Katarina Gjendem Murphy
Silje Marie Savland Moksnes

"Drills, Needles, and Pain": Design Recommendations for Digital Interactive Narratives in Dental Anxiety Prevention for Children

Master's thesis in Informatics: Interaction design, gaming and learning technology.
Supervisor: Yngve Dahl

July 2023

Master's thesis

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

◻ **NTNU**
Norwegian University of
Science and Technology

Katarina Gjendem Murphy
Silje Marie Savland Moksnes

"Drills, Needles, and Pain": Design Recommendations for Digital Interactive Narratives in Dental Anxiety Prevention for Children

NTNU
Norwegian University of
Science and Technology

Acknowledgements

Abstract

The prevalence of dental anxiety is extensive, impacting individuals in different age groups, including children and adults. This condition has the potential to lead to persistent dental health issues. Its onset is commonly observed during childhood, emphasizing the significance of preventive measures aimed at children, as they can effectively decrease the overall number of affected individuals. The objective of this thesis is to investigate the potential of digital technology, specifically digital interactive narratives, in preventing dental anxiety among children. To achieve this, the following research questions have guided our thesis: (1) Which measures are currently employed by dental professionals to prevent dental anxiety in children?, (2) How can existing preventive measures employed by dental professionals be transferred and potentially enriched through interactive narratives?, (3) How do children and dental professionals consider the idea of using digital interactive narratives as a dental anxiety prevention tool? These questions were answered through an investigation of relevant literature, semi-structured interviews with dental professionals, workshops with children, prototyping and evaluations with both dental professionals and children. This resulted in the digital interactive narrative prototype, ToothTales, for dental anxiety prevention as well as five design recommendations for digital interactive narratives for dental anxiety prevention: (1) Provide the individual child with the ability to make an impact on the story progression, (2) Ensure the digital interactive narrative conveys a realistic presentation of the dental situation, (3) Include visuals and audio effects to engage the child, (4) Design the interface and content with regard to the user group's age, (5) Use metaphors to visualize and simplify complex concepts. This thesis concludes that there is potential for using digital interactive narratives as preventative tool for dental anxiety in children.

Sammendrag

Forekomsten av tannbehandlingsangst er omfattende og påvirker enkeltpersoner i ulike aldersgrupper, inkludert både voksne og barn. Denne tilstanden har potensial til å føre til vedvarende tannhelseproblemer. Tannbehandlingsangst oppstår ofte i barndommen. Dette understreker derfor betydningen av forebyggende tiltak rettet mot barn, da slike tiltak effektivt kan redusere antallet berørte individer. Formålet med denne masteroppgaven er å undersøke potensialet til digital teknologi, spesifikt digitale interaktive narrativer, i forebygging av tannbehandlingsangst blant barn. For å oppnå dette, har følgende forskningsspørsmål veiledet vår oppgave: (1) Hvilke tiltak blir for tiden brukt av tannhelsepersonell for å forebygge tannlegeskrekk hos barn?, (2) Hvordan kan eksisterende forebyggende tiltak brukt av tannhelsepersonell overføres og potensielt berikes gjennom interaktive narrativer?, (3) Hvordan vurderer barn og tannhelsepersonell ideen om å bruke digitale interaktive narrativer som verktøy for forebygging av tannbehandlingsangst? Disse spørsmålene ble besvart gjennom en undersøkelse av relevant litteratur, semi-strukturerte intervjuer med tannhelsepersonell, workshops med barn, prototyping samt evalueringer med både tannhelsepersonell og barn. Dette resulterte i en prototype av et digitalt interaktivt narrativ kalt, ToothTales, for forebygging av tannbehandlingsangst, samt fem designanbefalinger for digitale interaktive narrativer for forebygging av tannbehandlingsangst: (1) Gi det enkelte barnet muligheten til å påvirke historiens utvikling, (2) Sørg for at det digitale interaktive narrativet formidler en realistisk fremstilling av tannbehandlingssituasjonen, (3) Inkludér visuelle effekter og audio for å engasjere barnet, (4) Design brukergrensesnittet og innholdet med hensyn til brukerens alder, (5) Bruk metaforer for å visualisere og forenkle komplekse begreper. Denne masteroppgaven konkluderer med at det er potensial for å bruke digitale interaktive narrativer som et forebyggende verktøy mot tannbehandlingsangst hos barn.

Contents

List of Figures

List of Tables

1   Introduction

Maintaining good oral health is an integral component of overall health, and as such, regular dental check-ups represent a crucial aspect of preventive oral care [3–5]. They are a cornerstone of preventative oral care, serving as an essential means of identifying and addressing dental issues before they escalate into more significant health problems. However, for some individuals, visiting the dentist can be a source of significant stress and anxiety. Dental anxiety represents a psychological state in which a negative emotional response is evoked during a dental treatment [6]. This state of mind can have a detrimental impact on oral health as it is associated with a reduced frequency of dental appointments as well as increased incidence of dental caries, resulting in a negative impact on oral health [7].

Dental anxiety affects individuals in all ages, with its onset often occurring during childhood and potentially persisting into adulthood [8, 9]. As such, implementing preventative measures aimed at children may contribute to a decrease in the prevalence of dental anxiety among children and adults.

Existing interventions and treatments for anxiety in children undergoing medical treatments are often expensive and resource-heavy [10]. There can exist a gap between the child and the counselor, which again can cause the child to withdraw from therapy [10]. Given these challenges, a low-cost and digitized tool focused on prevention of anxiety has been suggested might be a possible aid in reducing the need for interventions [10, 11].

The development of technological aids to prevent anxiety in both children and adults has yielded promising results in various health sectors [10, 11]. One immersive Augmented Reality (AR)-based game solution where the child can explore the narrative of a cartoon-based doctor have shown to "[...] increase overall positive affect during the preoperative time" [11]. A serious game solution recorded lower levels of anxiety in children when played one week before their respective surgeries [10]. Although these show very promising results in the reduction of anxiety in hospital treatments, there is a lack of studies done on the preoperative anxiety in dental treatments for children.

Another concept in the field of edutainment is the development of digital interactive narratives. A digital interactive narrative differs from serious games in the sense that it provides the user with the possibility of creating their own narrative through the choices they make and the consequences of these [12]. Not much research has been done on the effect of digital interactive narratives in the prevention of anxiety in

children, but studies show that the use of digital interactive narratives in children's education has proven effective on learning outcomes [13]. This thesis was guided by the following three research questions (RQs):

1. **RQ1:** Which measures are currently employed by dental professionals to prevent dental anxiety in children?

2. **RQ2:** How can existing preventive measures employed by dental professionals be transferred and potentially enriched through interactive narratives?

3. **RQ3:** How do children and dental professionals consider the idea of using digital interactive narratives as a dental anxiety prevention tool?

This research is of a qualitative nature and various methods were employed in order to answer the research questions. The research design utilized a combination of user-centered design and participatory design principles, incorporating appropriate activities to ensure user involvement and feedback throughout the process. The research questions were explored through a combination of investigation of literature, semi-structured interviews, workshops, prototyping and user evaluations.

To address research question 1, both a literature investigation as well as semi-structured interviews with dentists were conducted. The literature investigation mainly concentrated on research addressing techniques used in pediatric dentistry as well as the usage of narratives and storytelling in various health care sectors.

These two methods and their findings, contributed to answering research question 2. They provided us with a deeper understanding of the existing measures used in pediatric dentistry and their possible application in an interactive digital narrative.

Lastly, to address the third research question, we developed a interactive narrative named ToothTales based upon findings obtained from the literature review and interviews. In addition to this, findings from a workshop conducted with children within the age range of 7-9 were also incorporated into the development of the digital interactive narrative. The application was thence evaluated by dental practitioners and children. The data was gathering data from a combination of observations and interviews. The main contribution of this thesis is a set of five design recommendations for the design of an interactive narrative for dental anxiety prevention in children.

This thesis consists of eight chapters. Chapter 2 and 3 presents relevant literature related to dental anxiety and digital interactive narratives. Chapter 4 presents the research design methods applied in this thesis, and chapter 5 outlines the various research and design activities employed and their associated results. Chapter 6 discusses

the findings in this thesis and five emerged design recommendations, while chapter 7 discusses the methodological considerations related to the applied methods. Finally, chapter 8 summarizes and concludes the thesis.

2 Dental Anxiety

This chapter presents a brief overview of dental anxiety, commencing with a definition followed by a presentation of its prevalence, causative factors, and consequences. Additionally, common treatments and prevention methods are also presented.

2.1 Definition

The severity of negative emotions associated with dental encounters can be categorized. Individuals may exhibit emotional reactions to certain dental stimuli, such as feeling uneasy or uncomfortable at the sound of a dental drill, which is referred to as dental anxiety [14]. Moreover, dental anxiety is characterized by a continuous expectation of experiencing pain or apprehension during dental situations [6]. If the intensity of anxiety experienced is significant, it may qualify for classification as a phobia. Dental phobia is marked by a lasting and intense fear of specific situations or objects that are easily identifiable, resulting in avoidance of necessary dental or enduring a treatment with prominent apprehension. The impact of this phobia on daily life is often significant and can have a disruptive effect on daily life [6].

2.2 Prevalence

Although precise figures regarding the global prevalence of dental fear and anxiety are lacking, research estimates suggest that dental anxiety or dental phobia affects approximately 11 to 25 percent of adults in Western countries [9, 15]. This is similar to numbers regarding its prevalence in the younger population. A systematic review of papers conducted in 2017 examined dental anxiety and its prevalence among children. The findings indicated that approximately 10-20% of children and adolescents worldwide, aged 10-19 years, experience dental anxiety and fear [16]. There are lacking studies conducted in Norway regarding the prevalence of dental anxiety in children, but a study from 2007 revealed that 11.3% males and 19.8% females aged 25 years, experience dental anxiety [17]. A study from 1999 in Norway focusing on dental anxiety among children aged 12-18 years old, indicated that 22.4% experienced a high level of dental anxiety [18]. Regrettably, recent statistics concerning dental anxiety among children in Norway are unavailable. However, it is plausible to infer that the figures fall within the aforementioned range.

Moreover, given that this master's thesis is being conducted in Australia, we also explored the available data regarding dental anxiety among Australian children. Regrettably, obtaining such specific data proved challenging; nevertheless, data concerning dental anxiety within the general population was found to be 16.1%, aligning with

the previously mentioned range [1].

2.3 Causes

Dental anxiety can affect people in all ages and there are various factors which contribute to developing dental anxiety. However, dental anxiety's onset often occurs during childhood and can potentially persist into adulthood [8, 9]. One of the most common factors contributing to dental anxiety is the experience of past traumatic experiences in dental situations [19, 20]. Another common factor contributing to dental anxiety and the avoidance of treatments is the fear of pain [21, 22]. Additionally, many overestimate the pain they will feel prior to the appointment, as well as the experienced pain after the treatment [23, 24]. Dental anxiety can also be triggered by the fear of the unknown and loss of control if one is not provided with sufficient information about the treatment or do not understand the given explanation [25]

In addition to this, as children are easily influenced by the people around them, they can become anxious by seeing or hearing negative information from their family, friends, television, and social media, thereby affecting their perception of dental visits [26]. Likewise, studies have shown there is a correlation between parents' and their child's perception of the dentist as they often share the same attitudes towards dentistry [14, 27].

2.4 Consequences

Research has suggested that the effects of dental anxiety extend beyond the dental aspect and can have more far-reaching consequences for overall health. Studies indicate that individuals who experience dental anxiety may have lower levels of social well-being in comparison to those who do not experience dental anxiety [4]. It has also been associated to numerous quality of life concerns in youth, including pain, social withdrawal and difficulties eating [5].

Likewise, it can also lead to poor dental health as people with dental anxiety are prone to miss or delay dental appointments compared to those without dental anxiety [14, 28]. Thus, a vicious circle may arise in which poor dental health results in serious dental issues which can be painful and expensive to repair. This can in turn further intensify the existing fear and is known as the vicious cycle of dental fear. This idea is supported by several studies explaining dental fear [29–31]. The model of the vicious circle of dental fear can be seen in figure 1.
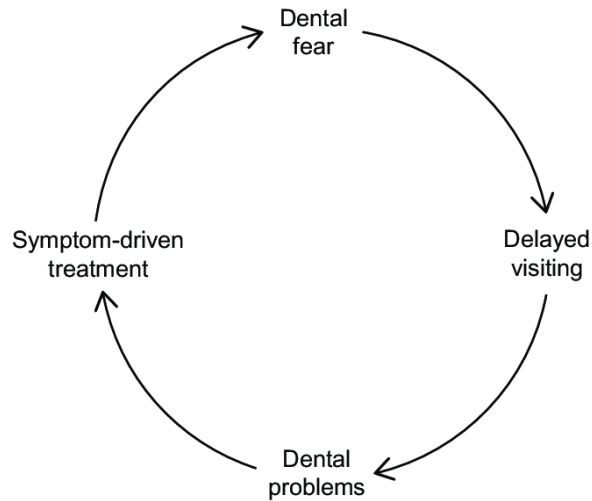
Figure 1: Model of the vicious circle of dental fear [1]

There is also a significant correlation between inadequate oral health and diminished mental and physical well-being, including conditions such as depression, social anxiety, heightened susceptibility to cardiovascular diseases and diabetes, and a decreased quality of life [7, 14, 32].

2.5   Treatment and prevention

A significant number of individuals who suffer from dental anxiety report that their anxiety originated in their childhood, typically following instances of experiencing pain or a perceived loss of control during dental appointments [14]. While dental anxiety may diminish as individuals grow older for some, this is not the case for a considerable portion of those affected [14]. Due to the typically high cost associated with dental treatment, poor oral health is not only a health concern but also an economic burden. Patients with dental anxiety and phobia often necessitate extensive and expensive therapeutic interventions to enable them to receive regular dental care. In Norway, a dental anxiety treatment service has been allotted 100 million NOK in the National Budget since 2011, as reported by the Norwegian Dental Association [33]. Thus, many methods for treatment and prevention are aimed at children.

To prevent dental anxiety, it is crucial for children to have positive experiences that instill a sense of control and predictability during their visits to the dental clinic. The American Dental Association lists, among others, familiarization with both the dental office and the procedures done in the office as means to alleviate dental anx-

iety in children [34]. Some of these measures include "pre-visit imagery" where the child and parents are presented with pictures and information about the upcoming appointment, and a "tell-show-do" approach where the details of the procedure are explained and demonstrated. In this technique, the dentist will first explain what will happen, followed by a demonstration of the before actually performing it [28, 35]. This measure helps desensitize children to the dental settings and help to prepare them through the process of familiarization [34].

In addition to this, cognitive behavioral therapy (CBT) is a widely accepted and successful therapy method for anxiety, including dental anxiety [28, 32, 36]. It aims to change undesired thought patterns and behavior by teaching individuals better ways to manage their anxiety [28]. Exposure therapy, a form of CBT, is used specifically for dental anxiety, gradually exposing patients to feared elements in a safe environment to reduce their fear and encourage them to seek dental treatment independently [28]. In recent years, digital solutions such as virtual reality exposure therapy (VRET) have been tested and proven effective in decreasing anxiety before medical procedures, including dentistry [37, 38]. However, the use of digital interactive narratives as a treatment for dental anxiety requires further research to fully understand its potential and effectiveness [28, 39].

3 Digital Interactive Narratives

This chapter presents an overview of digital interactive narratives, starting with defining the main properties of digital interactive narratives, before concluding with a presentation of how similar technologies have been used in various health situations.

3.1 Definition

A digital interactive narrative is also referred to in research as digital interactive storytelling. The research surrounding these terms often generally define them as "*[. . .] a form of interactive media*" [40], and more specifically as a distinction from legacy media, which can be defined as film, electronic media and printed artifacts [41]. The most recent definition is provided by Koenitz:

"*Interactive digital narrative is a narrative expression in various forms, implemented as a multimodal computational system with optional analog elements and experienced through a participatory process in which interactors have a non-trivial influence on progress, perspective, content, and/or outcome*" [42].

The field of study surrounding digital interactive narratives is evolving rapidly and has been through many changes since its beginnings around the 1960's [43]. It is based on the more traditional mediums of storytelling such as books and videos [43]. A common red thread through the last 50 years is the change of the traditional roles of an active author and an inactive audience [44]. Central to a digital interactive narrative is that the role of the author has become a more passive one, while the audience now takes an active role as the storyteller. Whereas books will guide you through a story, a digital interactive narrative will let you as a reader take a more active role as the author [44].

Janet Murray's research on digital interactive narratives resulted in a definition of three key concepts: immersion, agency, and transformation [40, 45]. These three concepts are essential in a participatory medium such as a digital interactive narrative where the user is given more control over the narrative [40, 45].

Immersion is the notion of an engaging and attention grabbing environment that not only engages the user in the unbelievable, but also encourages the user to actively create belief [40]. Immersion invites the user into an environment that occupies the users sensations and attention, creating an environment the user wants to remain in [40] .

Although a digital interactive narrative shares many of the same attributes as games, they are often distinguished in the key feature of agency [46]. Agency in digital interactive narratives concerns the engagement of the user, giving them the possibility of taking meaningful actions, and providing the user with feedback which responds coherently to those actions [40]. A key feature in games is the focus on ludic play, which can be defined as spontaneous and undirected playfulness [47].

Transformation surrounds the plasticity of computational environments, facilitating a multidimensional presentation that supports the user's own reflection [40]. Janet Murray relates transformation to a form of impact on enactment within an immersive environment, hoping to establish a catharsis effect that can be both entertaining and possibly useful in psychotherapy [40]. Murray also discusses the role of transformation in open-ended narratives, where a form of transformation is constantly listening to the immersion and agency of the narrative and forms it thereafter [40].

3.2   Elements of Engagement and Education

Digital interactive narratives are essentially digitized children's books with the added support of immersion, agency, and transformation. Books have a static storyline that invites children into a premade world of fantasy that follows the narrative of the author [48].

Engaging children to participate in immersive learning environments is important as children do not always find learning in itself to be motivational [49]. A study done on the effect of learning in an educational serious game showed that the children were more engaged when they felt like they participated in the creation of something [49]. This resulted in more satisfaction and a bigger learning outcome for the children who participated [49].

In terms of learning, dual-coding is shown to increase the learning outcome. In other words, information brought through more than one sensory channel causes better learning [50]. Multimedia is also more efficient than printed books when they are read without adults [51].

However, this is only beneficial as long as the individual media's features complement each other rather than cancel out each other [48]. There is also a limitation to how much information a child's working memory can hold at once. If the child must switch between processing one information to another and is not able to integrate them, it can lead to cognitive overload and the children might fail to understand the story [50]. Therefore, it is important to match the media used in a digital interactive

narrative to each other and the narrative [50].

Digital interactive narratives support constructivism, a theory in education. Constructivism states that learners develop their knowledge through active and subjective processes [52]. Through a digital interactive narrative, the child is put in a situation where it is actively involved and empowered by the story and receives meaningful feedback through the movement of the plot. A study by [53] has defined four essential traits for empowering children: co-design, customization, identity, and manipulation.

The first essential trait is co-design through the narrative. By allowing users to make choices throughout the story and making their interactions meaningful it creates immersion and ownership. This further contributes to engagement and motivation in the reader [54].

The second trait is to allow the user to customize how their learning should occur. Different people have different types of learning styles that work for them. In interactive narratives it is possible to make many types of interactions and further create many possible scene combinations. The user can then make their own decisions about how learning will occur by deciding what to interact with [55]. The narrative will transform and adapt itself based on the choices made, and will present the user with further possibilities for exploration as it progresses [40].

The third trait in interactive fiction is to take on a new identity which the user values and can become heavily invested in. This will lead to a commitment from the user, which again is essential in deep learning. There are two ways to create this commitment to an identity in a character. The first is to make the character in the narrative so intriguing that the users want to inhabit it. The second way is to have a character where the users chose the traits to create a deep history.

The fourth and last essential trait in interactive fiction is manipulation and distributed knowledge. Humans feel empowered when they can manipulate tools in ways that can expand their skills. By having a powerful tool that the user can manipulate in an interactive narrative the user can make a variety of choices and manipulate the outcome for the character. They can then go on to other adventures, learn from experiences and further manipulate outcomes of the story. This way the user will be able to explore the world and become engaged in the story.

3.3 Interactive storytelling for health

As mentioned above, digital interactive narrative allows for multiple storylines and outcomes, where it is affected by the readers choices. In the context of health, this possibility can be particularly relevant to health communication because the goal is often behavior change, demonstrated by benefits of some behaviors and disadvantages of others [56]. Current interventions for preoperative anxiety are often "*[. . .] costly, time consuming, vary in availability, and lack benefits*" [10]. Because of this, there arises a need for accessible and low cost solutions that can aid in reducing dental anxiety before it develops into an issue that requires more extensive interventions [10].

One such experimental and low-cost concept is the use of serious games in the prevention of perioperative anxiety in children [10]. An example of such a game is CliniPup, a serious game with the aim of preventing anxiety in children destined for surgery [10]. They tackle the challenge of managing anxiety by having the player play through a depiction of an actual surgery at the hospital. CliniPup focuses on explaining typical emotions on the day of the surgery, as well as explaining what anxiety could look like. The players combat these things by helping the main protagonist overcome these challenging feelings, while the protagonist explains the what and why of these challenges. The results of the study done with CliniPup indicated that the participating children experienced significantly less preoperative anxiety when CliniPup was played one week prior to their surgery. The game did, however, not have an effect on the tackling of pain the children felt after the surgery [57].

Another promising study is "Doc McStuffins: Doctor for a day", a Virtual Reality (VR) application used for reducing preoperative anxiety in children and for providing both the child and the parents with more satisfactory preoperative care [11]. Like CliniPup, Doc McStuffins lets the player take the role of the doctor for a day. Doc McStuffins differs, however, by letting the player take the role of a student doctor helping several different patients with different illnesses, instead of one main character dealing with a single condition. The study showed a significant decrease in patient anxiety, successfully distracting them from their own nervousness by creating an immersive and interesting game [11].

4   Research Design

This section will present the research and data gathering techniques employed in the project along with an outline of the methods utilized in the project.

4.1   Design Approach

The project employed a user-centered design approach with some activities inspired by participatory design.

