian

City: Trondheim

Interests: Fortnite, Rocket League, snowboarding, football with friends

Normal activities: Football practice, homework, school, gaming

Favourite apps: TikTok, Youtube, Snapchat

Devices: Uses iPad for homework and Salaby, and playstation to play games

Relation to the dentist: When Tobias has been to the dentist before, he has felt that he doesn't understanding what is going on. Once he experienced that the dentist, without giving any notice, prodded a tooth and that it suddenly hurt a lot. Because of this he is a little bit nervous as he is now going to the dentist again to fix a cavity.

🗓️ Tobias' dental treatment goal

- To be able to receive a cavity treatment without getting anxious

❌ Fear

- That the dentist does something unexpected which hurts

✅ Need

- To feel he is in control when he is getting a dental treatment
- To understand what the dentist is doing and why she is doing it

Scenario

Tobias is a little apprehensive about getting his upcoming cavity treatment because of previous experiences at the dentist. He didn't like the sudden pain and not knowing what was happening during the treatment. Because of how uncomfortable Tobias was during the treatment, the dentist recommended him for treatment at TBiT. Because of the long waiting lists however, he is still awaiting treatment. Because of the long waiting lists, the TBiT counsellors recommended that he in the meantime should try a game to prepare himself for his next dental treatment, which was a cavity removal treatment. He downloaded the game on his iPad and played it at home the week before the treatment. At the dental office, he remembered what he had learned from the game, and

therefore he knew what the dentist was planning to do. This made him feel comfortable enough to ask the dentist questions about all the instruments and to tell the dentist that he was a bit nervous. He had also learned about the stop-sign, which he knew he could use if he got too scared. He was able to complete the treatment without difficulties.

Kjersti Eide

Personal Information

Name: Kjersti Eide

Age: 44

Nationality: Norwegian

City: Trondheim

Occupation: Kjersti is a specialised psychologist at TBiT who treat children with dental anxiety.

Interest: Running, hiking, knitting

Normal activities: Exercise, housework, spending time with family

Apps: Strava, Facebook

Technology: Smartphone, computer

🗓️ Kjersti's goals as a therapist at TBiT

- To be able to motivate children to complete their treatment
- That children with dental anxiety become comfortable enough to receive regular dental treatment

✅ Needs

- To have a lightweight treatment offer for children on the waiting list
- To teach children about dental treatments as a way to possibly prevent dental anxiety

❌ Fears

- That the availability of the TBiT-service will be hindered by long waiting lists
- That children on the waiting list have to wait too long for treatment, which can negative dental health implications

Scenario

Kjersti has worked as a therapist at TBiT since it was established in 2017 and has treated many children since then. She knows that some of the children who are referred to treatment at TBiT are often in dire need of dental treatment, and that they need therapy treatment fast. Because of the long waiting lists however, she is unable to give treatment to these children when they need it. At the same time, she also knows that many children on the waiting list don't necessarily have dental anxiety or dental phobia. Instead, many children are simply uncomfortable with dental treatment situations because it is unfamiliar and strange to them. Kjersti thinks that a low-threshold solution which provides information about dental treatment would be enough for these children to become more comfortable at the dentist and to prevent them developing dental anxiety. Kjersti therefore sends

every child on the waiting list a game to teach them more about dental treatments and what they can do if they get anxious during a dental treatment. Kjersti knows the game is an entertaining and safe way for the children of learning about the dentist, and gives some of the children the confidence they need to receive regular dental treatment. As a result, the waiting list becomes shorter and the waiting time for children with more severe dental anxiety and dental phobia becomes shorter.

Appendix C

Interview Guide

The interview guide in Norwegian used in the user evaluations.

Intervjuguide

1. **Kort introduksjon (2 min)**

Hei, hva heter du? Jeg heter Therese og dette er Astrid og vi er studenter i Trondheim og når vi er ferdig skal vi jobbe med data. Vi jobber med å lage et spill om det å gå til tannlegen. Målet vårt er at de som spiller skal bli bedre kjent med tannlegen og det som ofte skjer på et tannlegekontor. Vi vil at spillet skal bli best mulig, og derfor trenger vi hjelp på deg. Vi er veldig glade for at du vil teste spillet vårt. Du er nemlig eksperten på hva du selv synes er morsomt og om du føler at du lærer noe nytt om tannlegen. Det du mener om spillet skal vi til å bruke til å gjøre det bedre, så egentlig er du med og bestemmer hvordan spillet kommer til å bli!

