”Design of a Simulated Hospital Tour in a Scanned 3D Model for Children”

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Abstract

In today's world it is important that all children have the right to have the most up-to date information presented to them in the easiest way possible. Working with members of Haukeland Hospital, and a lead psychiatrist for children from Barneposten, this project aims to help that process by creating a game that will allow hospitalised children to preview the environment that they will be staying in before being hospitalised. Relevant research has shown that children are more likely to feel anxiety when introduced to unknown environments without being given enough information.

The project also explores the use of serious games and gamification to make sure the experience is interesting and immersive. In this game the users explore the environment of Barneposten through fun tasks such as the Teddy Bear Challenge. The users also get to meet some of the therapist which they can interact with and ask questions about Barneposten. The users also receive information about the control commission, which is about the children's rights in the health sector.

There was a session with user testing of the application, and it was evaluated by the staff members of Barneposten and the children. The user evaluation was based on system usability scale (SUS), pre-made questionnaires, and an interview. The average score of the SUS questionnaire was 75.6%, which is a good score. The feedback from the questionnaires were positive, and we received wishes for what they want to see more of in the application from the interview.

The domain expert was satisfied with the result of the application, and showed excitement to test it further. In this project there were only a few people from the staff and a few children who evaluated the application. For later work it should be evaluated by more people. The application itself should be tested by children to see if they like the game and if the game provides the children information about Barneposten.

Acknowledgements

First and foremost, we would like to thank our supervisors, Harald Soleim and Atle Geitung. Their support and supervising helps us a lot during the project, and their constructive feedback got us to work even harder on this project.

We will also send a big appreciation to the domain expert Paul Joachim Bloch Thorsen, the leader of Barneposten in Haukeland Hospital. It was a good experience and fun collaborating with him. He was the one giving us the ideas of the challenges in the game, and showed excitement during the whole duration. This project would be less fun without him.

We want to thank Haakon Meyer and Roald Torkildsen for their contribution to the application as voice actors. Haakon was the voice the control commission poster which the character could interact with. He did a great job talking about children's right and the control commission's role in Barneposten. Roald was the voice to the character in Hospital School, where he did a great job telling about the school.

The music and sound effects in the game were done by composer Morten Georg Gismervik. The domain expert loved the music in the game, and I believe that the music did bring both excitement and personality to the game. We want to thank him for being a part of the team.

Contents

Acronyms

GUI Graphical User Interface. 6

MDSE Model Driven Software Engineering. 6

NPC non-playable character. 6

SDK Software Development Kit. 6

SE Software Engineering. 6

SUS System Usability Scale. 6

UI User Interface. 6

VR Virtual Reality. 6

Glossary

Agile Agile development focuses on delivering value to customers in smaller increments called iterations or sprints, rather than waiting until the end of a project to deliver a fully developed product..

Barneposten Barneposten is a five-day bed post for the assessment and treatment of children aged 0-13 with mental health problems..

Design Science Research Is a problem-solving paradigm that seeks to enhance human knowledge via the creation of innovative artifacts..

Game Engine Is a software framework primarily designed for the development of games and includes relevant libraries and support programs..

Gamification The idea of it is to change peoples behaviour by performing some kind of fun activity which rewards them - with some kind of score or prizes..

ScriptableObject A data container that you can use to save large amounts of data, independent of class instances. It helps to save and stare data during an editor session, and saving data as an asset in your project to use at run time.

Serious Game is a software where the purpose is other than gaming, yet has a game-like structure like scoring.

Singleton Pattern Singleton pattern is a software design pattern that restricts the instantiation of a class to a singular instance.

Chapter 1

Introduction

The following chapter will give the overview of the thesis, including the problem description, motivation and goals. We will as well give insight of what we researched and an introduction to the methodology used in the project.

1.1 Motivation and Problem Description

Barneposten is a five-day bed post for the assessment and treatment of children aged 0-13 with mental health problems. It is located in Bergen, Norway. An interdisciplinary team guides children and parents to master the challenges. It is the local children's and teens psychiatric outpatient clinics that apply for admission in collaboration with the parents and the child as stated by the main website of Helse Bergen [1].

There are approximately 60 children who are hospitalized annually at Barneposten and they stay there for 4-6 weeks. The challenges the department are facing are children who feel anxious about the hospital because of being forced to live away from home. Children who lack information about Barneposten according to a thesis by Randi-Marie Pedersen [2]. In that thesis Pedersen discussed that digital health innovations can simultaneously facilitate a greater degree of personalization of care processes, especially the use of gamification elements. The section leader of Barneposten, Paul Joachim Thorsen, wants an application to help children. Namely an application that will provide children an opportunity to explore the environment at Barneposten and give them information. Information that could make them feel more at ease before coming to Barneposten for the first time. He wants to use a scanned 3D model of Barneposten, and add tasks to give the children information about what Barneposten is. He was also the domain expert during our project.

The motivation of the project was to research if a game made in Unity can help children get familiarised with the hospital surroundings and feel more at ease by visiting the hospital, by reducing their anxiety. According to a study by Salmela Marja, 83% of pre-school and kindergarten-aged children suffer different kinds of anxiety symptoms related to hospital fear [3]. Additional findings report that; children were afraid of the unfamiliar environment, pain, bodily injuries and the

restriction of their freedom of choice as well as self-determination [3]. Children are scared of the unknown as they do not know what will happen to them and they cannot imagine what is going to happen as explained by this article on perioperative dialogues with children undergoing day surgery [4]. A natural problem description arises, what can be done to ease hospitalized children's fear and anxiety, and can elements of gamification and serious games help children and the outcome of their visit which is giving them information.