4.1.1   User-centered design

User-centered design is a design approach in which the aim is to develop usable and effective products by placing emphasis on the needs and requirements of both children and dental professionals as users. The main principle behind user-centered design is that in order to create such solutions, designers must have a comprehensive understanding of the needs of end-users and other stakeholders. A user-centered design method can enhance human-centered qualities such as usability, accessibility, user experience and avoidance of harm caused from use of the system[2]. In ISO 9241-210[2], which outlines the user-centered design process, four main design activities are presented: understanding and specifying the context of use, specifying user requirements based upon a thorough understanding of the user, producing design solutions which meet the specified requirements, and evaluating the solution against the requirements. The user-centered design process proposed by ISO 9241-210 [2] is illustrated in Figure 2, while the modified version we followed in our design process can be seen in Figure 3 below.
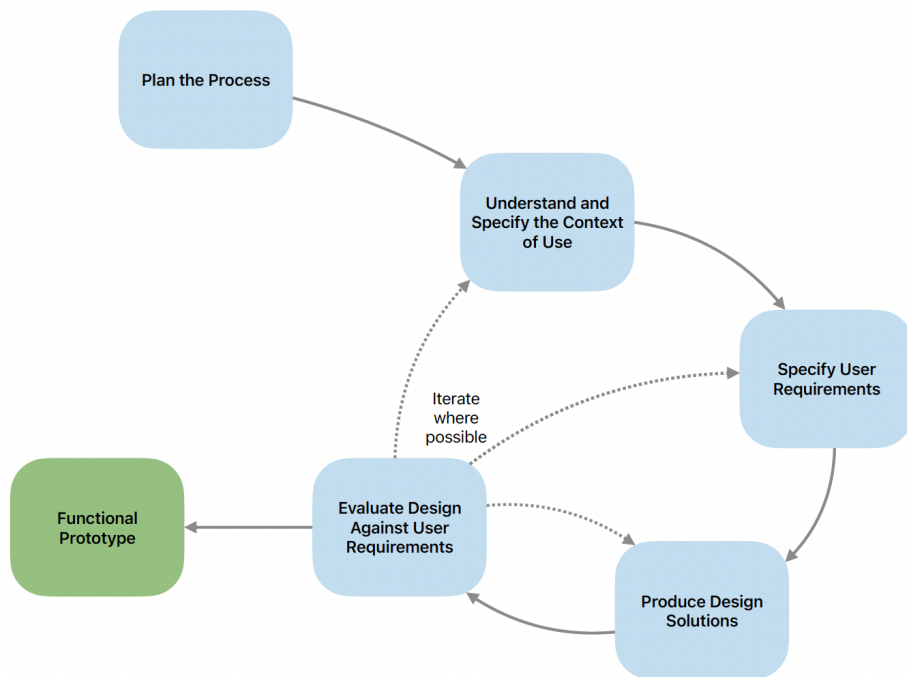
Figure 2: User-centered design process according to the ISO standard 9241-210 [2]
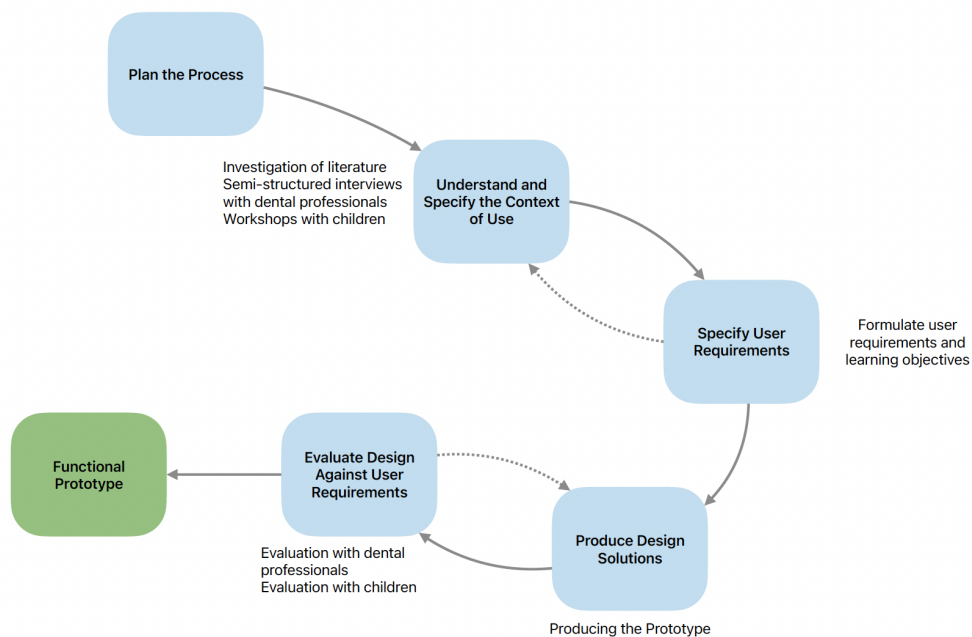
Figure 3: Our adapted design process with research and design activities

13

4.1.2 Participatory design

An important aspect of this design approach is to systematically involve users and stakeholders in decision-making processes, enabling them to assume a critical role and actively influence the design process towards addressing their needs[58].

This design approach was mainly applied during the process of conducting workshops in which the aim was to specify the user requirements for our interactive narrative named Tooth Tales through the involvement of end-users. In addition to this, participatory design was also employed during the evaluation of the product.

4.2 Design Process

This section will present the design process of this thesis and how we applied the user-centered and participatory design approach.

4.2.1 Plan the Process

In accordance with ISO9241-210, a user-centered project should plan and allocate time for how user-centered activities will be integrated into the overall project schedule.

At the project's outset, the general project constraints were identified in order to obtain an understanding of the project's time scale as well as the process of incorporating users and their insight into the project. Given the final submission deadline in June, the project is subject to a fixed time frame. Furthermore, since the project largely is situated in Australia, the plans also incorporate the involvement of both Norwegian and Australian stakeholders.

This thesis' plan is illustrated in the form of a Gantt chart which is illustrated in Figure 4.

	2022	2023														
	Aug-Dec	February			March				April					May		
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investigation of Literature																
Semi-structured interviews with dental professionals																
Workshops with children																
Specifying user requirements																
Prototyping																
Evaluation with dental professionals																
Evaluation with children																
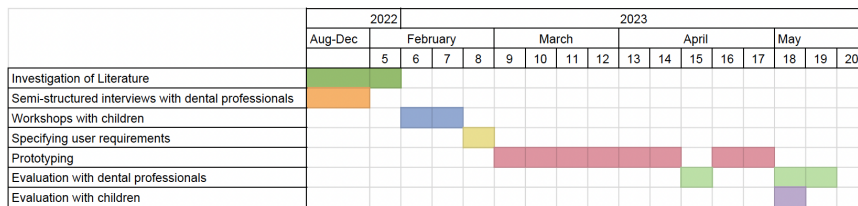
Figure 4: Gantt Chart with overview of research activities

Additionally, as there we were three students working on the same project, each with a different focus and research questions, we needed to carefully plan our process to ensure that both research areas were adequately covered throughout the various research and design activities. This was achieved by collaborating on all research and design activities and ensuring that we gathered a sufficient amount of data for both theses.

4.2.2 Understanding and Specifying the Context of Use

The context of use of a product refers to a specific amalgamation of users, goals, tasks, resources, and environment in which it is being used [2].

In order to acquire insight into the context of use, a preliminary study was undertaken. The study centered around acquiring knowledge with regard to the user groups, as well as identifying potential measures to incorporate into the product. This was accomplished through conducting initial semi-structured interviews with pediatric dentists in various dental clinics in Sydney to obtain a comprehensive understanding their approaches to treating and working with young patients. The interviews sought to answer questions related to dental anxiety and to identify which situations during an appointment might trigger it. The participants were also inquired about the techniques employed during appointments with children to mitigate anxiety and how these techniques impact the young patients. During each interview, written notes were taken along with an audio recording. The recordings were subsequently transcribed into written format which then were coded and meticulously analyzed.

Incorporating participatory design in the process also contributed to the understanding and specification of the context of use. As this democratic approach emphasizes the empowerment of participants and enables a systematic inclusion of users and stakeholders in the design process, it allows for a more comprehensive understanding of user needs and preferences [59].

This was achieved through conducting workshops with children in the targeted user group inspired by the participatory design approach. The workshop provided a more comprehensive understanding of user needs and preferences.

Moreover, the aforementioned investigation of literature also provided valuable insights into the product's context of use. The investigation furnished crucial information about existing and similar solutions, and their efficacy in addressing children's anxiety. Additionally, it also included an examination of research focused on children's accessibility to digital devices and their utilization patterns.

These activities proved valuable as a basis for developing personas and scenarios.

4.2.3 Specifying the user requirements

In a user-centered design process, the intended context of use serves as a constraint and provides valuable insights for determining user requirements[2]. These requirements are derived from the needs and goals of users and stakeholders, forming the fundamental basis for designing and evaluating products and services[2].

The user requirements for the solution were established by utilizing the personas and scenarios which were derived from the preliminary research, as well as insight obtained from the interviews with dental professionals and workshops with children. Thus, the user requirements also consider the context of use in which the product will be used. The user requirements are outlined in section 5.3.2.

In addition to user requirements, learning objectives were formulated, see section 5.3.2 for an overview. According to Warren and Jones, they are aims are intended to achieve as they engage with the system [60]. Moreover, Warren and Jones suggest learning objectives to be formulated with the with the following start: "The learner will..."[60]. Thus, we decided to follow the format given by Warren and Jones. However, we decided to change "learner" to "user" as the project process is inspired by user-centered design and the target group is often referred to as users in this approach.

The learning objectives state the aims in which the user is intended to achieve as they interact with the digital narrative. The objectives are based upon the semi-structured interview conducted with dental professionals. Moreover, including such domain experts in the formulation of learning objectives is crucial as they contributed their knowledge to the learning aspect of the narrative. Their involvement ensured that the learning objectives accurately reflected the desired educational and aligned with the subject matter addressed in the narrative.

4.2.4 Producing Design solutions

Designs are influenced by various factors such as the context in which the solution will be used, existing applications in the field, as well as design and usability guidelines along with the experience and knowledge of the design team [2]. In the process of producing design solutions, it is necessary to create concrete designs using prototypes, which are then evaluated based upon user-centered evaluations[2]. Such an evaluation, which is based upon obtaining user insights, is a necessary activity in a

user-centered design approach. It can be used to gain new insight into user needs, provide feedback on the design, assess whether user requirements have been achieved as well as establish a baseline[2]. It is advised to conduct such user-centered evaluations in the early stages of a design process.

Prior to proceeding with user evaluations, personas and scenarios were, as mentioned, developed based upon preliminary research, interviews with dental professionals and workshops with children. These tools provided a deeper understanding of the intended user group of the product. This understanding, along with the user requirements, allowed us to create a conceptual model which illustrates how the product were to be organized and operated[61]. The conceptual model can be found in Appendix B.

Based upon this, a functional prototype in the form of a digital interactive narrative was developed which was subsequently evaluated by a dental professional. Their feedback was then incorporated into the prototype and then evaluated by children before undergoing further evaluation by dental professionals and psychologists in the field of pediatric dentistry and dental anxiety.

5 Research and Design Activities

This section aims to outline the various design activities conducted in this thesis. Each research activity will encompass segments detailing its purpose, participants, our roles, preparation, procedure, and setup. For each research activity, the results and key findings will be presented. The design activity will include a presentation of the prototyping tools used to develop it, a description of the prototype as well as a brief overview of the top prioritized user stories and description of the each scene in the prototype.

5.1 Research Activity 1: Semi-Structured Interviews with Dental Professionals

This section will describe the semi-structured interviews conducted with dental professionals.

5.1.1 Purpose

The main purpose of the semi-structured interview was to gain more insight into preventative measures employed by dental professionals when interacting with children. Furthermore, we sought their evaluation of a digital interactive narrative aimed at mitigating dental anxiety and the concept's potential efficacy. Thus, the following subsequent goals were established for the interviews:

- Gain a deeper understanding of the factors contributing to dental anxiety in children

- Acquire knowledge about measures applied when treating children with dental anxiety.

- Gain insight and feedback from dental professionals regarding their perspectives on our proposed concept.

5.1.2 Participants

The semi-structured interviews took place in various dental offices in Sydney, Australia as well as online over video conferencing platforms. In total, 6 dental professionals participated in the interview process. The participants had varied backgrounds as some were research advisors and pediatric dentists while other were general dentists and oral health therapists. Prior to the interviews, all participants signed a form of consent informing them about the project as well as the impact of their participation.

The consent form can be found in Appendix H.

An overview of the participants and their occupation as well as country of origin can be found in Table 1 below.

Occupation	Dental Clinic	Country
Dentist	Randwick Dental Clinic	Australia
Dentist	Randwick Dental Clinic	Australia
Oral Health Therapist	Dental Paediatrix	Australia
Oral Health Therapist	Centennial Smiles	Australia
Research Advisor	TkMidt	Norway
Dentist	TkMidt	Norway

Table 1: Overview of participants

5.1.3 Roles

During the interviews, the three of us assumed two primary roles. The main role was the interviewer who was responsible for asking questions. The other role had the responsibility of taking notes and observing the interview process. By following this arrangement, it the interviews were conducted in an effective manner as the workload was shared between the two researchers.

5.1.4 Preparation

Prior to the semi-structured interviews and in order to facilitate the interview process, an interview guide was created. It encompasses objectives and corresponding questions formulated on the basis of the research questions of the thesis. The interview guide can be found in Appendix A.

5.1.5 Procedure and Setup

The five interviews were conducted at various dental offices over the course of two months during work hours. Each session lasted approximately 30 minutes. Furthermore, the interviews were mostly conducted individually with one participant at the time. However, when possible, we conducted the interviews with two dental professionals at a time.

Each interview was documented through audio recordings as well as video recordings when applicable in digital video conference tools. In addition to this, notes of the interview were taken to ensure accurate documentation of the interview.

The semi-structured interviews consisted of the following steps:

1. Introduction: Present the project and introduce us.

2. Information about the participant: Participant gives brief presentation about themselves.

3. Their experience with treating children

4. Their experience with dental anxiety in children

5. Question: Possible causes of dental fear

6. Present the project concept: Their evaluation of it and whether their measures can be applied in a digital interactive narrative

The complete interview guide can be found in Appendix A.

5.1.6   Results

This section will briefly summarize the main findings from the initial semi-structured interviews with dental professionals. The results will be presented pertaining to the aforementioned objectives for the semi-structured interviews.

Factors such as fear of the unknown, lack of control, the influence of others and an overactive imagination may contribute to dental anxiety in children
Data from the interviews indicate that varying factors contributing to dental anxiety in children. Previous negative experience with a dental situation can significantly influence children's perception of the dentist. Additionally, an overactive imagination may also play a role, particularly in individuals who have developed elaborate stories about dental procedures. Likewise, the influence of other's words and their opinions is also noteworthy and can have a significant impact. This includes statements from parents, siblings, friends, or peers at school, suggesting that dental procedures will be painful:
"Yeah, maybe parents or kids at school or older siblings have said, like 'Oh, you're going to the dentist! Oh, you're gonna get your teeth filled out or it's gonna hurt'"
(ID 1.1). This may cause feelings of apprehension and skepticism during their dental treatment: *"So, when they come in, they're like 'I know what you're going to do, and I'm not going to sit here for it'"* (ID 1.1).

In addition, anxiety can be further heightened by the fear of the unknown and a

sense of lacking control, as children can become uncertain about what will occur during the dental procedures. For some, the mere thought of dental treatment can be daunting, and the absence of clear explanations prior to procedures can increase fear and discomfort. Furthermore, the impact of anxiety on dental experiences and fear caused by not knowing what will happen, is exemplified in the following account from a participant:

"I had this patient. She was like super anxious about getting a tooth out and you could tell that she kind of understood about what was going on. But she was like, she had an infection. She did it. It was a horrendous experience you know. She is crying, her mom is like really stressed. Yeah, I'm nearly crying. Accidents happen sometimes, but then the tooth came out and she was just like 'Oh, is that it?' 'Yeah, but like, what did you imagine' but she was like 'I thought it was gonna be all black and there was gonna be an infection and there was gonna be blood and...'. Oh, so you just think like it's gonna be that bad? A lot of anxiety problems just come from unknown" (ID1.2).

However, some patients express fear towards specific dental instruments and tools, such as the syringe or sharp metal objects, as they are perceived threatening. *"Everything looks scary cause it's like made out of metal. They're like 'What's this?' and 'What's that?'"* (ID1.1)

Additionally, some participants also indicated that age of first visitation may also have an implication on fear of going to the dentist. Patients who have never visited the dentist until a later age, approximately around 7 years old, tend to be distrusting towards dentists due to unfamiliarity and possibly the intimidating appearance of dental equipment. *"I think, I tend to find like patients that come back older as well, maybe like 7, uhm, that haven't been to dentist before. They're just less trusting and are like, 'Oh, what's that?' and everything about the situation is scary"* (ID 1.1)

Furthermore, it is crucial to acknowledge that encounters with violence, abuse, and neglect significantly influence overall health, including dental well-being. The accumulated weight of these experiences frequently give rise to additional complications and thus intensifying pre-existing anxieties. As one participant explains: *"Very often, the total burden a person has experienced leads to encountering more problems. If the cup is already full when you have a bad experience at the dentist, it makes it easier for you to develop anxiety about new things as well."* (ID 1.6)

Knowledge, control, options, trust and metaphors are important factors when treating children with dental anxiety

Creating a positive and comfortable dental experience for children, particularly for those with anxiety or fear, is essential for their overall oral health and well-being. By

implementing specific strategies, dentists can help alleviate children's anxiety. An important aspect of this is to thoroughly present and introduce the dental environment to the child, especially during their first visit. Namely, the dentist may take time to properly introduce themselves, show the child around the office, as well as explain the various instruments in a simple and age-appropriate manner. Another important aspect of making the child more comfortable is to be at their level when talking to them. According to the participants, by doing so, the child will become more secure and familiar with the situation and their surroundings, and possibly reduce any fear or uncertainty they might have:

"The thing we do if it is a new patient is to introduce ourselves, just let them have a look around. It's really important to be at their level, so if they're this short we always have to carry down and talk to them eye to eye to make sure that they're comfortable." (ID 1.3).

Moreover, giving the child control and options can contribute to building trust which is crucial throughout the appointment. The data also indicated that dentists should prioritize the child's comfort by offering options like sitting in the chair or on the floor and stopping if the child becomes anxious or overwhelmed. By respecting their boundaries and allowing them to be in control, children will feel more at ease and develop a positive association with dental visits.

"Well, again, we give them options. It's like you can either sit on this chair or you can sit on that chair. You can sit on mum's lap, or, you know, we can do it standing up. So, we have lots of options. Sometimes we do it on the floor, so yeah, anything that they're comfortable with but you just have to give them a few options so they'll me more comfortable." (ID 1.3)

Additionally, the data also suggests that a structured and predictable appointment helps children feel more in control of the situation. For instance, dentists can explain each step of the procedure in a simple and understandable manner, allowing children to know what to expect. Offering choices, like asking whether they want to count their top or bottom teeth first, empowers children and increases their sense of control. According to one of the participants, *"We let them have a lot of control, like 'what would you like to do?' 'Would you like to count the top or bottom teeth'. So, we give them options. And yeah, so they feel like they're in control and a bit more comfortable in this setting.* " (ID 1.3).

Visual aids, such as mirrors that children can hold to observe their teeth, can enhance their understanding and engagement (*"So we tell them everything that we're going to do from showing them "this is a mirror, you can hold the mirror, you can have a look at your teeth. Then they'll understand more of what's going on"* (ID

1.3). Dentists may also recommend child friendly cartoons and TV shows about visiting the dentist to help familiarize children with the dental experience before their appointment. As one dentist explains, "*We talk about like cartoons like Peppa Pig. There's 'Peppa Pig Goes to the Dentist'. I remember there are other ones as well. We're like 'just watch that episode of whatever', and those are usually really good. They work most of the time and they sort of know what to expect.*" (ID 1.3).

Dentists can also explain basic concepts, such as what plaque is, the importance of brushing teeth, and what decay and cavities are using age-appropriate language and metaphors. Comparing dental instruments to more tangible concepts and giving them pet names was also often mentioned in the gathered data. For instance, like comparing the drill to a shower as stated here by one participant:
"*I like the way the appointment involves a little, like yeah, like little names for everything, that will make sense to them. Like the drill. Because when we're drilling, you don't feel the drill, you just feel a lot of water in your mouth. Like the high speed, you don't feel that. For real. It is just a lot of water. And that's like a tooth shower*"
(ID 1.2).

Some participants also proposed using analogies during treatments such as giving an injection of anesthesia: "*I'm just gonna put on a cream. I'm going to offer the tooth fairy to come in and make the tooth fall asleep. I'm going to draw a little X here so she knows where to land, and you know you might feel like your mouth is becoming like a marshmallow. That's ok, and after it's numb, which takes about 2 minutes to numb, we do the injection and then like the tooth fairy might land. Sometimes she's wearing high heels. You might feel her high heels landing and she's gonna walk around. And she's wearing a really pretty dress today and that's when I come in with the needle and then sometimes, they feel like, 'Oh, I can feel her high heels it is a little bit sharp'. And sometimes they don't feel that at all, which is really good.*" (ID 1.3).

Thus, creating a positive dental experience for children requires a combination of open and age-appropriate communication, distraction techniques, empowerment, and knowledge. By implementing these strategies, dentists can help children overcome anxiety, develop a sense of control, and maintain their oral health.

Familiarity, recognition, fun and nonthreatening instruments important for a digital interactive narrative for the prevention of dental anxiety
During the semi-structured interviews, the concept of a digital interactive narrative aimed at preventing dental anxiety in children was discussed. The participants were encouraged to provide feedback as well as to propose recommendations for developing such an application and what story elements to include.

Based upon the gathered data, the participants were positive towards a concept of creating a digital interactive narrative for the prevention of dental anxiety in children: "*I think it's really good what you're doing*" (ID 1.1) and "*It'll be exciting to follow the process*" (ID 1.5).

Several participants also emphasized the significance of familiarity and recognition, noting that it would contribute to a more predictable dental appointment for the child and consequently reduce their anxiety. One participant explained the following: "*I think it's just familiarity and realism. Like you just gotta show them an actual room in the app so when they come to the appointment, they recognize it and are like 'Oh, I saw this chair on the app' and like 'I saw this person and I know their masks'*" (ID 1.3) and "*They recognize all the tools and all the steps and they're like, 'OK we've talked about this before'. Then, hopefully, they become more realistic about what to expect and their imagination won't run wild* "(ID 1.3). This way, children can have a better understanding of what to expect during their appointment, reducing the likelihood of an overactive imagination.

Likewise, two participants suggested basing the story on a cavity treatment appointment as many children often will experience or have experienced this. "*I think maybe having a cavity treatment would be a good idea. Many kids often hear about this and will often sooner or later need a filling.*"(ID 1.2). The other participant agreed and stated the following:"*Yeah, maybe it would make them more prepared and make it seem not so scary?*" (ID 1.3).