Vi har bare startet med spillet og bare lagd en liten bit, og den vil vi at du skal se på. Det vi gjør nå er en spilltest og det vil si at du som spiller nå tester spillet og sier hva du mener. Du er eksperten her, og det derfor vi vil at du skal prøve.

Etter du har prøvd spillet vil vi gjerne at du svarer på et par spørsmål og fylle ut et skjema hvor du krysser av for hva du synes om spillet. Høres det greit ut? Har du noen spørsmål?

2. **Lite oppvarmings-intervju (3 min)**

Før du skal få prøve ut spillet har vi et par spørsmål til deg. Er det noen spill du har spilt mye i det siste?

Spiller du noen spill der du lærer noe? Som f.eks. matte eller engelsk?

Hva liker du best med dem?

Vårt spill handler jo om det å gå til tannlegen. Husker du sist når du var hos tannlegen? Hvordan var det?

3. **Test av prototype**

Da er det tid for å teste spillet! Men først er det fint om dere kan dele skjerm sånn at vi også ser hva som skjer i spillet. Instrukser hvordan dele skjerm.

Underveis kommer vi til å spørre litt hva du tenker.

Vi må bare gjøre noen innstillinger før du er klar til å spille. Kan du trykke helt oppe i høyre hjørnet og se om du får opp en ny meny? Der velger du “Scale to fit” og så kan du velge fullskjerm.

Du skal prøve å spille gjennom på egenhånd, men hvis du står fast så er det bare å si ifra.

Navn på lærer kommer til å filme skjermen og hendene dine mens du spiller. Hørtes det greit ut? Er du klar til å prøve?

4. **Intervju om prototype**

Nå har vi et par spørsmål hva du syntes om spillet.

Appendix D

Observation Form: Round 1

Scene 1: Hjemme hos Mari						
1.1. Skjønner at man kan trykke/"tappe" på elementene i rommet	**1.2 Trykke på moren for å få hjelp**	**1.3 Finner mobil**	**1.4 Samtale med tannlegekontoret:** skjønner at man må trykke/"tappe" på skjermen for å gå videre i samtalen	**1.5 "se" video**	**1.5 Gå videre når alle sommerfuglene er borte**	**Andre problemer**
Scene 2: Hos tannlegen						
2.1 Skjønner at man trykker rundt for å finne instrument	**2.2 Finner riktig instrument**	**2.3 Trykker på stolen for å gå videre**	**Andre problemer**			
Scene 3: Borring						
Steg 3.1: Skjønner at man kan dra instrumentene	**Steg 3.2: Sette bedøvelse**	**Steg 3.3: Bruke borr**	**Steg 3.4: Bruke vannsuger**	**Steg 3.5: Bruke fylling til å tette hullet**	**Steg 3.6: Bruke blått lyst til å tørke fyllingen**	**Andre problemer**
Forklaring						
1 - Løste oppgaven uten problemer						
2 - Noen problemer med å løse oppgaven						
3 - Store problemer med å løse oppgaven eller klarte ikke løse den						

Appendix E

Observation Form: Round 2

Scene 1: Hjemme hos Mari							
1.1. Skjønner at man kan trykke/"tappe" på elementene i rommet	1.2 Trykker på moren for å få hjelp	1.3 Finner mobilen	1.4 Finner lys og/eller bok (NY)	1.5 Hører på alle tekstboksene i dialogen med tannlege (NY)	1.6 Ser hele videoen	1.7 Merker at sommerfuglene forsvinner/er borte (NY)	Andre problemer
Scene 2: Hos tannlegen					Scene 3: Borring		
2.1 Skjønner at man må trykke rundt for å finne instrumenter	2.2 Finner riktige instrument	2.2. Finner de andre elementene (NY)	2.3 Trykker på stolen for å gå videre	Andre problemer	Steg 3.1: Skjønner at man skal dra instrumentene	Steg 3.2: Setter bedøvelse	Steg 3.3: Bruker borr
Scene 3: Borring							Kommentarer
Steg 3.4: Bruker vannsuger	Steg 3.5: Bruker fylling	Steg 3.6: Bruke blått lyst	Steg 3.7: Bruke pussebor	3.7. Klarer å svare på MPC (NY)	3.8 Får opp stopp-reglen (NY)	Andre problemer	Kommentarer