The importance of familiarity also extends to the language used and the names of instruments utilized during the dental appointment, as emphasized by the participants. One participant explained that by using the same pet names for instruments, they might understand more and get less nervous: "*If you know what a dental procedure entails and if you got the proper technical names. If you can give them each a little pet names, something that a child would understand. Then they can visualize and understand and not be as scared off.* "(ID 1.1). Another participant expressed a similar viewpoint, highlighting the advantage of continuity in terms of the dentist's familiarity with the objects and terms utilized in the application. This familiarity enables the dentist to seamlessly incorporate these terms and objects during appointments, allowing the child to easily recognize and comprehend them. "*Yeah, I think the dentist would need to know the story and its metaphors to kind of like make sure that there was a continuity there because some kids come in and they've watched 'Peppa Pig at the Dentist' and they're like, 'Where's the pink mouthwash?' and we´re like 'Oh, we have a blue one here'. I mean obviously like it is kinda the same stuff, but*

it's a little bit different and kids notice that stuff." (ID 1.1).

Another aspect is the visualization of dental instruments. As several tools can be perceived threatening, several participants stressed the importance of presenting them in a pleasant and nonthreatening manner One participant provided an example of the needle and suggested an alternative approach for its presentation: *"[The needle] with the cap so that it doesn't look like there is something sharp there. They're afraid of sharp things, everyone is afraid of sharp thing. So, anything that is sharp might not be received well with kids. So, make everything look really nonthreatening and nice. "* (ID 1.2).

Another suggestion put forth by a participant was to focus on the preventive aspects of oral health. By emphasizing the importance of regular brushing, proper oral hygiene, and preventative measures, the need for more extensive dental treatments, such as fillings, could be avoided. *"Maybe some brushing in the game? [..] Maybe focus on the more preventative side of dentistry? The more preventative side of dentistry, so they don't need to go through the other stuff [fillings, injections etc.]."* (ID 1.3).

One participant also suggested using fantasy and customizing language to the child based upon their interests as this is something they do make the appointments more fun. As explained by the participant: *"One can incorporate imagination into the approach. For example, if you have a child who is a fan of "Kaptein Sabeltann", we can use that as a starting point and incorporate it into the dental experience."* (ID 1.5). Similarly, another participant also suggested to include fun story elements and make it a fun experience, with a deliberate focus on avoiding any mention of pain: *"No, just don't talk about pain. Just make it a fun experience"* (ID 1.3).

5.1.7 Summary of Key Findings

This section summarizes the results to key design takeaways from the semi-structured interviews.

- **Metaphors and fantastical elements**: By using metaphors when explaining the steps of a dental treatment, concepts and dental instruments can become more tangible and relatable for children.

- **Explain the steps of the dental appointment to ensure predictability and familiarize children with dentistry**: By providing a clear and predictable outline of what will happen during the visit, children can feel more at

ease and understand the purpose behind each procedure. This not only helps to alleviate any fears or anxieties but also educates children about dentistry.

- **Nonthreatening visualization of dental instruments:** By presenting a gentle depiction of dental instruments, one may avoid creating negative associations with dentistry and avoid contributing to further anxiety.

5.2 Research Activity 2: Workshops with Children

This section will describe the workshops conducted with children.

5.2.1 Purpose

The primary objective of the workshop was to gather insight for further development of the digital interactive narrative and the characters it includes. The workshops also aimed to acquire knowledge about children's feelings toward and thoughts related to going to the dentist. Accordingly, the following objectives were formulated:

- Identify how insights from the workshops can be transferred to a digital interactive narrative.

- Gain insight into story concepts and plot ideas that can be further developed and used in a digital interactive narrative.

- Identify the main ideas of the narrative structure.

- Identify the narrative's underlying themes and message.

- Gain insight into which story elements the children choose to incorporate in their narrative and how they are employed.

- Identify how the story elements contribute to narrative progression.

- Gain insight into what the children consider interesting and engaging in a narrative.

- Gain insight into children's preferences in characters and potential supporting characters.

- Gain an understanding of children's feelings and thoughts associated with dentistry.

- Gain insight into children's existing knowledge about dentistry and oral health.

5.2.2 Participants

The workshops were held at St. Michael's Catholic Primary School, a primary school in Sydney, Australia. In total, 32 children in the ages of 7-9 partook in the workshop. The gender distribution of the participants was approximately equal with 18 girls and 14 boys. The groups were organized based upon who went to class together. All of the children had experience visiting the dentist and had varied feelings towards and experiences with visiting the dentist. Prior to the workshops, the children's guardians had signed a form of consent. The consent form can be found in Appendix G.

5.2.3 Roles

While conducting the workshops, the three of us divided our roles into two facilitators and one observer. This enabled us to have responsibilities for one group each through the facilitator role while the observer had the role of focusing on the overall group dynamics as well as assisting groups when needed. By following this division of attention, the observer was able to make meaningful observations about the workshop environment, participants' emotional state, utilization of story and cut out elements as well as other unforeseen events during the workshop.

5.2.4 Preparation

In preparation for the workshops, personas and scenarios were developed in order to represent user needs and the intended usage of the prototype. They were based upon data gathered during the semi-structured interviews with dental professionals. In total five personas were created, consisting of three children in the intended age group, two girls and one boy, as well as two adults, consisting of one parent and one dentist. Moreover, the scenarios were formulated to contextualize the personas and to describe intended use cases for the digital interactive narrative. An overview of personas and their associated scenarios can be found in Appendix C.

The personas and scenarios were applied during the workshop as a means of inspiration for tasks and scenarios given during the workshops. This ensured that the exercises were suitable for children in the targeted age group.

Figma was used for creating objects and elements to use in the workshops when developing stories. Figma is a collaborative web application commonly utilized by user experience and user interface designers for the development and evaluation of new system designs. These design elements were subsequently printed and used as cut-out elements for the participants to visualize their stories during the workshops.

Additionally, a pilot test was conducted with a co-student a day prior to the first workshop. The purpose of the pilot test was to ensure it was calibrated effectively, to validate the wording of the tasks and understand the time necessary for each task.

5.2.5 Procedure and Setup

The workshops were conducted 6 times over the course of two weeks in February during school hours in the afternoon. They were partly conducted in the school's library and a teacher's office. Each session lasted approximately 1 hour, and the teacher was present during the sessions. The teacher was responsible for organizing the groups and bringing the children to the workshop locations.

The workshops were conducted in groups consisting of 7-12 students which were split in two in groups of 3-6 students. Each group participated in two workshops in which the second one being held was a continuation of the first one.

The workshops consisted of the following steps:

1. Introduction: Brief introduction of the workshop and its purpose

2. Introductory question: Warm-up question in which the participants were asked about what they associate with the dentist

3. Create a character: Draw a character and if wanted, a friend or object to bring with the character

4. Create a story: Create a story using a predefined context about a cavity appointment and paper cut-out objects

5. Presentation of story: Present stories in groups

6. Semi-structured interview: Questions about the participants' perception of and feelings towards the workshop

The first round of a workshop consisted of steps 1- 4, and the second round continued with steps 4-6 as step 4, which consisted of creating the story, was somewhat time consuming.

Additionally, in order to accommodate unforeseen events, such as delays, and to better adjust the workshop to the available time and children, the workshop programs varied slightly. The changes, for instance, included removing certain parts in order to accommodate for delays as well as differences in the way each step was carried out.

28

For instance, the introductory question step was changed from a drawing and writing exercise to a discussion part so as to save time and engage the children. As part of the change, step 3 was also changed from a collaborative to an individual exercise.

The workshop sessions were recorded using integrated cameras on a tablet and a laptop. The two devices recorded the rooms and had the intention of documenting the interaction between the facilitator and participants of the workshop as well as the behavior and interaction in-between the participants. In addition to this, each facilitator, as well as the observer, both video and audio recorded their groups. This way, we managed to gain valuable and sufficient data material.

Additionally, observation was used to gain insight into story concepts, children's feelings and thoughts associated with dentistry as well as how the children interacted with each other. This was achieved through documenting the workshops through video and audio recordings as well as notes. After conducting the workshops, the recording and notes were analyzed and categorized.

During the introduction of the workshops, the children were inquired about what they associate with the dentist. Additionally, after completing the workshop, a semi-structured interview was conducted in plenary among the groups to gain a more in-depth understanding of how they experienced the workshops and their evaluation of it.

5.2.6 Results

A spectrum of feelings associated with going to the dentist
The experience of visiting the dentist can elicit a wide range of emotions in children, including nervousness, fear, indifference, and even excitement. This was also demonstrated during the workshops as they revealed that children experience a diverse range of emotions when visiting the dentist.

A number of children expressed nervousness and fear related to dental visits. They cited concerns about the unknown aspects of dental procedures and potential discomfort during treatments. One of the participants stated that they "*[. . .] sometimes gets nervous. It can be a bit scary.*" (ID 2.14). Likewise, another participant felt apprehensive about the usage of needles when creating a story with their group during the workshop: "*Why are there so many needles? [...] I do not like the needles*" (ID 2.1). One participant also stated that they were afraid of the dentist making a mistake: "*I'm scared they'll make a mistake and my teeth will fall out*" (ID 2.26), while another participant stated that they do not want to go to the dentists :"*Nah, I*

don't want to go" (ID 2.31).

Interestingly, a few children expressed excitement and positive associations with dental visits. They perceived the dentist's office as a place where their oral health is taken care of, and they often enjoyed the activities and rewards offered, such as stickers or surprises: "*I love it cause you get a sticker for just cleaning your teeth*" (ID 2.8). Additionally, during the workshop, it was observed that some children expressed that the presence of a reward made their dental appointment worthwhile: "*It's worth it cause I get a toy afterwards*" (ID 2.14). This indicates that the incentive or positive reinforcement offered after the visit played a significant role in shaping their overall perception of the experience. Additionally, notable amenities, such as ceiling-mounted televisions and video games in the waiting room, further contributed to their positive perceptions. "*I can watch TV at my dentist! It's in the ceiling!*" (ID 2.13). However, some of the participants had a somewhat special theory associated to going to the dentist and rewards: "*It's a scam! They give you candy so you get cavities in your teeth, then you have to come back!*" (ID 2.7).

Participants' emotional responses were also influenced by their past experiences with dental visits. Children who had overcome initial fears through regular dental care displayed reduced levels of apprehension and a growing trust in dental professionals: "*I used to be scared, but I'm not anymore after going to the dentist so many times*" (ID 2.29). Conversely, those who had negative experiences or perceived mistakes, pain, or discomfort associated with dental procedures exhibited lingering concerns and heightened anxiety: "*The needle really hurt one time, and now I don't like going there anymore*" (ID 2.18).

Character and companion preferences and dynamics: The workshop aimed to develop a digital interactive narrative centered around the experiences of children during a dentist appointment. By examining the main characters created and their accompanying characters, valuable insights into the children's perspectives and preferences were gained.

A consistent theme in the various groups' stories, was the main character's exhibition of anxiety prior to their dental appointment. The participants often chose a cut-out character displaying a nervous facial expression and intentionally crafted their narratives around the character's emotional state. An often-occurring story progression was the transformation of the main character from a state of nervousness to happiness following their dental appointment: "*Now she's back home from the dentist and is happy and wearing a crown!*" (ID 2.21).

A significant majority of the participants exhibited a preference for characters in the same gender as themselves. Female participants specifically chose female characters, while male participants demonstrated a similar inclination towards male characters. This gender alignment in character selection was a prevalent trend among the workshop participants. Namely, one group had a discussion about their character's gender as the group consisted of three girls and one boy who asked *"Why a girl? Can't it be a boy instead?"* (ID 2.7). Ultimately, the majority opinion of the girls prevailed, influencing the decision to create a female character for their story.

The presence of parents was a common theme among the participants. Interestingly, female participants consistently chose to depict their characters being accompanied by a mother figure, while male participants demonstrated a similar tendency by including a father figure in their stories. They depicted mothers and fathers accompanying the main characters to the dentist, perhaps emphasizing the importance of parental support during such experiences.

In the workshop, participants also explored the inclusion of mentally supporting characters. Therapy dogs in the waiting room were suggested by one of the participants (ID 2.8), indicating a desire for comforting and calming elements. Additionally, a doll was included as a supporting character for one of the participants, providing emotional support during and after the appointment (ID 2.22).

Participants also showcased their imagination through unique ideas. One participant envisioned a tooth and a World Cup trophy as supporting characters, adding whimsy to the narrative (ID 2.29, ID 2.30). Another suggestion involved a special tooth that could transform into animals, creating an element of magic and adventure during the dental visit (ID 2.26).

Objects alleviating anxiety, cleaning of mouth, decorated waiting room and magical elements

Upon analyzing the notes from the workshop, several recurring themes and elements can be identified in the stories created by the participants. The main character's journey at the dentist office typically followed a chronological order, starting with the waiting room, then the examination of their mouth, followed by cleaning, and addressing cavities. Many of the participants often did this through utilization of a paper cut-out of a mouth which they filled with drawn cavities: *"I'm making a dirty tooth! No, maybe that can be the cavity. Then it will be cleaned!"* (ID 2.20). One example of such treatment can be seen in Figure 5. Normally, the character would eventually finish their treatment and leave the dentist's office with their parents.

Furthermore, anxiety and nervousness before the appointment were prevalent emotions expressed by the characters, with a noticeable shift towards happiness and contentment after the dental visit. The participants emphasized the importance of cleaning teeth, fixing cavities, and removing germs from the mouth.

Figure 5: Example of how some participants intended to treat the mouth's cavity

Visual elements such as dental tools, gloves, mirrors, and a big mouth scene with germs added depth and detail to the stories. The use of props like flowers, lollies, and iPads served as means to alleviate fear and enhance the characters' happiness. Surprises and gifts, such as dolls, crowns, and candy, were often incorporated into the stories as rewards or tokens of appreciation. One such example can be seen in Figure 6.

Figure 6: A decorated dentist office provided by one of the participating groups

Additional elements included the presence of other children in a waiting room fully decorated with various objects such as flowers, animals, teddy bears, dolls as well as therapy dogs to provide comfort. The participants often spent a majority of their time decorating the waiting room, possibly because there was a lot of free space there and they enjoyed using the cut-out elements: *"I'll go and look for some more stuff!"* (ID 2.7).

In addition to this, some participants added creative elements such as a tooth fairy, a tooth wizard and a dream world with magical transformations which added imaginative and fantastical elements to the stories. One of the participants explained it as following: *"The kid comes in with his parents. The dentist says, 'Are you here for an appointment?'. He* (the kid) *says 'Yes'. And then we go to the chair. And the dentist looks inside his teeth. She* (the dentist) *says it's bad* (the teeth)*. They look inside the teeth with a mirror. She* (the dentist) *says 'We have 8 cavities'). So we put him* (the kid) *in a coma. Like sleeping pills. He goes to sleep. He holds the teddy bear. The fairy and the kid's friends appear in his dreams. And a rainbow. He has a crown. Butterflies. Dinosaur. Clean teeth. And the tooth fairy is there too. And then they are singing a song like 'teeth cleaning, teeth cleaning blablabla'"* (ID 2.2).

Overall, the participants demonstrated a basic understanding of the dental visit process and emphasized the importance of oral hygiene. They explored various strategies to alleviate anxiety and portrayed a positive outcome for their characters.

Another noteworthy observation from the workshops was the participants' inclination to draw from their own personal experiences. This was evident when one participant was asked about their choice of including two dentists: *"Because at my dentist's*

there's two. There's a boy and a girl." (ID 2.7). Likewise, it also became evident when choosing the weather outside the waiting room: "*It is going to be stormy outside because you usually go to the dentist while it is storming. At least I do. It is bad luck.*" (ID 2.22).

5.2.7   Summary of Key Findings

This section summarizes the results to key design takeaways from the workshops

- **Reward at the end of the dental appointment**: A great deal of participants emphasized the importance of receiving a reward after completing their dental appointment.

- **Emotional progression during dentist appointment**: A great amount of the participants focused on the character's facial expression as many opted for their character's transition from nervousness to happiness in their story. The participants also reported several feelings related to the dentist. The feelings varied from nervousness, neutrality and excitement.

- **Decorated waiting room**: Interactive and fun elements in the waiting room, such as other children to interact with and decorations.

- **Magical and fantastical elements:**   Magical creatures and elements were often added to their story as a fun and engaging aspect.

5.3   Design Activity 1: Producing the Prototype

This section will present the process of producing the interactive narrative prototype, ToothTales, as well as its content and related user stories.

5.3.1   Prototyping tools

Figma
The prototype was created using the design and prototyping tool, Figma. In this project, Figma was primarily employed in the creation of design elements for the application, rather than serving as a functional prototype for testing purposes.

A great number of design elements were mainly taken from Figma Community, a feature within Figma which allows users to share, discover and reuse design files and resources.

We also developed designs and elements for the prototype, which as the project progressed, could be exported and implemented into the coding environment.

React with Typescript
React is a JavaScript library which provides a framework for constructing user interfaces through the composition of modular components. Its component-based architecture facilitated component reusability, offering to the project an efficient approach for building interfaces. Moreover, the availability of comprehensive and well-documented resources online proved to be highly beneficial to the project's development process.

Additionally, Typescript was used along with React for type definition as it adds more readability to the code.

5.3.2 Prototype Description

ToothTales is a digital interactive narrative. Its purpose is to prevent dental anxiety in children between the ages of 6 to 10 years by explaining and teaching them about cavity treatments and related dental instruments.

Moreover, ToothTales is designed for usage on laptops. The backgrounds, characters and dental instruments were either created by us in Figma or sourced from the Figma Community. The incorporation of pre-made elements from the Figma Community significantly reduced the time and resources required for the development of ToothTales. The design elements were determined by evaluating their potential perceived entertainment value for the target audience, as well as their ability to accurately depict a bedroom and a dental office in the digital interactive narrative.

Prior to commencing prototyping, a conceptual model was developed. The conceptual model illustrates the organization and operation of the solution[61]. It provided us with a clear understanding of how the prototype is structured and how the various components work together.

The content and storyline were rooted in user stories developed from user requirements and learning objectives formulated based upon the initial semi-structured interviews with dental professionals and workshops with children. This led us to the following five user requirements:

- The solution must present information suitable for children aged 6-10

- The solution must be engaging and encourage an explorative user experience

- The solution must be available on PC

- The solution must provide information about common concepts encountered at the dentist

- The solution must aspire to contribute as a preventative measure to avoid dental anxiety

Additionally, two dental professionals proposed using a cavity treatment appointment as the foundation for the storyline, considering that numerous children have already undergone or will experience this procedure. This statement was also supported during the workshops, where several children shared their experiences of getting their cavities filled or associated it with dentistry. Thus, this became the main tale of ToothTales and was hence incorporated into the user stories and learning objectives.

The learning objectives convey aims that users are intended to achieve when interacting with the ToothTales. The user stories reflect the objectives and aim to facilitate them.

- The user will learn about the elements of the dentist office through a digital reconstruction of it.

- The user will learn about the different instruments used during a cavity treatment, and understand the role of each of them.

- The user will be taught the importance of brushing their teeth, and the consequences of neglecting oral hygiene.

- The user will learn that they are in control of the dental treatment through the usage of a stop signal.

- The user will be able to express thoughts and feelings regarding the dentist with other virtual child characters, and learn that being nervous is normal.

Based upon these learning objectives, we formulated user stories and prioritized these. Due to limited time and resources, we did not manage to implement all user stories nor achieve all learning objectives and user requirements.

In Table 2 below, are five of the highest prioritized user stories presented with their ID, name, description of user story and requirement. They are listed in a prioritized manner. A full overview of the user stories can be found in Appendix D.

Table 2: List of prioritized user stories

ID	Name	User Story	Requirement
1	Cavity treatment and dental instruments	As a user, I want to go through a cavity treatment, so I can learn about the instruments and understand what happens.	The app must presented in a friendly manner to show how a cavity is treated, what instruments are used, why they are used, how the instruments feel/sound, in what order they are used, and why the treatment is necessary. This must be shown through metaphors, visuals, audio and text
2	Dentist	As a user, I want the dentist to be friendly and guide me through the appointment and explain concepts in a recognizable manner suitable for children	The app must provide the user with understandable information and utilize metaphors, jokes and visuals.
3	Main character's emotions	As a user, I want the main character to go from nervous about the dentist to happy after, to convey that it can be a positive experience	The app must present the main character with nervous emotions in the beginning, and gradually progress these to happy emotions through dialogues and positive reinforcements
4	Customize Character	As a user, I want to be able to customize the appearance of my character, to make my character relatable and personable	The app must allow customization of name, gender, skin color, hair color, clothes and accessories

5	Tooth Fairy	As a user, I want the tooth fairy to be a narrator throughout the story, so that I am met with someone magical and recognizable	The app must guide the user through the story and its choices. It must also have a common thread and provide funny remarks from start to end

User Story 1: Cavity Treatment and Instruments
As suggested by the results from the various research activities, a focus on a realistic presentation of a cavity treatment was taken into account and implemented. Likewise, realistic but nonthreatening instrument was included as suggested by the design lessons.

User story 2: Dentist
As recommended by the data, ToothTales guides the user along the appointment with simple language through the dentist character. Through the use of metaphors graspable for children, the dental instruments become more comprehensible. This also done through the use of associated visuals in the form of metaphors.

User story 3: Main Character's emotions
In line with the key findings from research activity 2, the character's emotional state progressing towards happiness is displayed in the prototype. The character starts their appointment in a neutral state, and can become nervous during the appointment if the user chooses to express nervousness when asked about feelings towards appointment.

User Story 4: Customize Character
As the data gathered in research activity 2 suggested an inclination towards personalizing one's character, this was implemented in ToothTales. Before commencing the story, one has the opportunity to modify the character to one's preferences in hair, skin and eye color as well as clothes and accessories.

User Story 5: Tooth Fairy
The data also emphasized the importance of magical and imaginary elements in the storyline. The tooth fairy was often included in the storylines created during the workshops. Thus, it was chosen to implement a tooth fairy guiding and rewarding the user at the end of the story.

38

Storyline

The storyline of ToothTales commences with a letter that invites the user to undergo a cavity treatment. Upon entering the game, the user is taken to the waiting room of the dentist's office, where they can explore and interact with various elements. By clicking on the door to the dentist's office, the user is greeted by the dentist and guided into the treatment area. Inside the dentist's office, the dentist provides a proper introduction to the appointment and the user is given the opportunity to further explore and interact with different elements, including dental instruments and a creative analogy about cavities using a castle in the dentist office. Following this exploration, the cavity treatment itself takes place, during which the process of fixing the cavity is explained. Once the treatment is successfully completed, the user is returned to the dentist's office and presented with the opportunity to select a reward as a token of completing the appointment.

Below follows a more detailed description of each scene in chronological order:
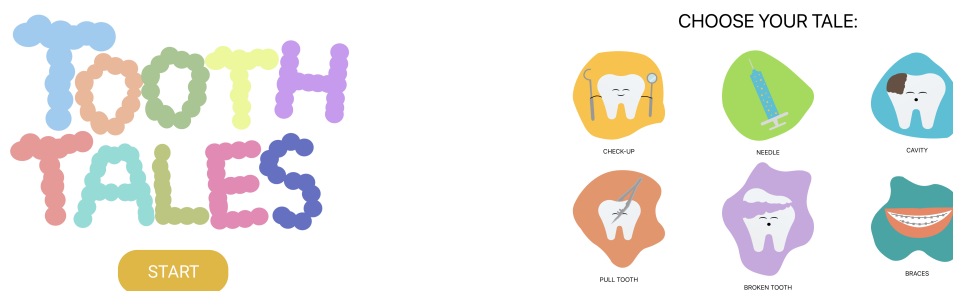
Figure 7: Introduction and choose Tale

1. **Introduction**
   The user is presented the logo of Tooth Tales and is given the opportunity to begin by clicking on the "Start"-button. A screenshot of this can be found in Figure 7

2. **Choose Tale**
   The user is presented the various possible tales, as seen in Figure 7. As of now, only the "Cavity" tale is developed and functional.

3. **Letter Inviting to Dentist Appointment**
   The user is presented with a written letter inviting the user to a dentist ap-
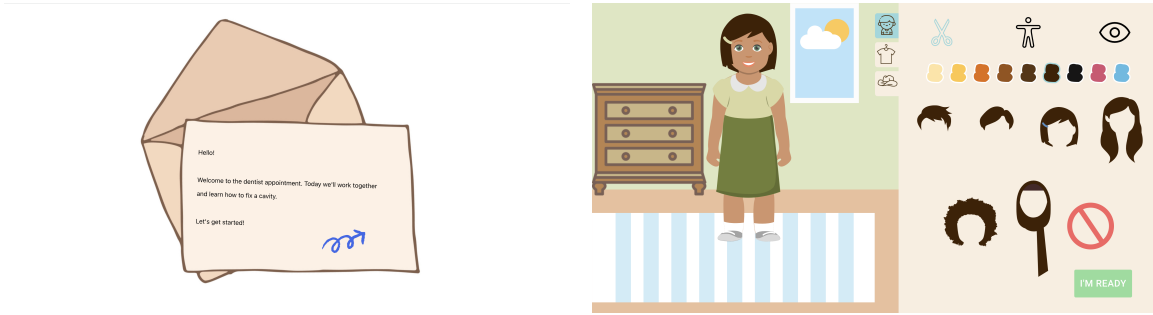
Figure 8: Letter inviting to dentist appointment and customize character

pointment where they will work together and learn how to treat a cavity. A screenshot of this can be seen in Figure 8

4. **Customize Character**

As seen in Figure 8, the user is provided with the opportunity to personalize their character's appearance by adjusting features such as hair color, skin color, eye color, clothing, and hats. The customization scene is set in the character's bedroom, and the user can modify the character's appearance through a menu located on the right side of the screen. This menu is composed of multiple tabs, each dedicated to a specific aspect of character customization. When the user is finished personalizing their character, they can press the "I'm Ready" button located at the bottom of the menu.
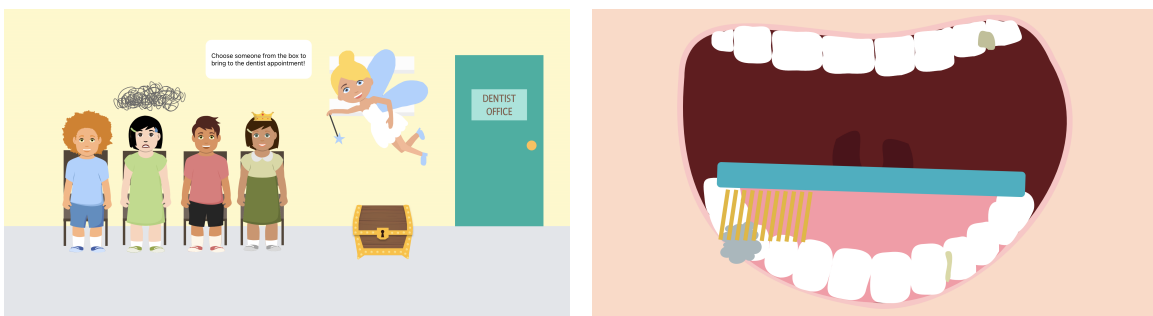
Figure 9: Waiting room and brush teeth

5. **Waiting Room**

In the waiting room, as seen in Figure 9, the user is first greeted by the Tooth Fairy who prompts them to choose someone from a chest of toys. By clicking on the chest, one is presented with various toys and stuffed animals which can be brought into the dentist office. After completing this, one appears once again in the waiting room and is free to explore the objects and elements in it. For instance, one may hover over the other children and see their facials expressions change. Moreover, by clicking on the toothbrush holder, one is presented a mouth filled with bacteria and must brush them away before returning to the waiting room. This is also displayed in Figure 9. After finishing interaction with the various elements, one can click on the door and be greeted by the dentist who will bring you to the office.
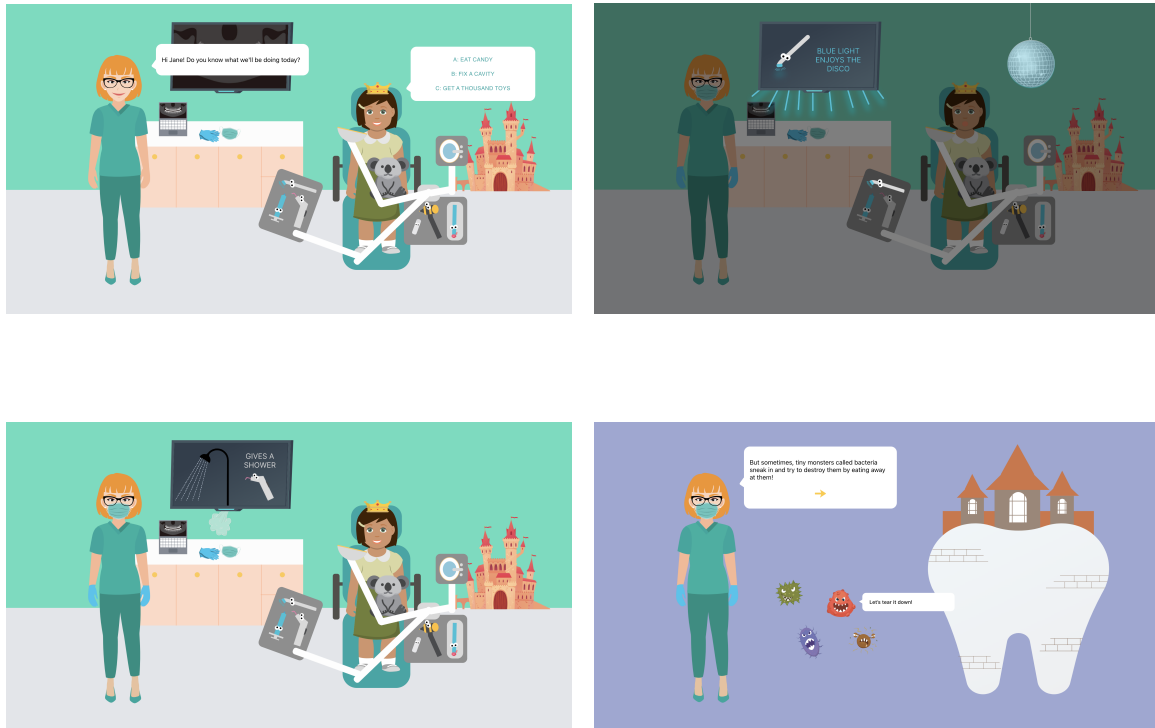
Figure 11: Exploring the dentist office and tooth castle analogy

6. **Dentist Office**

Upon entering the dentist office, the dentist introduces the appointment and briefly explains why it is important to treat cavities. One is then free to explore the office and interact with the various objects in it. The instruments displayed

on the table are clickable and a click will change the display on the TV into a short explanation or metaphor related to the chosen instrument. Furthermore, by clicking on the castle on the right side of the office, one is presented a story about how cavities appear and in which the tooth is presented as a castle being attacked by bacteria visualized as monsters. Some of these scenes can be found in Figure 11.
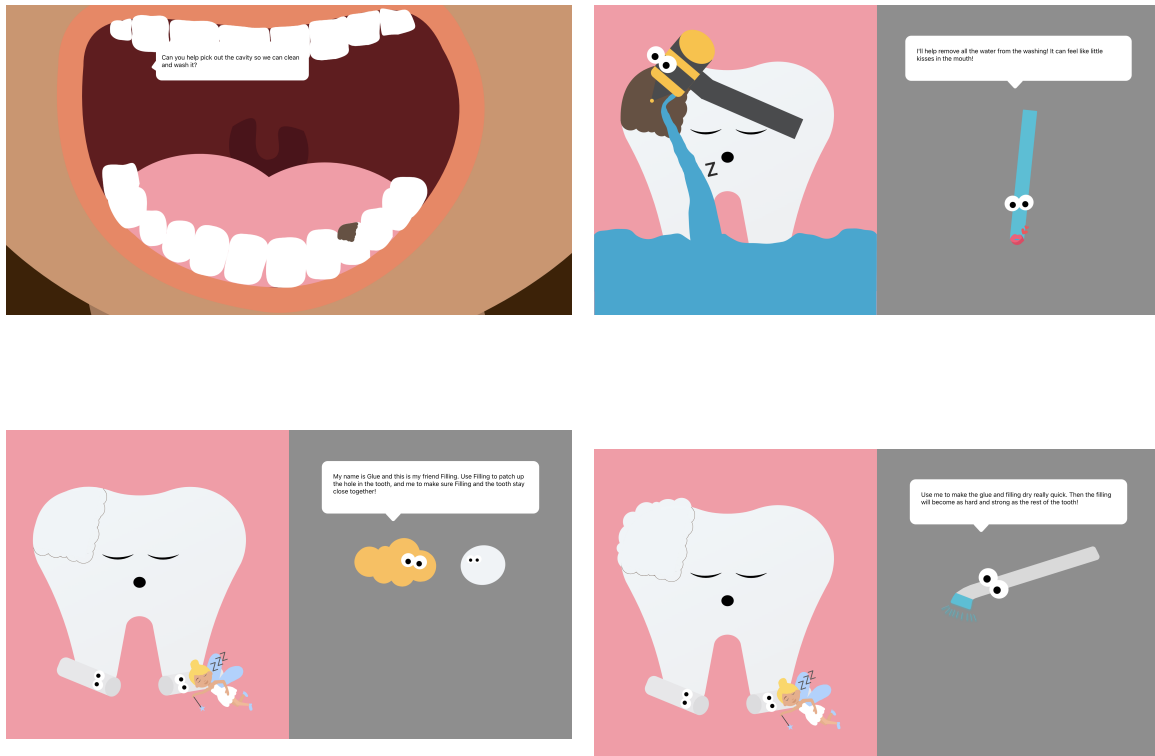
Figure 13: Overview of scenes associated to cavity treatment

7. **Treatment of Cavity**

The dentist briefly explains how to treat a cavity before starting the treatment by injecting anesthetic into the gum. The character's mouth, along with the cavity, is shown and the user is asked to locate it. Following this is the treatment of the cavity itself during which the user is guided through the various steps in an age-appropriate manner including metaphors for the instruments and a simple language. An overview of this process can be found in Figure 13.
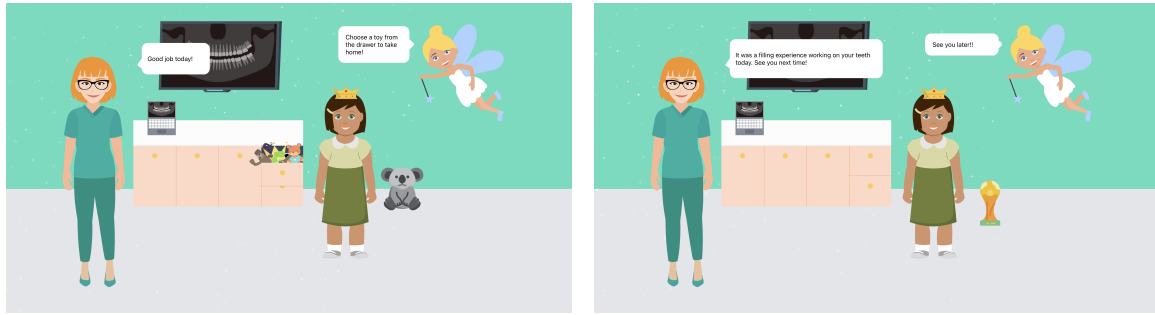
Figure 14: Choosing reward and end of appointment

8. **End scene**

   After completing the treatment, the user returns to the dentist office, as seen in Figure 17, where they are greeted and then congratulated by the tooth fairy for completing the treatment. Finally, the player gets the option to choose a reward in the form of various toys and stuffed animals from the drawer located in the dentist office.

5.4 Research Activity 3: Evaluation with Dental Professionals

This section will describe the evaluation conducted with dental professionals.

5.4.1 Purpose

The key purpose of the evaluation with dental professionals was to gain valuable insights and impressions of ToothTales as a digital interactive narrative tool for dental anxiety prevention. The evaluation aimed to acquire a professional's perspective on the potential for real-life usage of such a tool. We wanted a professional's perspective on both the content displayed and the visualization of it, and their opinion on whether the utilization of these two were suitable for children in the intended age range. This was done through a semi-structured interview. Based upon these different focus areas, the following objectives for the evaluations were formulated:

- Receive feedback on whether the information presented is age-appropriate

- Gain insight into the overall digital presentation of a dental treatment

- Receive feedback on the text presented

- Receive feedback on instruments and other dental elements

5.4.2 Participants

The prototype was evaluated by both dentists and psychologists from Norway and Australia. Of these were one dentist was from Randwick Dental Clinic in Australia, and the other was from TKMidt in Norway. The remaining two participants were psychologists from TKMidt. All participants were women, and had experience working with children, both with and without dental anxiety. Only the two dentists participated in the initial semi-structured interviews with dental professionals of this thesis project. An overview of the participants is shown in Table **??** below:

Occupation	Dental Clinic	Country
Dentist	Randwick Dental Clinic	Australia
Dentist	TkMidt	Norway
Psychologist Specialist	TkMidt	Norway
Psychologist	TkMidt	Norway

5.4.3 Roles

As the evaluation sessions also consisted of a semi-structured interview part, we took on the primary roles of one interviewer and two observers. The interviewer would ask questions based on the interview guide, and appropriate follow-up questions as the interview progressed. The observers took notes of the answers, the body language, and observed the interview process. Their job was also to ask follow-up questions during the semi-structured interviews. This distribution of roles ensured an even workload and gathered valuable data.

5.4.4 Preparation

To uncover usability issues and bugs, a pilot test was conducted with a fellow student prior to the evaluation with the dental professionals. An interview guide was also created to better facilitate the semi-structured interview. This interview guide ensured that vital questions related to our research questions were answered, as well as provide space for further exploration of questions that could arise during the interview. The full list of questions can be found in Appendix E.

5.4.5 Procedure and Setup

The evaluations with dental professionals were conducted physically at a dental office, and online via video conversations, in April and May 2023. When conducted physically, the dental professionals would be given access to the prototype to explore freely

as they wished. When conducted digitally, we would click through the prototype for them as we lacked the right equipment for remote steering. The dental professionals were allowed to navigate through vocal instructions, and if not, we would perform a walkthrough on behalf of them.

Both the screen and dialogue sessions with us were recorded. Each session included one or two dental professionals and started with an introduction of the development of the prototype since the last conversation we had. Each test lasted 30 minutes, and consisted of the following steps:

- Introduction: Introduction to the prototype and its purpose.

- Evaluation: Testing the prototype.

- Follow-up questions: A semi-structured interview regarding the user experience and the validity of the information included.

- Closing remarks: Ask if there is something additional they would like to add.

The first user evaluation was conducted physically with a dentist, in which the first version of the prototype was made available on one of our laptops. Due to time restraints we opted to test an early and unfinished version of the prototype. This gave valuable insight into bigger usability issues and issues with engagement. We changed some of the prototype based on the feedback from the first evaluation, and used the renewed version for the remainder of the evaluation sessions.

5.4.6 Results

When conducting the semi-structured interviews during the evaluations, we wanted to specifically get feedback on whether the prototype was educational and if it would be a good tool to help prevent anxiety.

When the dental professionals were asked if the prototype had a good balance between being educational and entertainment, they all agreed that the prototype provided a good mixture of learning and fun. Stated by ID 3.2, children enjoy being able to choose and explore instead of solely listening and watching:

"Children like to be interactive, not just watch movies. So the prototype is very good" (ID 3.2).

It is important that the children have enough that grabs their attention, so that

they will not be bored. It is important that they are engaged, and that the experience of the prototype is immersive and supports the children's want to explore:

"*I think it would be really good because, as we talked before, kids are so visual as well and I feel like when you talk to them sometimes they're like, "Yeah, sure". If we can then reference that as well, like remember in the video the cotton rolls, that's really good*" (ID 3.1).

Although the prototype provides a good number of interactive elements, two of the dental professionals suggested adding more to keep the attention span of the children. Instead of going through the treatment with predetermined animations and information, they suggested adding more freedom to explore for the children, letting them steer the treatment of the cavity:

"*The only thing is that, I was gonna say interaction in the part where they're doing the filling. Like you know how you did it with the toothbrush. For them to put the drill or the bond or something and, do that a little bit*" (ID 3.1).

"*It may have been a good idea in terms of attention span then, because they tend to, well at least every other, so that there was something they had to do, some activation. They are very nice, but just so that you don't lose them halfway through that book, an important book*" (ID3.3)

With regard to the intended age range of the prototype, 6-10 years, all dental professionals agreed that the prototype is suitable for the intended age range. However, three of them suggested that perhaps it is better suited for the younger children of the age range:

"*Yeah, I think it would be good for that, maybe even five to probably nine? Because I think older than that you don't tend to use metaphors, like the sleepy juice, the cotton roll stuff, they're generally more understanding*" (ID 3.1).

Likewise, two participants expressed similar statements: "*And then I believe that you have hit the mark very well in terms of the age group, that it is the youngest children up to maybe 10 years old. I think that 11 years old children might find it lacking in action, but the youngest children would surely find this very enjoyable*" (ID 3.3).

"*[...] I imagine that it is actually for the very youngest children, and in that case, I think it is fine just the way it is*" (ID 3.4).

46

As stated by ID 3.1, when treating older children the dental professionals do not often use metaphors. They understand more of what the dental professionals are telling them, letting them ask the questions they are curious about.

Empowering children with knowledge about the treatment they are about to undergo can better prepare them. However, allowing them to have a say in choosing the specific information they want to learn more about grants them a greater sense of control over their learning process: "*Children often want to choose for themselves how much information they want, and they are given the opportunity to do so here. They don't have to click on what they don't want. They can also do it if they want. And that is great*" (ID 3.2).

Especially important is the familiarization with the sounds encountered at the dental office:"*It's nice that there is sound, as some people react to sounds. Many are prepared for drilling, but not for suction. It makes quite a lot of noise. So some people react negatively to the suction because they weren't really aware of it*" (ID 3.2).

5.4.7 Summary of Key Findings

Realistic representation: The dental professionals expressed the importance of presenting the cavity treatment as realistically as possible to avoid any misconceptions between the real experience and the digital one.

Give children option to reflect on own feelings: The dental professionals expressed that it would be beneficial to add a separate reflection part to the end of ToothTales where the children could reflect on own thoughts and feelings regarding the experience they just played through.

Mix of play and realism: The dental professionals found the mix of play and realism to be balanced, and liked the addition of the magical elements.

5.5 Research activity 4: Evaluation with Children

This section will describe the evaluation conducted with children.

5.5.1 Purpose

The aim of the user evaluation with children was to assess whether the children found the prototype engaging, entertaining and educational. We also wanted to gain insight into whether the children saw a potential for real use of the prototype. The

evaluations were conducted through semi-structured interviews and playthroughs of the digital interactive narrative.

5.5.2 Participants

The prototype was evaluated by children from St. Michaels Catholic Primary School in Sydney, Australia. The prototype was evaluated by 22 children from 3rd and 4th grade in the ages between 7 and nine, all of whom had participated in the workshop from Research Activity 2. None of the children had dental anxiety, and some of them had previously gone through cavity treatments.

5.5.3 Roles

During the evaluations, all three of us took the roles of both interviewer and observer. Everyone was responsible for asking questions during the playthrough of ToothTales, observing the children's body language, and asking follow-up questions after the playthrough. In addition, both the screen and the dialogue during the sessions with us were recorded.

5.5.4 Preparation

In preparation for the evaluations with the children, changes based on the findings from the evaluation with the dental professionals were implemented to make the prototype more suitable for the evaluation. We also implemented some planned features we did not have time to implement prior to the first evaluation with the dental professional.

This included changes primarily concerning the presentation of dental instruments and their appearance as more metaphors and exploration were included when conveying the use of instruments. The tooth castle analogy was also fully implemented as it was only partly implemented during the first evaluation the dental professionals.

In addition to this, an interview guide was formulated in order to ensure the desired data would be covered. It was based upon the learning objectives, taking into consideration the learning objectives outlined in the design activity 5.3.2 to ensure that sufficient data would be gathered for the purpose of evaluating their achievement. The complete interview guide for the evaluation can be found in Appendix F.

In addition to this, a pilot test was conducted with a co-student to make sure the prototype worked as intended with the newly added implementations after the first evaluation with the dental professionals.Moreover, the wording of the questions in

the interview guide underwent testing to ensure clarity and effectiveness. Additionally, the pilot evaluation sessions provided an understanding of the estimated time required for each session.

5.5.5 Procedure and Setup

The evaluation with the children were conducted in the school's library in the first week of May 2023. A teacher was always present during the sessions, but was sat at the back of the room without an active role. Each child was asked to test the prototype individually on computers that had the prototype running, whilst being seated alongside one of us during the testing process. In addition, the interaction with the prototype and the dialogue between the child and us were recorded.

Each test session included three children, and started with a joint introduction to both the development of the prototype, and what they could expect during the evaluation. Each test lasted 20 minutes, and consisted of these steps:

- Introduction: Warm-up questions with the children, and expectations for the session.