Appendix F

Questionnaire: Round 1

The statements from the questionnaire can be found below:

Jeg ble forvirra flere ganger når jeg testet spillet

Jeg synes spillet var lett å spille?

Jeg hadde ikke klart å spille uten hjelp fra en voksen

Jeg skjønte alltid hva jeg skulle gjøre i spillet

Noen av tingene i spillet ga ikke mening

Jeg tror vennene mine hadde klart å spille dette spillet

Noen av oppgavene jeg måtte gjøre i spillet var litt rare

Egne utsagn:

Hvis jeg hadde en venn som ville lære mer om tannlegen, ville jeg ha anbefalt dette spillet

Dette var en morsom måte å lære mer om tannlegen på

Jeg ville ha spilt dette spillet før en tannlegetime for å forberede meg

Jeg har lært noe om borring som jeg ikke visste fra før av

Appendix G

Questionnaire: Round 2

Spørsmål om tannlegespill

Svar på hvor enig du er i påstandene under.

1 = Veldig uenig
2 = Uenig
3 = Verken enig eller uenig
4 = Enig
5 = Veldig enig

1

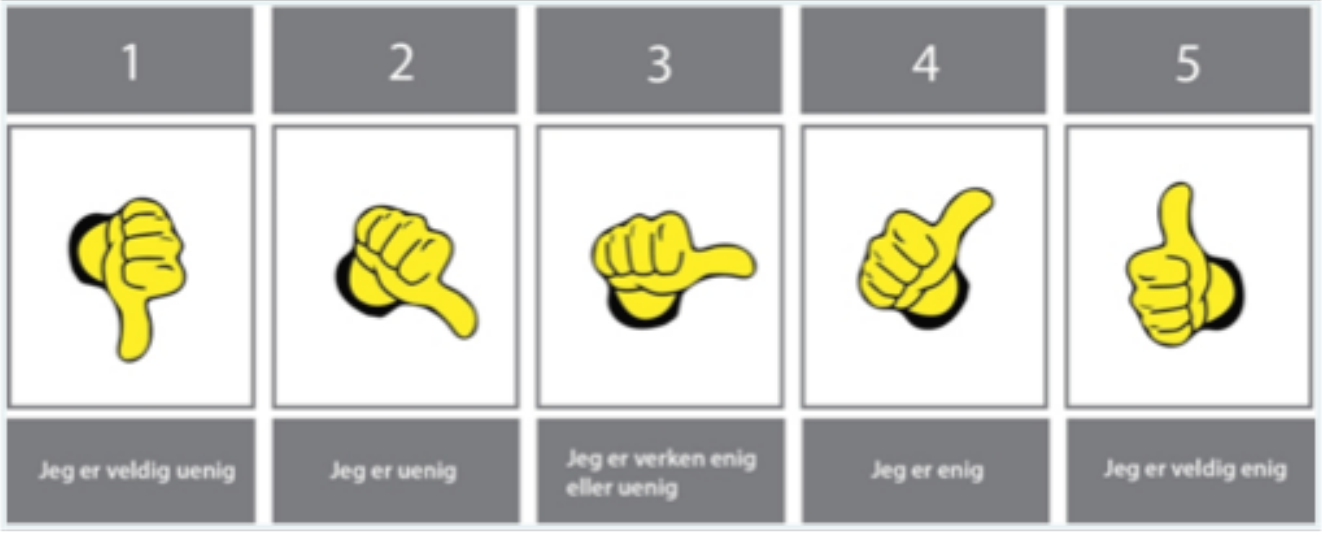
Les dette først!

Du skal bruke tallene 1, 2, 3, 4 og 5 til å si hvor enig du er i setningene lenger nede.