- Evaluation: Testing the prototype.

- Follow-up questions: Semi-structured interview regarding the user experience.

5.5.6 Results

Data from the participants were gathered through screen recordings of the physical evaluation, transcripts of the voice recordings, and our own notes and observations on body language and reactions from the participants. Based on this, the findings from the evaluation can be divided into four categories:

- Usability

- Storytelling

- Engagement

- Education

Usability

After examining the notes and recordings derived from the evaluation sessions with the participants, we categorized feedback and issues related to usability into the following three categories:

1. Uncertainty about how to interact with story elements in the prototype

2. Uncertainty about how to progress the story from one scene to another

3. Bugs in the prototype

These categories are further detailed in Table 4, where the five detected issues are categorized based on what we define as similarities.

Table 4: Usability Issues

Issue	Category
Respondents did not attempt to explore the interactable elements in the dental office, scene displayed in Figure 11	Uncertainty about how to interact with story elements in the prototype
Respondents did not know how to brush the teeth in scene seen in Figure 16	Uncertainty about how to interact with story elements in the prototype
The respondents expected to drag the interactable elements in the treatment scene, when they are only clickable.	Uncertainty about how to interact with story elements in the prototype
Respondents did not know how to progress to the treatment scenes after exploring the dental office.	Uncertainty about how to progress the story from one scene to another
Respondents could not progress story when clicking on the dentist during the tooth castle analogy in scene. Bug displayed in Figure 17.	Bugs in the prototype

Uncertainty about how to interact with elements in the prototype
The main issue we observed when the participants interacted with the prototype was uncertainty about where to click and how to explore the dental office. The participants were met with a dialogue box from the virtual dentist telling them to explore the dental office and to click on her when ready to proceed to the cavity treatment, as illustrated in Figure 15.
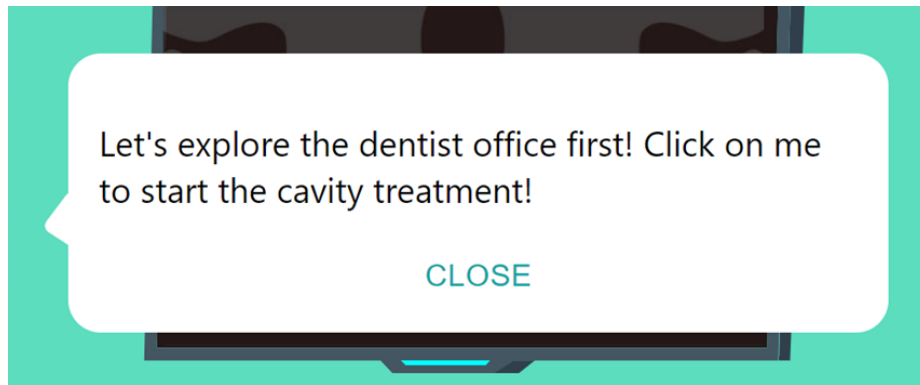
Figure 15: Instructions for exploration of the dental office and how to progress the story when finished.

Through the findings from the data collected it became clear that the participants did not understand how to find the interactable elements in the dental office. Even though written encouragements were given to explore the dental office, few of the participants either did not understand what that meant or forgot it shortly after being given the information. Some participants thought it was difficult to understand which elements were subject to exploration around the dental office, and we observed that many children were confused as to where to click. They often asked for directions of what they should be doing next in terms of interaction: *"OK, now what do I do?"* (ID 4.3), and: *"I don't understand what to do now"* (ID 4.17), and: *"Now, what do I do?"* (ID 4.4).

It also became clear that the participants did not understand which elements could be interacted with. One respondent expressed that it was hard to navigate without visual cues when exploring both the dental office and the waiting room: *"Right, so this is fun, but it's also hard. But when you're trying to make it easier, I don't want you to put arrows everywhere, that would be too easy. They need to point to something and then you try to figure out like what to do"* (ID 4.15).

When going through the treatment scene of the prototype the respondents were underwhelmed with the interaction possibilities. Instead of letting the respondents themselves move the instruments, the animation of them were predetermined. The respondents expressed that they would have found the prototype more engaging if they themselves could drag the instruments where they wished: *"I also think that the kids. Want make go into the app. I think that they should do it, not just the computer"* (ID 4.15). This was also expressed through the following statement: *"No, not like this. The kids should be able to do it themselves"* (ID 4.8).

51

Many of the participants did not explore the waiting room or dental office and opted to progress the story instead. Through the data collected it became clear that the participants did not see what elements could be interacted with, and when they did, they found it hard to understand where to click. Often, instead of trying to find the elements the participants asked us for directions: "*Can I put a face mask and gloves on him?*" (ID 4.2).

Another issue that arose was how to brush the teeth in the waiting room, as visualized in Figure 16. The toothbrush follows the mouse pointer when it is moved around. When the toothbrush is moved side to side over a bacteria between the teeth dirty foam is produced. When done a few times the foam becomes whiter, and finally disappears, showing shining stars instead. Other than the foam and stars, no other feedback is given. We observed that the participants moved the mouse around, and often clicked down on the touchpad when hovering over bacteria. When asked for instructions they were often told to think of how they would brush their own teeth. This was almost all the instructions they needed, as they often grasped the concept shortly after.
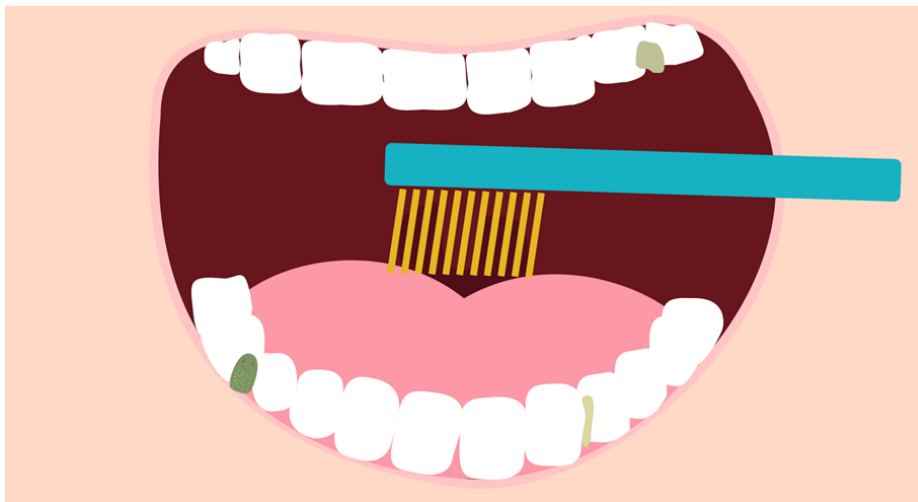

Figure 16: Teeth brushing scene

Even though a significant number of the participants had trouble finding the interactable elements, several others had no trouble exploring the dental office.

Uncertainty about how to progress the story from one scene to another
Another issue that arose during the evaluation process was difficulty knowing how to

move on from one scene to another, and therefore how to progress the story. This was especially the case when moving from the dental office to the cavity treatment. As mentioned above, the participants were given written instructions to click on the dentist when ready to progress, as seen in Figure 15. These instructions did, however, not reappear once the respondent had clicked away from the speech bubble. Some participants had trouble knowing what to do next: "*How do I go away from here?*" (ID 4.18), and: "*This is too hard, I don't think other children will know what to do*" (ID 4.11), and: "*It is nice, I am just not sure what to do next*" (ID 4.5).

One of the participants suggested adding a time-determined remainder that could appear to remind the user of what to do when they want to move on to the next scene. They suggested that this remainder could be conveyed in the form of another speech bubble from the dentist, as this would make them curious about what the dentist had to say.

Bugs in the prototype
When playing through the tooth castle analogy, one respondent encountered a bug when clicking on the dentist who is narrating the story. As mentioned earlier, the way one progresses from the dental office to the cavity treatment is by clicking on the dentist. She will then give you the option to either progress or explore more. When the dentist is clicked the speech bubble appears behind the tooth castle analogy, effectively hindering the progression of ToothTales, forcing you to start from the beginning. The bug is visualized in Figure 17 below.

Figure 17: The bug visualized, there are no further actions that can be taken when the dentist is clicked

Storytelling

The participants liked the overall playthrough of the prototype, stating that they

would like to play it again before a dental appointment: "*I really liked it I want to play it again*" (ID 4.16), and: "*I would like to have played this before going to the dentist*" (ID 4.17).

They particularly seemed to enjoy creating their own characters in the start of Tooth-Tales, where they could customize the character to either look like themselves or make someone else entirely. One participant expressed joy when the character they created ended up looking like them: "*Look, it looks just like me!*" (ID 4.6).

They also enjoyed choosing their own supporting character in the waiting room. One participant stated that: "*I love cats, I want to bring a cat with me*" (ID 4.8), while another stated that: "*Can you only take one with you? I want to take more*" (ID 4.22). However, some one participant expressed that they would rather choose a supporting character as a toy after they had completed the cavity treatment: "*I think you should choose a toy after, you know, like a reward*" (ID 4.9).

Although most of the participants enjoyed playing through the story, some expressed that they would have liked the presence of more emotions throughout the narrative. To make the story in ToothTales more tailored for them they wished to be able to choose the emotions of their character and have these impact the storyline more. One participant said that: "*So I would have added like, if you could change the emotion of something. Or like people beside the character, helping him like overcome his. You would usually like have someone next to you to help you.*" (ID 4.3).

Likewise, one participant suggested the inclusion of an optional voice-over which could tell the story in a vocal form, eliminating the need to read text which might be difficult for some younger children:"*And maybe there there should be like a little note that says, would you like a voice over that actually reads that like would you like a voice over? Then they click yes or no and if they click yes then they will do it. Maybe little kids can understand more then?*" (ID 4.10). **Engagement**

From our own observations of the interaction between the respondents and the prototype it became clear that the prototype includes a lot of engaging elements, but that there could be more of them: "*I really think this (story) fits to me, and I would also recommend it to people younger than me, like from 5 years old*" (ID 4.20).

When the children compared the story in ToothTales to the ones they created during the workshops in Research Activity 2 it became apparent that they recognized a lot of the story elements. They enjoyed seeing their own creations included in the story and showed special interest in interacting with these story elements. We observed

that they would often inch closer to the laptop screen to get a better look of story elements they recognized, and smiling when they found them.

When going through the story some of the children noticed differences from the story they made and wanted to express how we could improve the aesthetic and content of the prototype. One child stated: *"I would like to have more decorations on the walls, like we had in our story. I wanted the character to have the parents with her, I miss them in this story"* (ID 4.16).

Additionally, it became clear that the prototype was lacking more movable and dynamic ways for the participants to interact with as one participant expressed the following: *"I would have liked to be able to do more and not just clicking on things. Like dragging or something like that would be nice"* (ID 4.2).

Education

After the evaluation the participants were asked if they could retell the cavity treatment story, if they remembered the instruments used, and if they learned something they did not already know.

When asked about what they remembered from the story after playing through it, their responses varied. Some remembered the instruments and their uses the best: *"I did not know that there were that many instruments/tools to fix ix a cavity! I had only heard about the toothbrush."* (ID 4.3). Others remembered the metaphors used the best.

During the evaluation we observed that many children made references to their own experiences at the dentist. They wanted to both share how our story differed from what they remembered, and how they recognized some of the instruments that were used during the treatment scene: *"I had a cavity. And then there was, like, my gum. It was like bleeding, so they had to put those cotton rolls in there"* (ID 4.5).

One of the children shared that if they had access to a story like this, they would have learned that the treatment would not hurt as the dentist gives you anesthetic before fixing the cavity: *"I used to be a bit scared of going to the dentist, and I really think this would have helped me. I did not know that you got sleepy juice, so it would not hurt. That really helps so it won't hurt*t" (ID 4.3).

55

5.5.7 Summary of Key Findings

- **Overall satisfaction:** The participants did enjoy playing through ToothTales and wanted to play through it again.

- **Better guidance for interactions:** The participants were often confused of how to explore the dental office, and expressed that they would like more guidance to help them find the elements they could interact with.

- **Bigger impact on the storyline:** The participants wished that their choices could have more of an impact on the story progression, including the wrong options.

- **Use of voice-over:** A significant amount of the participants had trouble progressing through the narrative through textual instructions. Some participants expressed that they would have liked to have the option of a voice-over in the narrative.

5.6 Summary of Main Results

The results of the initial semi-structured interviews with dental professionals revealed several factors contributed to dental anxiety in children. These factors include fear of the unknown, lack of control, the influence of others, and an overactive imagination. Additionally, negative experiences with dental procedures can significantly impact a child's perception of dentistry, and the opinions of parents, siblings, friends, or peers can also further contribute to anxiety.

To address dental anxiety in children, dental professionals highlighted the importance of knowledge, control, options, trust, and metaphors. They emphasized the importance of creating a positive and comfortable dental experience by introducing the dental environment to the child, explaining procedures in a simple and age-appropriate manner, and being at the child's level when communicating. Moreover, giving children control and options during their appointment, as well as using visual aids and metaphors, can help alleviate anxiety and build trust.

In the context of a digital interactive narrative for the prevention of dental anxiety in children, dental professionals expressed positive feedback. They emphasized the importance of familiarity, recognition, fun, and nonthreatening instruments in the narrative. For instance, familiarity with the dental environment, using consistent language and instrument pet names can help prevent dental anxiety. Likewise, visualizing dental instruments in a pleasant and nonthreatening manner is also crucial

to prevent anxiety. Participants also suggested focusing on preventive aspects of oral health and incorporating fantasy elements to make the experience more enjoyable, and to avoid mentioning pain.

Moreover, the dental professionals agreed that the prototype achieved a good balance between education and entertainment. They also emphasized the importance of interactivity and exploration for children in the narrative, rather than passive watching. As an improvement, the professionals suggested adding more interactive elements to maintain children's attention throughout the experience, particularly during the cavity treatment part.

The dental professionals also agreed that the prototype was suitable for the intended age range of 6-10 years old, although some suggested it might be better suited for younger children within that range. They noted that older children tend to understand dental procedures better and may not require metaphors or simplified explanations.

Furthermore, the dental professionals appreciated the option for children to choose the information they wanted to explore more, as it gave them a sense of control and catered to their individual interests. They also highlighted the importance of familiarizing children with the sounds of the dental office, as some sounds can trigger anxiety if unfamiliar.

In addition to this, some participants expressed difficulty in understanding where to click and how to explore certain areas of the prototype. They suggested providing clearer visual cues without excessive arrows. Additionally, they desired more freedom to manipulate objects during the treatment scene rather than pre-determined animations. Another challenge was not knowing how to progress from one scene to another. Some participants found certain scenes, such as brushing teeth, difficult due to a lack of instructions. Instructions given in one scene did not reappear in subsequent scenes, leading to confusion about how to proceed. Thus, some participants became uncertain and had trouble navigating the narrative.

However, on the other hand, the evaluation also provided us with valuable suggestions and insights into what needs to be addressed for an improved user experience.

6 Discussion

This section will answer the this thesis' research questions (RQ). The first RQ will present preventative measures currently employed by dental professionals, while the second RQ will discuss how these measure can be transferred and potentially enriched through a digital interactive narrative. After this we will consider how dental professionals and children perceive ToothTales and assess whether the learning objectives were achieved. Lastly, the proposed design recommendations of this thesis will be presented.

6.1 RQ1: Which measures are currently employed by dental professionals to prevent dental anxiety in children?

From the initial semi-structured interviews with dental professionals, it became evident that a great variety of measures are employed to prevent dental anxiety in children. By creating a familiar and comfortable environment, using age-appropriate communication, and involving children in decision-making, dentists aim to build trust and reduce fear. By taking a gentle and slow approach and avoiding negative associations, dental practitioners strive to create a positive and enjoyable dental experience for children and potentially alleviate any dental anxiety.

These measures include for instance the use of metaphors, familiarization with dental instruments, and allowing children to touch and feel the instruments beforehand, all of which contribute to creating a sense of familiarity and reducing anxiety.

Empower the Child by Offering Control and Respect
Giving the child a sense of control during a dental appointment is important. For instance, dental professionals may allow the child to choose whether to start by looking at the upper or lower teeth. During the appointment, the child may also be given a mirror to observe what the dentist is doing and receive explanations. This empowering of the child might make them feel more in control of the appointment and thus more comfortable during it.

Additionally, practitioners ensure they communicate with the child at their eye level and maintaining eye contact to establish a connection and build trust. It may create a sense of respect and equality between the two parties as it may indicate that the dental practitioner values and acknowledges the child's presence and perspective. Hence, by engaging at eye level, the practitioner may establish a connection with the child, making them feel seen, heard, and understood. This helps to build trust and rapport, as the child might feel more comfortable and reassured knowing that the

58

dental practitioner is genuinely interested in their well-being. Likewise, proceeding with the treatment in the child's pace is also an important aspect of empowering as rushing the process may result in stress and negative associations. Hence, it is vital that the dentist takes a gentle and slow approach, allowing the child to gradually become comfortable with the surroundings and procedures.

Moreover, creating a predictable and structured environment is also crucial. This way, the child will have an idea of what will happen during the appointment and know what to expect. The dentist may also ask about the child's expectations for the appointment, providing an opportunity for the child to express their concerns or fears.

Create a Positive and Engaging Atmosphere

Having fun during the visit is encouraged to create a positive atmosphere. Counting the child's teeth in the beginning of the appointment can serve as a warm-up activity and contribute to a fun and relaxed tone. This can also be done by incorporating fantastical and magical elements during the treatment. One dentist emphasized the importance of creating small and fun stories functioning as analogies for the actual treatment. For instance, blaming the tooth fairy and her pointy heels when injecting a needle in the patient's gum. This creates a fun and playful atmosphere and may also serve as a distraction while amusing the child at the same time. By doing so, they might not be so attentive to what is actually happening, thus taking their mind off of potential aspects triggering nervousness.

Introduce and Explain the Dental Situation

For the first visit, the child is often introduced to the dental office and given a tour to familiarize them with the environment. By doing so, the child becomes more comfortable about the dental situation and might learn more about their surroundings. As learning more about the dental situation is important, dentists also often explain the treatment and the associated dental instruments in a simple and understandable manner suitable for children. This often involves the use of metaphors for the instruments, by comparing them to more tangible objects known to children. By using metaphors, dentists can effectively convey complex concepts in a way that children can easily grasp. Hence, they ensure that children understand and comprehend the situation and treatment. At the same time, it is important that the explanations given about the treatment are realistic, thus ensuring the child is adequately prepared without any surprises during the appointment. This approach aims to strike a balance between preparing the child and not shielding them from any necessary information.

Another method is preparing the child for their next visit, providing them with a

better understanding of the treatment. One may do so by suggesting educational resources online such as children's TV series about what to expect at the dentist, hence providing them with a better understanding of the procedures.

6.2 RQ2: How can existing preventive measures employed by dental professionals be transferred and potentially enriched through interactive narratives?

Digital interactive narratives have the potential to transfer and enhance existing measures used by dental professionals in several ways.

Utilize the Interactive Narrative to Learn and Become More Prepared

As a means of enrichment, the child may transfer the knowledge acquired from the digital narrative to their dentist appointment and become more familiar with the process, and possibly more comfortable during an appointment as well. Through detailed explanations covering the treatment of cavities, the child will learn more about the process which ToothTales offers from the perspective of the mouth. Showing the treatment done to a single tooth and how it is handled in detail will offer a more visceral and tangible approach to learning, as opposed to sitting in the chair and receiving a verbal explanation. This is similar to a method commonly used during appointments, in which the patient is given a mirror to get a view of their mouth and the treatment it receives. Thus, by offering a more comprehensive preview in the digital narrative, it can complement and enhance existing dental methods.

Additionally, the child can go through the narrative's content at their own pace. They also have the freedom to replay the narrative multiple times, allowing for reinforcement of learning and better comprehension of the content. This individualized approach thus enables children mentally prepare for their forthcoming visit to the dentist on their own terms.

Children can also benefit from the opportunity to express their thoughts and concerns before the appointment. Through the narrative, they can write down their thoughts or fears, enabling the dentist to address any anxious thoughts and provide reassurance and the necessary measures. Additionally, dental professionals can suggest using the narrative as a tool for a pre-appointment review, allowing child to familiarize themselves with the upcoming dental visit through ToothTales.

Present the Instruments in a Tangible Manner

As mentioned earlier in RQ1, dental professionals utilize several metaphors suitable for children as a means of explaining various procedures and dental instruments. As an extension of this measure applied at the office, ToothTales visualizes some of these metaphors, making the metaphors even more tangible as they are brought to life through interactive visualizations. For example, as demonstrated in Tooth Tales, the metaphor of a suction instrument giving a kiss is digitally rendered with a portrayal of the suction machine and its kissing mouth in a lighthearted manner. This takes the visualization of these metaphors a step further, making them even more easily understandable and engaging for children.

Additionally, as dental professionals often present the child with the instruments and let them feel and hear the sound of them during appointments, ToothTales incorporates the sound of the instruments during the treatment in the narrative. This may contribute to a normalization of dental sounds and thus the child might feel more relaxed when encountering the instruments during an actual appointment.

Digital Reproduction of Rewards and Stuffed Animals Furthermore, as it is common for children to bring their stuffed animals to dental appointments, this practice has been digitally reproduced in ToothTales which also provides the child the opportunity to bring a stuffed animal with them to the virtual appointment. This aims to create a familiar environment for the child, that is an environment of reduced anxiety and increased comfort.

Likewise, the concept of receiving a reward for visiting the dentist is also transferred to the narrative. After completing the appointment, the user is rewarded by the tooth fairy and given the opportunity to choose a new toy.

Such transfer of concepts from actual dental appointments may prepare the child for their appointment as they can become more familiar with the processes of it and what to expect.

6.3 RQ3: How do children and dental professionals consider the idea of using digital interactive narratives as a dental anxiety prevention tool?

Storytelling

During the evaluation of ToothTales the children appeared involved in the story.

They reacted by inching closer to the computer screen when interesting interactions were clicked, and laughter when the interactions included noises and animations. While playtesting ToothTales a lot of the children stopped playing to tell us about similarities or differences they have experienced when going to the dentist. After the playtesting, a lot of them the also managed to retell a lot of what happened during the story. All of these factors suggest that ToothTales is appropriate for the intended target group. However, when asked both the children and the dentists would have recommended the prototype for younger children as the interactions were not complex enough for the older children. This indicates that although ToothTales seemed enjoyable for children aged 6-10 years, the older children might demand a higher level of immersive interactions to remain engaged with the prototype.

Engagement

ToothTales is a digital interactive narrative where the storyline is predetermined, but the progression of the narrative is user-determined. The balance between fun, exploration and learning is an important tool to hold the user's attention while providing them with a more active way of learning about dental treatments. This balance, however, can be hard to obtain. During the evaluations dental professionals deemed the distribution of fun and educational elements as good as it provided a good mixture.

While ToothTales does offer a seemingly good amount of interactable elements, many children had difficulty finding them during the evaluation. However, when found or shown, they did express that they enjoyed the actions of the various interactions. Another aspect of ToothTales is the role of the user. The user chooses their own character at the start of the story, and follows the narrative of said character throughout the story. Thus, the user takes the role of both the main protagonist as well as the role of the treater during the cavity treatment. Nearly all the children expressed a positive response towards the dental treatment portion, as they were delighted to have the opportunity to actively participate in fixing the cavity themselves. Enabling children to experience the perspective of the dentist in this situation can offer them valuable insights into the procedures and activities involved. This firsthand experience may enhance their understanding and provide a normalization of the dental treatment process. Thus, helping eliminate anxious thoughts and feelings resulting from the uncertainty they previously may have experienced from having a cavity.

Education

The dentists considered ToothTales to be a fun and visual way of learning about what happens during a dental visit when a patient has a cavity. They particularly

liked that the instruments shown had been personified and the sounds they made were close to the real sounds in the dentist office. They also mentioned that Tooth-Tales could be an educational tool for dental professionals as well, as it could provide valuable insight into a child's thoughts and feelings during treatment.

The children also showed interest in the use of each instrument, and questioned the usage of them in the cavity treatment scene. One child expressed that they did not know that a cavity treatment required so many steps and instruments. However the responses of the children are varying. Some managed to retell the cavity treatment in great detail after playing through the prototype, while others did not remember much else other than certain interactions they had done. Together with our own observations this could indicate that the prototype is providing a good base for learning, but might be missing some crucial elements for keeping the children more engaged in their learning.

Utilization in real life

The dental professionals saw a potential for ToothTales to be a valuable tool in reducing dental anxiety in children. One dental professional thought ToothTales could also be used as a tool for dentists to teach how to approach children who might be nervous.
They found the prototype to have a good balance between learning and playful elements, and thought it could be included in real life practices after some adjustments. The dental professionals asked questions about when a tool like like such as this could be used in real life, and when the prototype would be ready to launch. They also commented on additional features and adjustments, such as adding information about the "stop-signal", that they would like to be included. This indicates that the dental professionals all felt that even the early version of ToothTales would be useful as an additional tool before dental treatments, and that with some more adjustments and refinements it could become functional to use before real dental treatments.

The children found ToothTales, as mentioned earlier, to be a fun, interactive narrative that they would have liked to explore more. Some of the children would have wanted to play with it before they had their dental appointments, while others would have recommended the prototype for younger children. This shows that there are sizable differences in how the different age groups perceive the digital interactive narrative, and that its usage in actuality might yield variable responses. It became clear that older children would require more interactions for the digital interactive narrative to be sufficiently immersive. Younger children liked the interactions in the prototype more, but they would perhaps require a voice-over or simpler instructions

in order to understand the context of the digital version of the dental treatment.

6.4 Evaluation of Learning Objects

The aim of the evaluations was also to assess whether the user achieved the learning objectives of ToothTales. In the light of our findings from the evaluations, we have evaluated whether they were achieved and will present this below.

Learning objective 1: The user will learn about the elements of the dentist office through a digital reconstruction of it

During the evaluation sessions, all who had participated in the workshops recognized both the waiting room and the dental office. When asked about what elements they particularly recognized, most participants expressed familiarity with some of the instruments used during the cavity treatment, and the general setup with the dental chair, sink and computer screen. While interacting, many also compared it to their own experiences with the dentist, indicating the design of ToothTales resembled an actual dental situation. One participant thought the digital version of the dental office was very similar to their dental office: "*It looks like at my dentist with the chair and all the extra around it*" (ID 4.14).

Learning objective 2: The user will learn about the different instruments used during a cavity treatment, and understand the role of each of them

The participants were presented with each instrument in chronological order, with an accompanying explanation of their role. They were also given freedom to explore the different sounds and feels of the instruments in the dental office. Most of the participants expressed that they learned something new about the instruments: *I did not know that there were that many tools to fix a cavity! I had only heard about the toothbrush*" (ID 4.20). Some remembered the metaphors and analogies best: "*I remember the buzzy bee, he was really fun*" (ID4.7).

Learning objective 3: The user will be taught the importance of brushing their teeth, and consequences of neglecting oral hygiene

To teach the respondents about the importance of brushing one's teeth, the prototype included a tooth brushing scene in the waiting room, as well as dialogue which conveys the possible consequences of not taking care of your teeth. During the evaluation sessions, the children were asked why it is important to fix cavities, and what they would have told someone who were going to treat a cavity for the first time.

Learning objective 4: The user will learn that they are in control of the dental treatment through the use of a stop signal

Unfortunately, we did not have enough time to implement the stop signal as a feature in the prototype before evaluation. Therefore, the prototype is lacking a visible and tangible signal to pause the cavity treatment, and a connection between the digital interactive narrative and the real-world dental office. Nevertheless, the participants did express that they liked having the option to explore the waiting room, dental office and closing scene freely. They decided what elements they wanted to interact with, such as the face mask: *"I want the dentist to wear a mask, I like the gloves"* (ID 4.9), and: *"I want to play it again so I can go back and do a bad choice!"* (ID 4.8).

We therefore feel that the learning objective was partially achieved, as the participants were given some control over own actions and own learning. They were given freedom to explore, and freedom to make their own choices. Although a significant portion of the learning objective were not implemented, and should be in future development, we still feel like the prototype does accomplish parts of the learning objective.

Learning objective 5: The user will be able to express thoughts and feelings regarding the dentist with other virtual characters, and learn that being nervous is normal

We did, unfortunately, not fully implement the dialogue between the main character and the side characters in the waiting room. The learning objective states that the user should be able to express their thoughts and feelings with other characters, while the implemented feature in the prototype only allows some interaction between the two on hover with no dialogue present. The side characters do, however, show their feelings and come with an encouraging phrase. The side characters' emotions primarily display nervousness, which does answer part of the learning objective. One participant did, however, express that they wanted to have more conversations with the characters in the waiting room: *"I would have wanted to talk to the other children. To talk about their life at school, and if they are scared of the dentist, and stuff like that"* (ID 4.13). Another stated that they *"[. . .] would like to talk to the children in the waiting room and ask them for advice for going to the dentist, and have them tell my character that everything is going to be alright*t" (ID 4.10).

6.5   Design Recommendations

Based upon the design and evaluation of ToothTales, along with insights derived from relevant literature, we propose five design recommendations. The design recommendations intend to provide insight to others planning to design a digital interactive narrative for the prevention of dental anxiety.

6.5.1   Recommendation 1: Provide the individual child with the ability to make an impact on the story progression

The participants, particularly the children, who partook in the research, indicated a preference towards influencing the story. This was observed in both the workshops conducted with children as well as during the evaluations.

As mentioned in Research Activity 1, the children showed great interest in creating a character and developing a story. This inclination was also present during research activity 2, as during the evaluations it became evident that the children enjoyed interacting with the narrative. For instance, many said they enjoyed interacting with the instruments and helping treating the cavity. Thus, this suggested an overall preference for having an impact on the storyline.

At the same time, some expressed a need for even more interactable elements. As mentioned earlier, this was especially indicated by the older children. Likewise, one participant suggested giving the user the option to choose between various feelings and have more varied facial expressions based upon one's choices in the narrative.

This is also supported by the notion of agency in digital interactive narratives. By letting the users take control and make meaningful choices, they are empowered through the impact their choices have on the progression of the narrative [40, 46]. This can then also support the user's feeling of transformation, as their actions can have a direct impact on the world they are immersed in [40].

Overall, the children enjoyed personalizing their character and having an impact on the story. Therefore, the digital interactive narrative should be designed with different interactive elements that have an effect on the progression of the storyline.

6.5.2   Recommendation 2: Ensure the digital interactive narrative conveys a realistic presentation of the dental situation

When designing and evaluating ToothTales with both dental professionals and children, both user groups expressed the importance of familiarity. The dental profes-

sionals introduce the children to various aspects and instruments at the dental office to prepare them for what is going to happen. They use this technique as a form of exposure therapy that helps limit potential paranoia the children might experience. From the perspective of a dental professional, it is clear that any tool with the aim of reducing anxiety or nervousness in children has to prepare them for what they will meet in a real-life dental office. This is in line with research which suggests exposure therapy when treating children with dental anxiety as it aims to gradually normalize the dental situation to the child [28].

The participating children had experience with going to the dentist for regular checkups and were comfortable with the dental environment when participating in the workshops. They recognized different scenes, elements and instruments commonly used at dental offices, and expressed the importance of including some of them in their stories. During the evaluation they also felt comfortable talking about their own experiences, comparing their own experiences to the ones they were exposed to in ToothTales. They remembered what they made in the workshops and expressed both what elements they wished were included in the prototype, and what elements they were happy with which were included. Based on this, it became clear that portraying a realistic presentation of the dental situation was beneficial as the children drew lines between real experiences and the digital representation of these in ToothTales.

However, as ToothTales is just a prototype, further features can be included to better prepare the children for their potential dental treatment. As mentioned earlier, the information and creation of stop signals would be an important feature to include as most dental professionals use this during their actual appointments. The dental professionals also suggested adding support for self-reflection at the end of ToothTales. They thought it could help the child identify scary thoughts and come better prepared to the appointment.

Familiarity with dental situations is important to be better prepared and comfortable during the appointment. Therefore the digital interactive narrative should include real objects and sounds from the dental office.

6.5.3 Recommendation 3: Include visuals and audio effects to engage the child

ToothTales includes a scene in which the user is free to explore the dentist office. One can interact by clicking on the various dental instruments displayed in the room, which will trigger corresponding and fun sounds that metaphorically represent them

in an engaged and appropriate manner. For instance, the curing light presented as a blue light which displays a blue light and is used to set fillings, will play a snippet of funky disco music when clicked on. This playback of audio is also included in scenes which include treatment of the cavity. For instance, each instrument will make an audio of the actual sound they make or feel like. Hence, instead of relying on textual information, one is provided with visuals and audios presenting the instruments.

Through user evaluations, specifically those involving children, it became evident that they greatly enjoyed the audio played in the narrative. This was indicated through observation of them during evaluations as they were observed laughing and even dancing when audio was played.

Additionally, through these evaluations it also became apparent that the children also enjoyed the visuals displayed in the ToothTales. This included visuals such as ones displaying how the various instruments work and how they appear. This was deemed more engaging as it seemed the children paid more attention to visuals and audio rather than textual information.

Children can become bored or overwhelmed by textual information. By including visual and audio effects, textual information can be presented in a more engaging way.

Thus, as it is shown that children enjoy audio and visuals as opposed to text, and the digital interactive narrative should incorporate a combination of visuals and audio effects.

6.5.4 Recommendation 4: Design the interface and content with regard to the user group's age

Although ToothTales is intended for children aged 6-10 years, it was tested only on children aged 7 to 9. Feedback from children, especially older ones, indicated that some parts were not suitable for their age group. Some also stated that the narrative perhaps would be better suited for their younger siblings as they themselves perceived some aspects as being childish or boring. This was also demonstrated through their interaction with the narrative as many were quite fast and did not pay much attention to the content. This was an indication that it was uninteresting and not suitable for their age group or interests.

Based upon the evaluation data it was indicated that the older children wished for more interaction in the narrative. In addition to this, some of the aspects, such as

the metaphors for dental instruments, were perceived as juvenile by some of the participants. This suggested that some features of the narrative were not suitable for the intended age group. Moreover, as mentioned in recommendation 3, adding voice-overs for younger children to understand the content more easily. Hence, an improvement would be to include more interaction and present the dental instruments according to the user's age group.

Thus, as it is important to adjust the content to the user group, the digital interactive narrative should be designed with regard to the intended user group and their age.

6.5.5 Recommendation 5: Use metaphors to visualize and simplify complex concepts

When complex dental treatments are explained to children, the information and overall situation can sometimes go over their heads. In those situations, it is important to ensure that the child understands what is being asked of them, or what they are going to go through. It is especially vital to avoid misunderstandings such as those that can lead to "paranoid thoughts" and wild fantasies, as these can often be the foundation of the start of anxiety. This is one of the focal points dentists have when preparing children for dental treatments.

A widely used technique for helping children retain information explained to them is through the use of metaphors. These can help children draw associations to objects and concepts from their everyday lives, and thus give them the opportunity to then understand a situation based upon concepts they already know. The dentists we interviewed all expressed that they used a lot of metaphors for children, especially when treating younger children. The dentists often drew associations to popular TV shows, sounds that the children would be used to from everyday life, and concepts that they were already familiar with, such as bees, showers, kisses and pillows.

When the children were asked what they remembered from playing through Tooth-Tales they often answered that it was the fun things like the disco sound and animation from the blue light instrument, the kissing sound from the suction, or how the tooth pillows worked as actual pillows for the tooth fairy. They also liked that the drill had eyes and looked like a bee embodying the "buzzy bee" metaphor.

At the same time some children and dentists expressed that our use of the metaphors were better suited for the lower end of the age range. Older children are often more understanding and curious about the instruments and procedures, and can better distinguish between their imaginations and what has been explained to them.

A possible improvement to this could be better utilization of the metaphors. By using more immersive analogues like the tooth castle analogue, the children would be more immersed in the story. The metaphors used in such a feature could also support the immersive experience of the analogue.

It can be difficult for children to grasp complex concepts such as the dental treatment of a cavity. It is therefore beneficial to use metaphors to portray this. We therefore recommend to use age-appropriate metaphors to visualize and simplify complex dental concepts.

7 Methodological Considerations

Prior to presenting the conclusion, we deem it fitting to examine our findings in the light of the utilized methodology. In this section, we will provide a brief analysis of three methodological constraints encountered in our work.

The first limitation concerns the number of participants of the study. The study involved in total 32 children and 8 dental professionals. Although this might be an adequate amount in terms of a master's thesis, it is not enough in terms of being able to generalize the findings, as the sample size is too small. This is largely due to limited time and resources as well as the struggle to recruit more participants, especially those in the category of dental professionals. Similarly, we encountered challenges recruiting Norwegian children, which regrettably led to their exclusion from this study, hence possibly weakening the thesis' internal validity as Norwegian dental professionals were included, but not Norwegian children. The study is also limited in the sense that although the intended target group is 6-10, we only managed to recruit participants in the age group of 7-9. Consequently, due to significant variations in maturity level, cognitive abilities as well as interests among children, the generalizability of the findings in this study to other ages included in the target group aged 6 and 10 may be diminished.

The second limitation concerns the fact that this is an interpretative study largely based upon statements from participants. Thus, there is always a risk of misinterpretation due to factors such as potential ambiguity in participants' statements [62]. We attempted to mitigate this by properly transcribing all recordings and reassessing interpretations multiple times as well as comparing notes within the team.

The third limitation pertains to insufficient testing of the effect of the prototype, and thereby limiting our ability to assess its impact on preventing dental anxiety. It is important to note that our research focus was not centered on evaluating the prototype's impact on preventing dental anxiety in children, as it focused more on their perception of the prototype. Thus, assessing its effectiveness in that specific context is beyond the scope of our study. However, acknowledging this limitation is crucial as it indicates our ability to legitimately describe the potential influence of the prototype on dental anxiety prevention. It also affects the prototype's generalizability as it is challenging to make broader claims or draw conclusions that can be applied to other settings or populations. This limitation highlights the importance of future research to explore the prototype's effect on generalizability and external validity, thereby providing a more comprehensive understanding of its potential implications in other contexts.

Moreover, despite the limitations listed here, we have involved various stakeholders and applied several methods in our research. This includes methods such as semi-structured interviews, workshops, prototyping and evaluations. Such method triangulation strengthens the reliability of this study.

8 Conclusion

This thesis intended to explore the potential of a digital interactive narrative in the prevention of dental anxiety in children. To accomplish this, we consulted dental professionals with varying experience in working with children, conducted workshops involving children from the target user group, and developed a prototype that was evaluated by both dental professionals and children. This approach was inspired by a user-centered and participatory design process. The result of this project is a digital interactive narrative called ToothTales which allows its users to explore and learn more about the process of treating a cavity.

The thesis was guided by three research questions which will be presented with a summary of main findings below.

RQ1: Which measures are currently employed by dental professionals to prevent dental anxiety in children?

The semi-structured interviews with dental professionals showed that they employ various methods to prevent dental anxiety in children. This includes creating a familiar environment, involving children in decision-making, and using age-appropriate communication. They take a gentle approach, avoid negative associations, and empower the child by offering control and respect. Fun and engaging activities are incorporated to create a positive atmosphere, while explanations are given using simple language and metaphors. Additionally, preparing children for their next visit through educational resources further enhances their understanding of dental procedures and may prevent dental anxiety.

RQ2: How can existing preventive measures employed by dental professionals be transferred and potentially enriched through interactive narratives?

Digital interactive narratives have the potential to transfer and enhance existing measures used by dental professionals in several ways. For instance, dental professionals often employ metaphors to explain procedures and dental instruments to children. ToothTales takes this approach a step further by portraying these metaphors through interactive visualizations, thereby making them more tangible and engaging. Likewise, ToothTales might encourage normalization of dental instruments by incorporating their sounds in the narrative, simulating the real-life experience of feeling and hearing the instruments during an appointment. This immersive approach can lead to an acceptance of the instruments and contribute to the child feeling better

prepared for their actual dental visits. Additionally, the child can potentially apply the knowledge acquired from the narrative to their dental appointment, leading to increased familiarity with the process and thus potentially enhancing their comfort during the appointment. Furthermore, ToothTales incorporates familiar concepts such as bringing a stuffed animal and receiving rewards, creating a comforting and familiar environment.

RQ3: How do children and dental professionals consider the idea of using digital narratives as a dental anxiety prevention tool?

The evaluations with both dental professionals and children revealed that the respondents were overall happy with ToothTales as a concept. The children were actively engaged with the story, showing excitement through for example laughter and smiles when finding and interacting with elements of the narrative. However, some of the older children indicated a need for more complex interactable elements to remain engaged in the narrative, suggesting the interactive narrative to be more suitable for younger children. At the same time, some of the children did not always find the elements intuitive to locate and interact with, but expressed enjoyment when guided to them. Both dental professionals and children shared their experiences of their own during playtesting, indicating that the interactive narrative invited to reflection over their own dental encounters. Furthermore, ToothTales allowed the user to experience both the role of the dentist and the patient, which encouraged curiosity to learn about the instruments and techniques used. This curiosity might have helped the user understand more of the logic behind the treatment from a dental point of view, and better prepare them for what they can expect during treatment. Moreover, both user groups found the interactive narrative to potentially be a useful tool in real life anxiety prevention. Dental professionals expressed that ToothTales had potential to teach them about children's experiences and how to account for that. Children expressed that playing through ToothTales would have helped them feel less nervous before treatment. These two important points of view show that familiarity with a possibly unknown process is important for keeping both child and professional comfortable during treatments.

Drawing upon the findings of this study, we suggest a set of five design recommendations for the design of an interactive narrative for dental anxiety prevention in children:

- Provide the individual child with the ability to make an impact on the story progression

- Ensure the application conveys a realistic presentation of the dental situation

- Include visuals and audio effects to engage the child

- Design the interface and content with regard to the user group's age

- Use metaphors to visualize and simplify complex concepts

This thesis asserts that the utilization of a digital interactive narrative holds promise as a valuable tool in the prevention of dental anxiety among children. An appropriate progression in the research would involve assessing the efficacy of the narrative as a preventive measure in an actual context of use.

References

[1] J. M. Armfield, A. Spencer, and J. F. Stewart, "Dental fear in australia: who's afraid of the dentist?" *Australian dental journal*, vol. 51, no. 1, pp. 78–85, 2006.

[2] International Organization for Standardization, "ISO 9241-210:2019 - Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems," *ISO*, 2019.

[3] S. J. Frisbee, C. B. Chambers, J. C. Frisbee, A. G. Goodwill, and R. J. Crout, "Self-reported dental hygiene, obesity, and systemic inflammation in a pediatric rural community cohort," *BMC Oral Health*, vol. 10, no. 1, pp. 1–8, 2010.

[4] A. Luoto, S. Lahti, T. Nevanperä, M. Tolvanen, and D. Locker, "Oral-health-related quality of life among children with and without dental fear," *International Journal of Paediatric Dentistry*, vol. 19, no. 2, pp. 115–120, 2009.

[5] L. Foster Page, W. Thomson, A. Jokovic, and D. Locker, "Validation of the child perceptions questionnaire (cpq11-14)," *Journal of dental research*, vol. 84, no. 7, pp. 649–652, 2005.

[6] G. Klingberg and A. G. Broberg, "Dental fear/anxiety and dental behaviour management problems in children and adolescents: a review of prevalence and concomitant psychological factors," *International journal of paediatric dentistry*, vol. 17, no. 6, pp. 391–406, 2007.

[7] G. Klingberg, U. Berggren, S. G. Carlsson, and J. G. Noren, "Child dental fear: cause-related factors and clinical effects," *European Journal of Oral Sciences*, vol. 103, no. 6, pp. 405–412, 1995.

[8] D. Locker, A. Liddell, L. Dempster, and D. Shapiro, "Age of onset of dental anxiety," *Journal of dental research*, vol. 78, no. 3, pp. 790–796, 1999.

[9] F. M. Oosterink, A. De Jongh, and J. Hoogstraten, "Prevalence of dental fear and phobia relative to other fear and phobia subtypes," *European journal of oral sciences*, vol. 117, no. 2, pp. 135–143, 2009.

[10] S. Verschueren, J. van Aalst, A.-M. Bangels, J. Toelen, K. Allegaert, C. Buffel, and G. Vander Stichele, "Development of clinipup, a serious game aimed at reducing perioperative anxiety and pain in children: Mixed methods study," *JMIR Serious Games*, vol. 7, no. 2, Jun 2019. [Online]. Available: http://games.jmir.org/2019/2/e12429/

[11] J. I. Gold, E. T. Annick, A. S. Lane, K. Ho, R. T. Marty, and J. C. Espinoza, ""doc mcstuffins: Doctor for a day" virtual reality (docvr) for pediatric preoperative anxiety and satisfaction: pediatric medical technology feasibility study," *Journal of medical Internet research*, vol. 23, no. 4, p. e25504, 2021.