Tallet 1 vil si at du er veldig uenig (tommel helt ned).

Tallet 5 vil si at du er veldig enig (tommel helt opp).

Bare spør oss hvis det er noe du ikke forstår :-)



2

Jeg synes spillet var lett å spille

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

3

Jeg ble forvirra flere ganger når jeg testet spillet

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

4

Jeg hadde ikke klart å spille uten hjelp fra en voksen

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

5

Jeg skjønte alltid hva jeg skulle gjøre i spillet

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

6

Noen av tingene i spillet ga ikke mening

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

7

Jeg tror vennene mine hadde klart å spille dette spillet

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

8

Noen av oppgavene jeg måtte gjøre i spillet var litt rare

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

9

Dette var en morsom måte å lære mer om tannlegen på

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

10

Jeg ville ha spilt dette spillet før en tannlegetime for å forberede meg

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

11

Jeg har lært noe om boring som jeg ikke visste fra før

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

12

Jeg vet mer om instrumentene som tannlegen bruker nå enn det jeg gjorde før

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

13

Jeg vet mer om hva som skjer hos tannlegen etter å ha spilt spillet

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

14

Hvis jeg hadde en venn som ville lære mer om tannlegen, ville jeg ha anbefalt dette spillet

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

15

Etter å ha spilt tannlegespillet kan jeg forklare en venn hvordan tannlegen borer

	1	2	3	4	5	
Veldig uenig	○	○	○	○	○	Veldig enig

Appendix H

Interview Questions: Round 1

Questions

Først, kan du fortelle oss hva spillet handlet om?

Hva tenker du om fortellingen? Er det noe du kjenner deg igjen i?

Var det noe du synes var morsomt i spillet? Hva da?

Hvordan var det å trykke seg rundt?

Var det noe du ikke skjønte?

Var det noe du synes var vanskelig?

Hvordan var det å lese teksten? Var den enkel å forstå?

Hva synes du om borringen?

Lærte du noe du ikke kunne fra før?

Det Mari gjorde i spillet er ting som du selv kan gjøre for å forberede deg til tannlegen: blant annet det å ringe til tannlegen for å få vite mer om det tannlegen skal gjøre. Var dette en tanke som slo deg?

Har du noen tanker om hva vi kan ha med i spillet for å gjøre det mer spennende eller mer utfordrende for deg å spille? Tenk da litt på hva det ikke var mulig for deg å gjøre nå, som du kanskje trodde var mulig.

Hvis du fikk utforsket tannlegekontoret, hva ville vært morsomt å kunne utforske?

Appendix I

Interview Questions: Round 2

Questions

Kan du fortelle hva spillet handlet om? (kun nye)

Var det noe du synes var vanskelig i spillet?

Visste du alltid hva du skulle gjøre?

Var det noe du synes var morsomt i spillet? Hva da?

Hva synes du om videoen? Fikk du med deg alt som ble sagt?

Likte du å få teksten opplest? Hvorfor/hvorfor ikke?

Ble det lettere å spille spillet med teksten opplest, eller hadde det ikke noe si for din del?

Vise fram instrumenter og spørre om de husker hva de heter og hva de brukes til.

Var det morsomt å høre lydene fra instrumentene?

Når du hører lyden fra et instrument, tror du at du kan si hvilket instrument du hører?

Kan du fortelle oss hva tannlegen gjør når han/hun skal fjerne et hull i ei tann?

Hvordan klarte du den siste oppgaven, altså borringa på denne gangen? Var det lettere eller vanskeligere å borre riktig?

Hvis du hadde hatt noen venner som var redde for å bore. Hvis du tenker på det du akkurat har gjort i spillet, har du et råd du kunne gitt vennene dine før de skal til tannlegen?

Har du også et forslag til hva de kan gjøre hvis de blir nervøse under boringen?

Føler du at du har lært noe som du ikke kunne fra før? Hva har du lært?

Hva synes du om spillet nå sammenlignet med forrige versjon?

Astrid Vik and Therese Federl

Exploring the Potential of a Serious Game Concept for Dental Anxiety Prevention in Children

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