[12] M. Cavazza, F. Charles, and S. Mead, "Character-based interactive storytelling," *IEEE Intelligent Systems*, vol. 17, no. 4, pp. 17–24, 2002.

[13] S. Wang and H. Zhan, "Enhancing teaching and learning with digital storytelling," *International Journal of Information and Communication Technology Education (IJICTE)*, vol. 6, no. 2, pp. 76–87, 2010.

[14] L. D. Seligman, J. D. Hovey, K. Chacon, and T. H. Ollendick, "Dental anxiety: An understudied problem in youth," *Clinical psychology review*, vol. 55, pp. 25–40, 2017.

[15] A. M. White, L. Giblin, and L. D. Boyd, "The prevalence of dental anxiety in dental practice settings," *American Dental Hygienists' Association*, vol. 91, no. 1, pp. 30–34, 2017.

[16] S. Cianetti, G. Lombardo, E. Lupatelli, S. Pagano, I. Abraha, A. Montedori, S. Caruso, R. Gatto, S. De Giorgio, R. Salvato *et al.*, "Dental fear/anxiety among children and adolescents. a systematic review," *Eur J Paediatr Dent*, vol. 18, no. 2, pp. 121–30, 2017.

[17] A. N. Åstrøm, E. Skaret, and O. Haugejorden, "Dental anxiety and dental attendance among 25-year-olds in norway: time trends from 1997 to 2007," *BMC oral health*, vol. 11, no. 1, pp. 1–7, 2011.

[18] E. Skaret, M. Raadal, E. Berg, and G. Kvale, "Dental anxiety and dental avoidance among 12 to 18 year olds in norway," *European journal of oral sciences*, vol. 107, no. 6, pp. 422–428, 1999.

[19] U. Berggren and G. Meynert, "Dental fear and avoidance: causes, symptoms, and consequences." *Journal of the American Dental Association (1939)*, vol. 109, no. 2, pp. 247–251, 1984.

[20] R. Hmud and L. J. Walsh, "Dental anxiety: causes, complications and management approaches," *J Minim Interv Dent*, vol. 2, no. 1, pp. 67–78, 2009.

[21] R. A. Kleinknecht, R. K. Klepac, and L. D. Alexander, "Origins and characteristics of fear of dentistry," *The Journal of the American Dental Association*, vol. 86, no. 4, pp. 842–848, 1973.

[22] J. Woolgrove and G. Cumberbatch, "Dental anxiety and regularity of dental attendance," *Journal of dentistry*, vol. 14, no. 5, pp. 209–213, 1986.

[23] G. Kent, "Anxiety, pain and type of dental procedure," *Behaviour research and therapy*, vol. 22, no. 5, pp. 465–469, 1984.

[24] ——, "Cognitive processes in dental anxiety," *British Journal of Clinical Psychology*, vol. 24, no. 4, pp. 259–264, 1985.

[25] G. Humphris and K. King, "The prevalence of dental anxiety across previous distressing experiences," *Journal of anxiety disorders*, vol. 25, no. 2, pp. 232–236, 2011.

[26] E. Townend, G. Dimigen, and D. Fung, "A clinical study of child dental anxiety," *Behaviour research and therapy*, vol. 38, no. 1, pp. 31–46, 2000.

[27] M. THEMESSL-HUBER, R. Freeman, G. Humphris, S. Macgillivray, and N. Terzi, "Empirical evidence of the relationship between parental and child dental fear: a structured review and meta-analysis," *International journal of paediatric dentistry*, vol. 20, no. 2, pp. 83–101, 2010.

[28] D. P. Appukuttan, "Strategies to manage patients with dental anxiety and dental phobia: literature review," *Clinical, cosmetic and investigational dentistry*, pp. 35–50, 2016.

[29] J. M. Armfield, J. F. Stewart, and A. J. Spencer, "The vicious cycle of dental fear: exploring the interplay between oral health, service utilization and dental fear," *BMC oral health*, vol. 7, pp. 1–15, 2007.

[30] R. K. Klepac, J. Dowling, and G. Hauge, "Characteristics of clients seeking therapy for the reduction of dental avoidance: reactions to pain," *Journal of Behavior Therapy and Experimental Psychiatry*, vol. 13, no. 4, pp. 293–300, 1982.

[31] R. Moore, I. Brødsgaard, and H. Birn, "Manifestations, acquisition and diagnostic categories of dental fear in a self-referred population," *Behaviour Research and Therapy*, vol. 29, no. 1, pp. 51–60, 1991.

[32] U. Wide Boman, V. Carlsson, M. Westin, and M. Hakeberg, "Psychological treatment of dental anxiety among adults: a systematic review," *European journal of oral sciences*, vol. 121, no. 3pt2, pp. 225–234, 2013.

[33] Den norske tannlegeforening, "Ingen kutt i tannhelse i årets statsbudsjett," 202. [Online]. Available: https://www.tannlegeforeningen.no/arkiv/nyhetsarkiv/nyheter/2020-10-07-ingen-kutt-i-tannhelse-i-arets-statsbudsjett.html

[34] A. A. of Pediatric Dentistry, "Behavior guidance for the pediatric dental patient," *The Reference Manual of Pediatric Dentistry*, vol. 11, 2020.

[35] F. Gozin, F. Tabe Bordbar, and M. Esmaeili, "Audio–visual storytelling for reducing dental anxiety in iranian children: a randomized controlled trial," *European Archives of Paediatric Dentistry*, pp. 1–8, 2022.

[36] D. Gordon, R. G. Heimberg, M. Tellez, and A. I. Ismail, "A critical review of approaches to the treatment of dental anxiety in adults," *Journal of anxiety disorders*, vol. 27, no. 4, pp. 365–378, 2013.

[37] R. Monterubbianesi, V. Tosco, F. Vitiello, G. Orilisi, F. Fraccastoro, A. Putignano, and G. Orsini, "Augmented, virtual and mixed reality in dentistry: A narrative review on the existing platforms and future challenges," *Applied Sciences*, vol. 12, no. 2, p. 877, 2022.

[38] A. Cunningham, O. McPolin, R. Fallis, C. Coyle, P. Best, and G. McKenna, "A systematic review of the use of virtual reality or dental smartphone applications as interventions for management of paediatric dental anxiety," *BMC Oral Health*, vol. 21, no. 1, pp. 1–11, 2021.

[39] C. Campbell, M.-T. HOSEY, and S. McHUGH, "Facilitating coping behavior in children prior to dental general anesthesia: a randomized controlled trial," *Pediatric Anesthesia*, vol. 15, no. 10, pp. 831–838, 2005.

[40] F. Nack, "Interactive digital narrative (idn)—a complexity case," pp. 69–75, 2022.

[41] H. Koenitz, "Towards a theoretical framework for interactive digital narrative," in *Interactive Storytelling: Third Joint Conference on Interactive Digital Storytelling, ICIDS 2010, Edinburgh, UK, November 1-3, 2010. Proceedings 3*. Springer, 2010, pp. 176–185.

[42] ——, *Understanding Interactive Digital Narrative: Immersive Expressions for a Complex Time.* Taylor & Francis, 2023.

[43] J. H. Murray, "Research into interactive digital narrative: A kaleidoscopic view," in *Interactive Storytelling*, R. Rouse, H. Koenitz, and M. Haahr, Eds. Cham: Springer International Publishing, 2018, pp. 3–17.

[44] H. Koenitz, "Towards a specific theory of interactive digital narrative," in *Interactive digital narrative*. Routledge, 2015, pp. 91–105.

[45] J. H. Murray, *Hamlet on the Holodeck, updated edition: The Future of Narrative in Cyberspace*. MIT press, 2017.

[46] L. Joyce, "Creating collaborative criteria for agency in interactive narrative game analysis," *The Computer Games Journal*, vol. 4, pp. 47–58, 2015.

[47] A. Y. Kolb and D. A. Kolb, "Learning to play, playing to learn: A case study of a ludic learning space," *Journal of Organizational Change Management*, vol. 23, no. 1, pp. 26–50, 2010.

[48] N. Kucirkova, "An integrative framework for studying, designing and conceptualising interactivity in children's digital books," *British Educational Research Journal*, vol. 43, no. 6, pp. 1168–1185, 2017.

[49] M. C. Ramos-Vega, V. M. Palma-Morales, D. Pérez-Marín, and J. M. Moguerza, "Stimulating children's engagement with an educational serious videogame using lean ux co-design," *Entertainment Computing*, vol. 38, p. 100405, 2021.

[50] A. G. Bus, Z. K. Takacs, and C. A. Kegel, "Affordances and limitations of electronic storybooks for young children's emergent literacy," *Developmental Review*, vol. 35, pp. 79–97, 2015.

[51] Z. K. Takacs, E. K. Swart, and A. G. Bus, "Can the computer replace the adult for storybook reading? a meta-analysis on the effects of multimedia stories as compared to sharing print stories with an adult," *Frontiers in psychology*, vol. 5, p. 1366, 2014.

[52] R. J. Amineh and H. D. Asl, "Review of constructivism and social constructivism," *Journal of social sciences, literature and languages*, vol. 1, no. 1, pp. 9–16, 2015.

[53] D. Kozdras, D. M. Haunstetter, and J. R. King, "Interactive fiction:'new literacy'learning opportunities for children," *E-Learning and Digital Media*, vol. 3, no. 4, pp. 519–533, 2006.

[54] A. Sadik, "Digital storytelling: A meaningful technology-integrated approach for engaged student learning," *Educational technology research and development*, vol. 56, pp. 487–506, 2008.

[55] M. U. Bers and J. Cassell, "Interactive storytelling systems for children: Using technology to explore language and identity," *Journal of Interactive Learning Research*, vol. 9, pp. 183–215, 1998.

[56] M. C. Green and K. M. Jenkins, "Interactive narratives: Processes and outcomes in user-directed stories," *Journal of Communication*, vol. 64, no. 3, pp. 479–500, 2014.

[57] L. E. Matthyssens, A. Vanhulle, L. Seldenslach, G. Vander Stichele, M. Coppens, and E. Van Hoecke, "A pilot study of the effectiveness of a serious game clinipup(R) on perioperative anxiety and pain in children," *Journal of pediatric surgery*, vol. 55, no. 2, pp. 304–311, 2020.

[58] M. R. Dekker and A. D. Williams, "The use of user-centered participatory design in serious games for anxiety and depression," *Games for health journal*, vol. 6, no. 6, pp. 327–333, 2017.

[59] T. Bratteteig and I. Wagner, "Disentangling power and decision-making in participatory design," in *Proceedings of the 12th Participatory Design Conference: Research Papers-Volume 1*, 2012, pp. 41–50.

[60] S. J. Warren and G. Jones, *Learning games: The science and art of development*. Springer, 2017.

[61] J. Johnson and A. Henderson, "Conceptual models: begin by designing what to design," *interactions*, vol. 9, no. 1, pp. 25–32, 2002.

[62] S. Kvale, "Ten standard objections to qualitative research interviews," *Journal of phenomenological psychology*, vol. 25, no. 2, pp. 147–173, 1994.

Appendices

A Semi-Structured Interview with Dental Professionals

Semi-structured interview with experts

Introduction
- Introduce ourselves and ask the interviewee to introduce themself
- Briefly present what the conversation is about
    - We are concerned with their interaction with children,
- Brief presentation of our task and preliminary concept
    - Children
    - Safe children going to the dentist, Prevent dental treatment anxiety
    - Digital interactive narrative

Information about the interviewee (remember that the person must sign a consent form).
- Position and possible specialization
- How long experience in position
- Email
- Phone no.

How much experience do they have with general treatment of children?
- Certifications or experiences gained during the career (specific to the interviewee)?
- Interact differently with children compared to adults? How?
- What do they do to make children feel safe in the chair? (behavior, giving toys, etc.)
- Measures they usually recommend outside the dentist's office, which you can do prior to an appointment?

To what extent have they treated children with dental anxiety?
- Do they interact differently with these children? How?
- If the same measures that are used on children with dental anxiety are used on children without - do they also work preventively?

What makes children afraid?
- Objects/tools, treatment, process (specific parts?, waiting room?)
- Behavior and age of children

- How do children/children with anxiety experience different treatments and objects (such as chairs and tools).
    - What objects/instruments are children most afraid of?
    - When one starts developing cavities? If you have to extract a tooth? Do a little more than a regular dental health check?
- How does the dentist notice that what they are doing was perhaps a little extra scary?

- - Does the dentist notice that the child has dental anxiety, or is it usually the parents or the child who inform about this?
    - How does the child behave?
    - Is the child scared during the entire process (e.g. from the waiting room until they are out of the dentist's office or only during certain parts)
  - At what age do you notice that children start to show signs of dental anxiety?
    - Aren't children scared until they are 8-12 years old (bearing in mind that this is the age group for TkMidt)?
  - (What differentiates children with dental anxiety from children who just find it uncomfortable?)

Demonstration of the measures they take/what is a normal dental appointment like?

Explain our concept, and hear what they think about it.
  - Is this something they think can be preventive for dental fear or nervousness before a dental appointment?
  - Is it possible to implement some of your methods/measures in our solution?
  - Do they have any specific ideas (things/concepts/treatments/tools) that should have been included in such a narrative, which could have a preventive effect?
  - Could this concept help in other ways than just preventing dental anxiety?
 - Any other ideas/thoughts?

If time: How does the dental system work in Australia? In short.
  - How often do children visit the dentist?
  - When do children start going to the dentist?
  - Do they get any information before they have a dental appointment?
  - What differentiates a pediatric dentist from a regular dentist in terms of knowledge about children and dental anxiety?
  - Are there big differences between private and public/school dentists? Both in general and in relation to children and dental anxiety.
  - Do they offer any special treatment for children with dental anxiety in Australia (eg something a la tbit)?

B   Conceptual Model
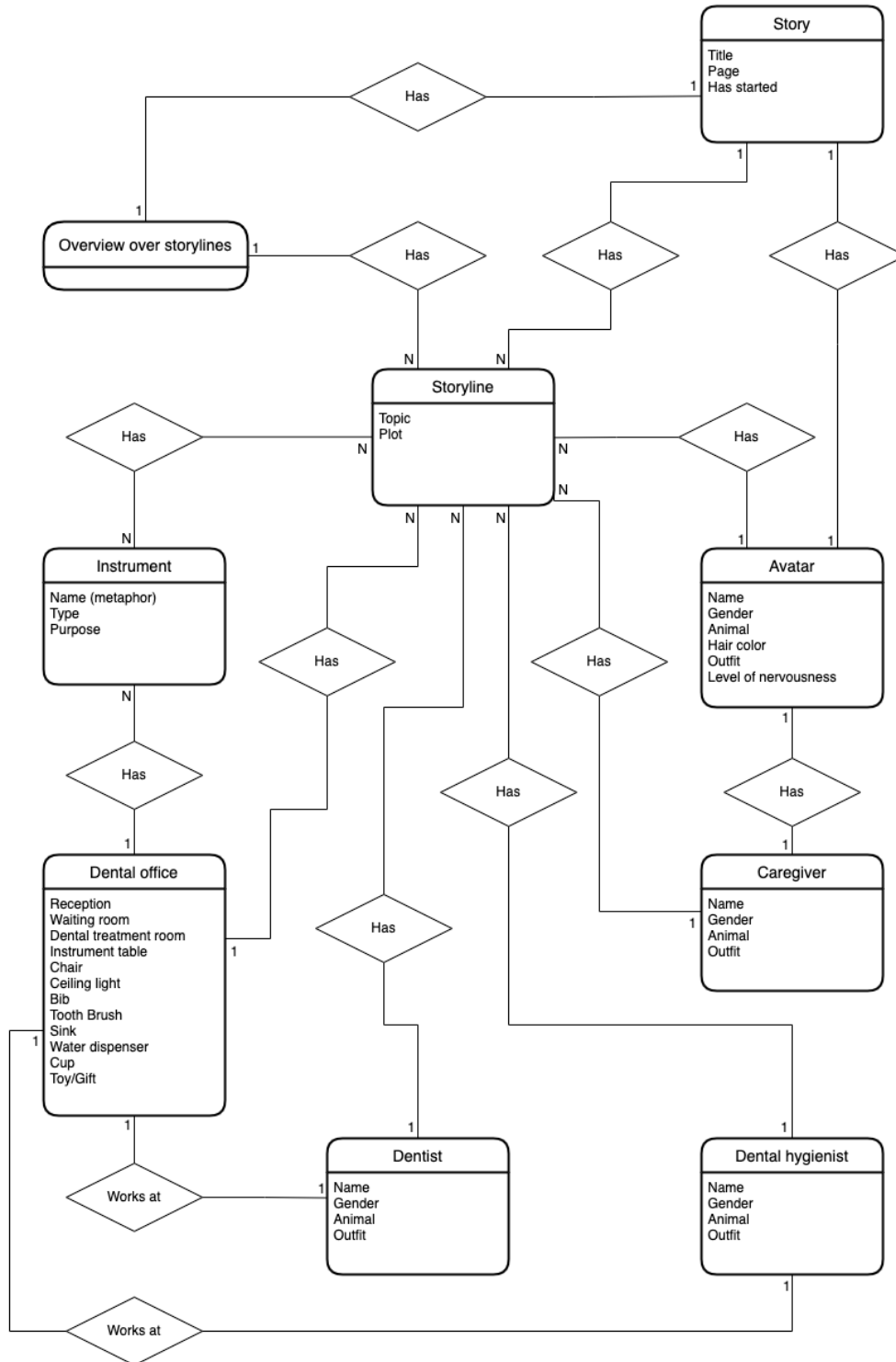
C Personas and Scenarios
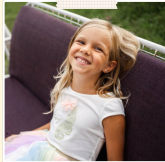
Olivia

"Explorer"

- 7 years old
- Primary School
- Sydney

Bio

Oliva is a social girl who loves spending time with her classmates. She is a very curious girl and enjoys learning new things, especially through fun games on her tablet at home. However, she is not a big fan of the textbooks they have at school, nor is she particularly fond of reading. She is a visual learner and her favorite subject at school is arts and crafts.

She is an avid football player and often plays with her older brother. They have very competitive matches and her brother is a great player. Olivia admires his skills and wishes to one day become as good as him.

Relation to dentist

Olivia has been going regularly to the dentist since she was two years old. Her parents have always encouraged her to brush her teeth and not eat too many sweets. She has never had the need for any special treatments, only regular check ups. Her visits to the dentist are always fun and she always looks forward to receiving her toy/gift by the end of her appointments.

However, at her last appointment she was told that she had a pre-cavity. This made her a bit anxious as she has been told by her brother that cavities and their treatments are painful. Hence, she wants know more about what causes cavities and how to avoid them.
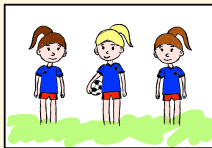
Personality

|	
Introvert	Extrovert
Analytical	Creative
Busy	Time rich
Messy	Organized
Independent	Team player
Passive	Active
Safe	Risky

Olvia was told at her last dentist appointment that she had a pre-cavity.

She had heard from her brother that cavities and cavity treatments are painful. This made her a bit nervous for actually getting a cavity later.

Olivia also got curious on what cavities are, and asked her friends if they ever have had cavities and knew how to avoid them or how the dentist treats them. One of her friend had had a cavity in the past.
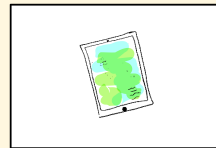
On their way home Olivias friend showed Olivia an storytelling app where Olivia could find out more about cavities.
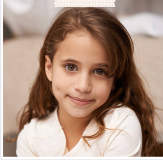

Olivia downloaded the app when she came home. Olivia used the app to find more about cavities, how to avoid them, and how the dentist treats them.

She now understood that the treatment did not seem as scary as her brother told her, but that she still should avoid getting a cavity.

7

Sophie

"Sage"

- 8 years old
- Primary School
- Sydney

Bio

Sophie loves learning new things and has a passion for books. She loves exploring fictional characters and the universes they inhabit. She is an imaginative child who sometimes has a bit overactive mind causing her to create her own stories and fantasies. She loves sharing these stories and her interests with friends and family. She sets high goals for herself, and likes to prove both to herself, her familiy and friends that she is good at what she does. At the same time she likes being challenged and can easily become bored if it is not engaging enough.

Relation to dentist

Sophie has been going regularly to the dentist since she was two years old. Her parents have always encouraged her to brush her teeth and not eat too many sweets (although she has a sweet tooth and loves candy). Over the past years she has never had the need for any special treatments until recently when her dentist found a cavity in one of her teeth and thus must have her tooth drilled at her next appointment. This has made Sophie a bit anxious for her next visit at the dentist's as she has never had such a treatment. She does not know what to expect and does not feel in control of the situation.

Personality

|		
Introvert		Extrovert
Analytical		Creative
Busy		Time rich
Messy		Organized
Independent		Team player
Passive		Active
Safe		Risky

At Sophie´s last dentist appointment the dentist found a cavity in her tooth.
She is therefore scheduled for a cavity treatment in two weeks.

Sophie gets a bit nervous before the next appointment as she has never had such a treatment before. She does not know what to expect and does not feel in control over the situation.
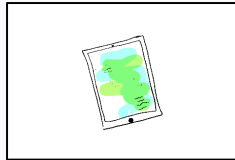
Sophie downloads the game as she want to learn and know more about what that will happen during her cavity treatment.
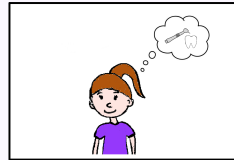
After using the app she feels that she knows more about the treatment and the instruments that the dentist will use during the appointment. She now feels a bit more in control and believes that the treatment will go well.

William

"Jester"

- 9 years old
- Primary School
- Sydney

Bio

William is an active 9-year old. He loves using his body and according to his parents he never runs out of energy. He enjoys spending time outside with friends climbing trees and running around exploring the woods. He rarely stands still and there is always something happening. His current goal is to make a tree house with his friends from the hockey team he is on.

He is easily bored and can get quite impatient if things are going too slow. He is not particularly fond of school as he finds passive learning dull. He likes practical learning where he gets to interact with the learning material.

Relation to dentist

William has been going regularly to the dentist since he was four years old. His parents try to keep him still during dentist appointments which results in him not getting the necessary treatment he needs. His previous dentist didn't listen to William, and he is not looking forward to his next appointment because of this. Recently he broke off part of his tooth when falling down from a tree in the school yard. He needs to have part of his tooth replaced and is not looking forward to sitting still for so long.
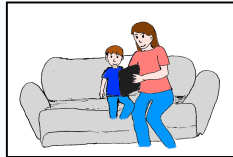
Personality

| Introvert | | Extrovert |
Analytical		Creative
Busy		Time rich
Messy		Organized
Independent		Team player
Passive		Active
Safe		Risky
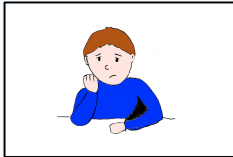
William struggles to sit still when he has to learn new material in a passive way. He thinks it is boring to hear his parents talk to him about the dentist and why dental hygiene is important.

William's parents find an app that can teach him about the dentist and dental hygiene. They show it to him after school.
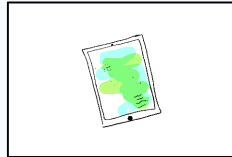
William loves using the iPad and gaming and spends the evening using the app.
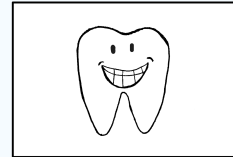
William has now learned about the dentist and dental hygiene in a fun way, and will remember to brush his teeth extra good tonight.

David

"Caregiver"

- 44 years old
- Pilot
- Sydney

Bio

David is a pilot, and father of three kids ages 7, 11, and 14. He shares the responsibility of his children with his wife, Lisa. When he is not working he enjoys spending time with his kids, working out and playing football.
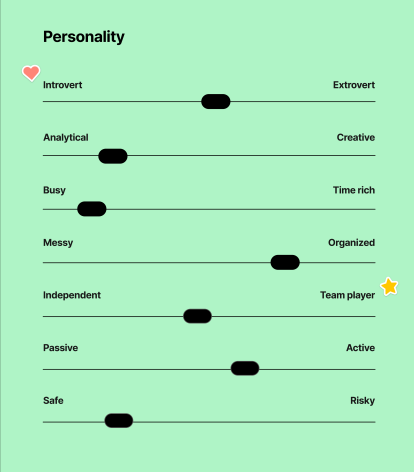
It is important for David to lead a healthy lifestyle, which includes healthy eating and spending time outdoors. It is important to him that his kids take part in this lifestyle, and he is therefore rather strict with their dental health. But because of his busy schedule he does not always have time to follow up on teeth brushing.

Relation to dentist

David goes to the dentist for yearly check-ups, and is always making sure his teeth are clean. He has had some cavities throughout the years and does not want to get any more.

He has attended most of his children's dentist appointments and always encourage them to take good care of their teeth.
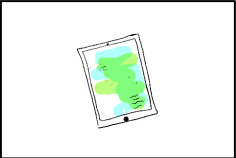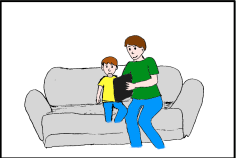
Personality

Introvert	Extrovert
Analytical	Creative
Busy	Time rich
Messy	Organized
Independent	Team player
Passive	Active
Safe	Risky

After David's youngest son's previous dental check-up two years ago, the son was not particularly happy afterwards. The dentist had done something sudden and unexpected that hurt. Therefore his son was not too pleased when he now had to go back for a check-up with the dentist.

David told his colleague about his son's feelings for the next dental checkup. Then a colleague told him about the storytelling dentist app. When David came home, he downloaded the app.

One week before his son's next check-up at the dentist, David wanted to prepare his son better to the appointment, so he knew what to expect. He sat down with his son after dinner and showed the app to him. They started using it together.

At the next check-up appointment David's son knew what instruments the dentist would use and how they would feel like. This made both David and his son more calm both before and during the check-up.

10

Rebecca

"Sage"

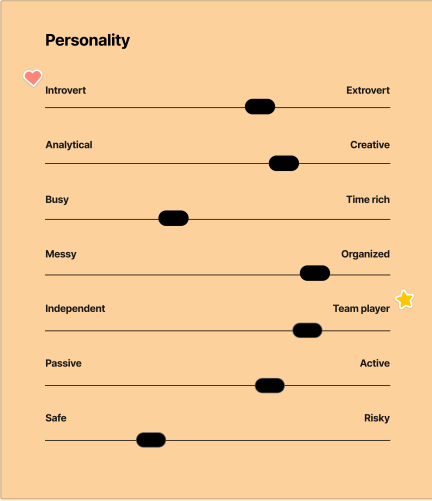- 35 years old
- Dentist
- Sydney

Bio

Sarah works as a dentist in Sydney and loves working with people. Throughout her work day she treats many children and loves introducing her tiny patients to healthy habits. She enjoys explaining what she is doing in simple terms and wants to make every appointment a fun experience and help her patients look forward their next appointment. She finds it very fulfilling to help nervous patients feel safe and overcome their dental anxieties. She finds it important to involve children in decisions about their dental health, and likes to involve them the same way she involves adults.

In her spare time she cultivates a healthy lifestyle and spends most of her time outdoors or in her local yoga studio.
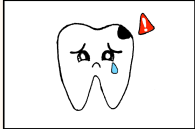
Relation to dentist

Growing up with two parents who are dentists, Rebecca knew from an early age how important it is to take good care of one's teeth. As she later grew up to become a dentist herself, she now enjoys talking to her patients about the importance of brushing and flossing one's teeth from an early age. She believes that learning about preventative dental care is very important to avoid big treatments/interventions later. She always try to set aside time to explain why and answer any questions about dental care during her appointments.
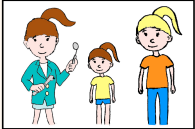
Personality

Introvert		Extrovert
Analytical		Creative
Busy		Time rich
Messy		Organized
Independent		Team player
Passive		Active
Safe		Risky

Rebecca discoved a cavity in a 8 year old patient's teeth. The patient has never had a cavity before, and Rebecca knows that many patients are nervous before such a treatment.

To prepare the patient to the next appointment she recommends the app to the patient and her parents.

When the patient comes back to do her cavity treatment, she has used the app and knows a little about the cavity treatment Rebecca will do.

Before and during the cavity treatment, Rebecca shows the patient the instruments that she will use and refer to the relevant elements in the story. The patient recognizes and tie the instruments and actions to the story she knows from the app.

The patient seems happy after the cavity treatment, and Rebecca is happy should could help another child and at the same time make it a fun experience.

D   User Stories

Requirements
Prioritized version

1
Name: Cavity treatment and instruments
User Story: As a user, I want to go through a cavity treatment, so I can learn about the instruments and understand what happens
Requirement: The app must in a friendly manner show how a cavity is treated, what instruments are used, why they are used, how the instruments feel/sound, in what order they are used, and why the treatment is necessary. This must be shown through metaphors, visuals, sound and text
Priority: High

2
Name: Dentist
User Story: As a user, I want the dentist to be friendly and guide me through the appointment and explain concepts in a recognizable manner suitable for children
Requirement: The app must provide the user with understandable information and utilize metaphors, jokes, visuals, sounds, animations and text
Priority: High

3
Name: Main character's emotions
User Story: As a user, I want the main character to go from nervous about the dentist to happy after, to convey that it can be a positive experience
Requirement: The app must present the main character with nervous emotions in the beginning, and gradually progress these to happy emotions through dialogues and positive reinforcements

Character show usual emotions related to the different situations
Priority: High

4
Name: Customize Character
User Story: As a user, I want to be able to customize the appearance of my character, to make my character relatable and personable
Requirement: The app must allow customization of name, gender, skin color, hair color, clothes and accessories
Priority: High

5
Name: Tooth fairy
User Story: As a user, I want the tooth fairy to be a narrator through the story, so that I am met with someone magical and recognizable
Requirement: The app must guide the user through the story and its choices. It must also have a common thread and provide funny remarks from start to end
Priority: Medium

1
Name: Learn stop signal
User Story: As a user, I want to learn the stop signal, so I can be in control during the treatment
Requirement: The app must allow the user to pause the story momentarily during the treatment, and give the user reassuring information about the treatment.
Priority: Medium

2
Name: Supporting characters with emotions
User Story: As a user, I want the story to include supporting characters in the waiting room showing other emotions children have before going to the dentist
Requirement: The app must give the user a overview over emotions children feel before going to the dentist, by letting the user interact with other child characters in the waiting room. The characters should show their emotions through facial expression and dialog.
Priority: Medium

3
Name: Brush teeth
User Story: As a user, I want to be able to brush the main character's teeth so they have a clean mouth during the treatment
Requirement: The app must inform the user about the importance of brushing one's teeth
Priority: Medium

4
Name: Choose Companion
User Story: As a user, I want to be able to choose a companion to bring to the dentist, to be a comfort for the character
Requirement: The app must allow the user to choose an animal, a toy, or an object that will follow the character through the story.
Priority: Medium

5
Name: Companion
User Story: As a user, I want my companion to react to my choices, and be a conversation partner when needed.
Requirement: The app must give positive feedback during the story.
Priority: Medium

7
Name: Objects in waiting room
User Story: As a user, I want the story to include objects to interact with in the waiting room, so I can make my own choices in the story and to be able to explore in story
Requirement: The app must provide different objects in the waiting room for the user to interact with. The objects should provide useful dental information, funny jokes or minigames.
Priority: Medium

1
Name: Reward after treatment
User Story: As a user, I want an achievement or an award after the cavity treatment, as a positive reinforcement.
Requirement: The app must display the tooth fairy at the of end of the story, presenting the achievement shelf. (and her fairy dust in the story)
Priority: Low

2
Name: Accessories, impact on story
User Story: As a user, I want my accessories to have an impact on the story, to get a more personalized experience.
Requirement: The app must display different backgrounds and surroundings, and change the character dialogues, depending on the chosen accessory.
Priority: Low

3
Name: Parent
User Story: As a user, I want to be able to bring the main character's parent(s) to the dentist office, to make the story more realistic.
Requirement: The app must have at least one grown-up character that enters the dentist office with the child.
Priority: Low

4
Name: Brush teeth
User Story: As a user, I want to choose if I want to brush my teeth or not
Requirement: The app must be a tooth brush to click on to brush my teeth
Priority: Low

5
Name: Tooth paste flavor
User Story: As a user, I want to choose which flavor of the tooth paste to use
Requirement: The app must
Priority: Low

6
Name: Drink soda
User Story: As a user, I want to choose if I can drink soda
Requirement: The app must have soda in the waiting room that the user can choose to drink from and learn why sugar is bad for you teeth (?)
Priority: Low

7
Name: Color of bib and glasses
User Story: As a user, I want to choose the color of the bib and glasses
Requirement: The app must
Priority: Low

13

E Interview Guide for Evaluation with Dental Professionals

Interview questions about prototype

Present ourselves: Names, writing master's thesis in computer science, making an app to prevent dental anxiety in children

Present application: We have developed a prototype with the intention of informing children about cavities and how they are treated at the dentist. The storyline covers how cavities appear and the tools used to treat them. We have tried to incorporate aspects you and other dentists have mentioned. In addition to this, we have held workshops with children and gained insight about what they think is fun in such an app. We have tried to include this in our prototype.

Our goal for today is to test its concept and hear what you think about it. Bear in mind that this is an unfinished prototype with flaws and that some functionality might not work as expected or is not fully implemented yet.

While going through the story we want you to think that you are a child between the age of 6-12 years old. Your dentist has told you that you need to fix a cavity, and that you can use our story to learn more about what that means.

While going through the story we want you to **think out loud.** For example when you see a new page or click on something, we want you to say out loud what you think about it, and why you do what you do. No detail is too small.

We want you to go through the application and give **feedback on the information presented,** such as text, instruments and other elements. As well as how it is presented. Feel free to give feedback both from a child's perspective as well as from a dentist's perspective.

If there is something you don't understand, it's on us and our prototype, not you:)

You can, of course, also ask us any questions you might have.

1. We want the application to be both educational and fun, but we don't want the game aspects to overshadow the learning. Do you have any thoughts regarding this?

2. How useful do you think the app is with regards to our goal of reducing dental anxiety in children?

3. How useful do you think the app is with regards to our goal of teaching children about what happens during an appointment?

4. Is the presentation of the appointment realistic? Is it too scary, does it show enough?

5. Do you think the metaphors used are descriptive and appropriate? Do you have any suggestions here?

6. Do you feel like we have included what you normally do in your appointments?

7. Do you find the application appropriate for the age group of 6-10/12 years old?

8. Do you have any other suggestions/aspects we can include that you typically use during appointments?

9. Do you think a child could learn anything from the application and be more prepared for the appointment? Do you think they could potentially be less nervous?

10. Would you find a voiceover during the story useful?

11. Do you think children think it is fun to learn this way, or do you think there are too many game elements or too much presentation of text?

12. Do you find the application overall to be intuitive? Is there something that isn't intuitive?

13. Do you think the storyline can have a negative effect on children and their perception of going to the dentist?

14. Do you think it's a good idea to incorporate the tooth castle in the treatment part of the story? E.g use this analogy when treating the cavity

F   Interview Guide for Evaluation with Children

Objectives:

What do the children learn/remember after using the app?

Do the children find the digital interactive narrative fun/interesting/boring?

To what extent do they feel they have influenced the final design?

Observe their body language. Look for smiles, laughter, leaning towards the screen. Take note of the number of questions they ask.

Introduction

We have created this app based on what you taught us the last time we were here, in addition to things we have learned from dentists. It is meant to be a digital story where you can explore a dental office and learn how to fix a cavity at the dentist.

We call this a test, but I'm not testing you at all. We're asking you to help us test our application. You are the experts on being kids, and we want you to teach us how kids use applications and what you think about them. We need to see what's fun, too easy or what's too hard for children your age so we can fix it and make it better. We'll ask you to figure out things on your own most of the time, but we're here if you get stuck.

There ARE some issues we need you to find out, that's why you are testing it!

Questions to ask while going through the application:

What did you like *about this*? What did you not like?

Maybe we need better language here, what do you think is best for kids like you to understand this?

Questions to ask after going through the application:

Education

If I were to go to the dentist to fix a cavity for the first time. What would you tell me about a cavity treatment?

Can you retell what you remember from the story?

What type of dental instruments do you remember? Do you remember their name? Do you remember what they are used for?

Why is it important to fix cavities?

Influence on design/application

Do you recognize some parts/elements from the story you made the last time we were here?
>What do you recognize?
>Is there something that you are really missing?
>Something you recognize a lot?

Engaging

Would you recommend this app to a friend or a sibling?

Do you think your friends would have liked to play through the app?

Would you like to play this in the future/some other time/ before going to the dentist?

Did you like that you could click on different parts of the application, was there too much to click on? Is there something you expected or wished would have happened?
- Was it easy or difficult to understand what was clickable?

What do you think of the story, if you could change anything about the story, what would you have done?

We haven't finished all the stories, are you particularly interested in learning about any of the others?

Do you recognize things from one of your own dentist appointments? Any tools or rooms?

G   Consent Form for Children

Are you interested in taking part in the research project

"*Service innovation for safe children in dentistry*"?

You are invited to participate in a research project where the main purpose is to design a digital service that can be used to prevent dental anxiety in children aged 6 - 10 years. In this document, we provide you information about the aims of the project and what participation will mean for you, and possibly your child.

1. Purpose
Dental treatment anxiety is one of the biggest reasons why patients avoid going to the dentist. This can result in long-term health problems among such patients, which in turn can become a major burden on the public health system.

Our Master's project at the Department of Computer Science at the Norwegian University of Science and Technology (NTNU) aims to find how children, their parents/guardians and dental practitioners evaluate the possibilities of developing a digital solution to prevent dental anxiety, and how the same actors experience the effects of such a prototype.

2. Which institution is responsible for the research project?
NTNU is responsible for the project (data controller).

3. What does participation involve for you?
To carry out the research project, we are dependent upon the participation of children as they are the intended end user of the application. Without your input, experiences and feedback, our digital solution will have little value. We therefore hope you want to help us with this.

4. What does participating mean for you?
4.1. As a child/parent/guardian
If the child participates in the project, they agree to participate in a workshop. The duration of the workshop will be approximately one hour. The workshop will be conducted during out of school hours care.

The personal data we gather is age and gender. Otherwise, we are only interested in comments on and interactions with the solution being developed.

We want to make audio and video recordings during the workshop to be able to use this for data collection. However, you can of course choose whether you consent to this or not.

4.2 Participation is voluntary
Participation in the project is voluntary. If you choose to participate, you can withdraw your consent at any time without giving any reason. All your personal data will then be deleted. There will be no negative consequences for you if you do not want to participate or later choose to withdraw.

5. Your privacy - how we will store and use your information
We will only use your personal data for the purposes specified here and we will process your personal data in accordance with data protection legislation (the GDPR).

5.1. Who has access to the information
Only three master's students (Katarina Murphy, Silje Moksnes and Silje Villandseie) as well as our supervisor (Yngve Dahl) will have access to the information.

5.2. How we store the information
We will replace your name and contact details with a code that is stored on our own name list separated from other data. The data material (sound recordings) is stored on NTNU's systems.

5.3. How the information is used
In the master's thesis, and possibly later publications, we will only use anonymised data. Participants in the project will therefore not be identified in the master's thesis nor in any other publications.

5.4. What happens to your information when we end the research project?
The planned end date of the project is 01.09.23. After the end of the project, personal data will be anonymised. Audio and video recordings will be deleted after project completion.

5.5. Your rights
So long as you can be identified in the collected data, you have the right to:
- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
  send a complaint to the Norwegian Data Protection Authority regarding the processing of your personal data

6. What gives us the right to process your personal data?
We will process your personal data based on your consent.

Based on an agreement with NTNU, Data Protection Services has assessed that the processing of personal data in this project meets requirements in data protection legislation.

7. Where can I find out more?
If you have questions about the study, or want to know more about or exercise your rights, please contact:
- NTNU at Silje Moksnes, master's students at the Department of Computer Computer Science (silje.m.s.moksnes@ntnu.no, tel.: +61 481 577 729)
- NTNU by associate professor and thesis supervisor Yngve Dahl, at the Department of Computer Science (yngveda@ntnu.no, tel.: +47 905 27 892)
- Our data protection representative: Thomas Helgesen (thomas.helgesen@ntnu.no)

If you have questions related to Personal Protection Services' assessment of the project, you can contact:
- Privacy services by email (personverntjenester@sikt.no) or by phone: +47 53 21 15 00.

Yours sincerely,

Yngve Dahl   Katarina Murphy, Silje Villandseie, Silje Moksnes
(Supervisor)   (Master´s students)

Declaration of consent

I have received and understood information about the project *Digital Service Innovation for Safe Children in Dentistry* and have had the opportunity to ask questions. I agree to:

- □ to participate in the study
- □ that an audio recording of the interview is made
- □ that a video recording of the interview is made

I agree to my child's information being processed until the project is finished

---   on behalf of   --
(Signed by parent/guardian, date)   (Child's name)

H   Consent Form for Dental Professionals

Are you interested in taking part in the research project

"*Service innovation for safe children in dentistry*"?

You are invited to participate in a research project where the main purpose is to design a digital service that can be used to prevent dental anxiety in children aged 8 - 12 years. In this document, we provide you information about the aims of the project and what participation will mean for you, and possibly your child.

1. Purpose
Dental treatment anxiety is one of the biggest reasons why patients avoid going to the dentist. This can result in long-term health problems among such patients, which in turn can become a major burden on the public health system.

Our Master's project at the Department of Computer Science at the Norwegian University of Science and Technology (NTNU) aims to find how children, their guardians and dental practitioners evaluate the possibilities of developing a digital solution to prevent dental anxiety, and how the same actors experience the effects of such a prototype.

2. Which institution is responsible for the research project?
NTNU is responsible for the project (data controller).

3. What does participation involve for you?
To carry out the research project, we are dependent upon the participation of dental practitioners. Without your input, experiences and feedback, our digital solution will have little value. We therefore hope you want to help us with this.

4. What does participating mean for you?
4.1. As a dentist
If you decide to participate in the project, you agree to participate in two interviews. The duration of an interview will be approximately one hour. Interviews will be conducted digitally (via Skype, Zoom, or similar).

The personal data we gather is age, gender, and position. Otherwise, we are only interested in your experience with treatment of dental anxiety, and your comments on and interactions with the solution being developed.

We want to make audio and video recordings of the interviews to be able to use this for data collection. However, you can of course choose whether you consent to this or not.

4.2 Participation is voluntary

Participation in the project is voluntary. If you choose to participate, you can withdraw your consent at any time without giving any reason. All your personal data will then be deleted. There will be no negative consequences for you if you do not want to participate or later choose to withdraw.

5. Your privacy - how we will store and use your information
We will only use your personal data for the purposes specified here and we will process your personal data in accordance with data protection legislation (the GDPR).

5.1. Who has access to the information
Only three master's students (Katarina Murphy, Silje Moksnes and Silje Villandseie) as well as our supervisor (Yngve Dahl) will have access to the information.

5.2. How we store the information
We will replace your name and contact details with a code that is stored on our own name list separated from other data. The data material (sound recordings) is stored on NTNU's systems.

5.3. How the information is used
In the master's thesis, and possibly later publications, we will only use anonymised data. Participants in the project will therefore not be identified in the master's thesis nor in any other publications.

5.4. What happens to your information when we end the research project?
The planned end date of the project is 01.09.23. After the end of the project, personal data will be anonymised. Audio and video recordings will be deleted after project completion.

5.5. Your rights
So long as you can be identified in the collected data, you have the right to:
-   access the personal data that is being processed about you
-   request that your personal data is deleted
-   request that incorrect personal data about you is corrected/rectified
-   receive a copy of your personal data (data portability), and
    send a complaint to the Norwegian Data Protection Authority regarding the processing of your personal data

6. What gives us the right to process your personal data?
We will process your personal data based on your consent.

Based on an agreement with NTNU, Data Protection Services has assessed that the processing of personal data in this project meets requirements in data protection legislation.

7. Where can I find out more?
If you have questions about the study, or want to know more about or exercise your rights, please contact:
   • NTNU at Silje Moksnes, master's students at the Department of Computer Computer Science (smmoksne@stud.ntnu.no, tel.: +47 906 44 055)
   • NTNU by associate professor and thesis supervisor Yngve Dahl, at the Department of Computer Science (yngveda@ntnu.no, tel.: +47 905 27 892)
   • Our data protection representative: Thomas Helgesen (thomas.helgesen@ntnu.no)

If you have questions related to Personal Protection Services' assessment of the project, you can contact:

• Privacy services by email (personverntjenester@sikt.no) or by phone: +47 53 21 15 00.

Yours sincerely,

Yngve Dahl

Katarina Murphy, Silje Villandseie, Silje Moksnes

(Tutor)

(Master´s students)

Declaration of consent

I have received and understood information about the project *Digital Service Innovation for Safe Children in Dentistry* and have had the opportunity to ask questions. I agree to:

- □ to participate in the study
- □ that an audio recording of the interview is made
- □ that a video recording of the interview is made

I agree to my information being processed until the project is finished

----
(Signed by project participant, date)