1.2 Goal

The goal of the project was to develop a game with android and virtual reality (VR) support using the 3D models of Barneposten and Hospital School. All these parts belong to the Haukeland University Hospital. The application would include tasks for players to handle. Tasks should help children get the information they need about what Barneposten is, and make them explore the environment. An example of a task can be exploring Barneposten and find a specific object, go to the section leader's room to ask a question, or interact with different objects.

An additional goal for this project was to make the project scalable for future work. Our ambition was to create a framework where users can login to the system, import their scanned 3D model and publish it online for other players to explore. This approach will give an option to add a world using Unity game engine with a software development kit (SDK). This consists of an game element from the base game, the Player object, which consist of every necessary functionalities to play the game.

1.3 Research Question

When developing a serious game, we set a clear goal on what to achieve with this game. As stated in Section 1.1, 83% of pre-school and kindergarten-aged children suffer different kinds of anxiety symptoms related to hospital fear, and 50% of children do not understand why they are hospitalized at Barneposten. We also needed to find a solution to give the players the information about Barneposten, and show them a replica of the different floors of Glassblokkene.

Having that in mind we came up with two sets of research questions, one primary and one secondary:

Primary Research Questions

1. How can we design a game that will provide interactive information about Barneposten and its experience?
2. How can we optimized the application making it entertaining and serious?

Secondary Research Questions

1. How can we develop a scalable framework where the client can request a 3D model from a server that will consist of a library of 3D models with levels and tasks?

2. If added multiplayer, how can it we make the players interact with each others?

The primary research questions we researched were, if the application gave the children information about Barneposten and prevented them from being anxious of visiting Barneposten. If proven, this research would contributes to the field of serious game and digital healthcare. The secondary research questions was about a scenario where we expand on this project and tackle a wider audience. The idea of this research was to see what happens if we give the users the opportunity to upload their 3D models and share it with other users.

1.4 Scope and limitation

A problem we faced during the evaluation phase of the project, was the amount of participants. By the time we reached the date of the user testing, there were only a small amount of children who could test the application. To prevent that we should have planned a better date where we knew there would be more children who could try the game.

One limitation that can limit a lot of people using this program is a solution to create and import a 3D model to the game. This is based on the secondary research questions. Currently there are not many ways to scan a room in real life and import it as a 3D model. The way the 3D model of Glassblokkene was created was by scanning with Matterport's Pro2 camera and use a 3D modelling software such as 3DS Max to export it as a 3D model. This solution is an expensive one because of the cost of equipment. However Apple's smartphones support LiDAR which is used to measure physical objects position. Matterport's systems support use of Iphone 13 pro's scanning and can be used to create a 3D model. Not many people have iPhone 13 pro, but this technology means that the possibilities for a huge amount of people with phones with LiDAR support can create a 3D model of buildings and rooms in the future.

1.5 Expected Result

To answer the research questions above, we have listed goals to be complete during the project. By using Unity game engine, to create a dynamic scene where children can move around and interact with the environment.

The expected results of this thesis:

1. Create a game application with Android and VR support where users can move around and interact with its environment.
2. Create an user interface where the player can teleport between scenes.
3. Import 3D model of Barneposten and the Hospital School with tasks.
4. Create possibility for users to add other 3D models and use it however they want.
5. Make it scalable for future works such as multiplayer.

1.6 Methodology

During this project we developed a game with Android and VR support using serious game principles, which are discussed further in Section 2.3. When the development was finished the children got to try out the game, during which, the therapists recorded their reactions based on their interactions. During this process we gathered data of the children's experience of the game with two sets of questionnaires.

1.6.1 Research

To find the answers to the research questions, we have to figure out a way to evaluate the user testing process, and find a way to answer our research questions by searching for research methods. To understand how to carry out our research tasks, we used this article that explained the pros and cons of different research methods [5]. To summarise, choice of research methods depends on the type of knowledge one wants to develop. The main research methodologies are quantitative and qualitative methods. For questions about ideas, experiences and meanings, or to study something that can not be described numerically, collect qualitative data. For a more mechanistic understanding of a topic, or your research involves hypothesis testing, collect quantitative data. Based on the same article, a mix between those two methods was the best approach as this would allow us to explain quantitative data better, but also add more precision to qualitative data. In addition, we would have the ability to use the strength of one method of research to counter or overcome the weaknesses in another method as also explained in this article [6]. To accomplish this, we used a system usability scale (SUS) questionnaire and two specific questionnaires made to answer our research questions and we used interviews with observations to add more value to the SUS results. These methods are outlined further in Chapter 3. In the development phase we used the design science research paradigm.

1.6.2 Development

The methodology used in the development phase builds on a iterative approach. Agile development helps to ensure that development teams complete projects on time and within budget. It also helps to improve communication between the development team and the product owner [7, 8]. This team consisted of two developers where one of the developers did the planning and distributed the work load. The developers was the one brainstorming ideas which was inspired by the domain expert's wishes and feedback. It formed the following interpretation and execution of the method; An iterative process where the application develops until a state, receive feedback and task from the domain expert, which forms the foundation of the new iteration. The next iteration uses the feedback from the last iteration to better the application.

1.7 Outline

Outline of this thesis in order:

Chapter 1: Introduction; An introduction to this thesis and our motivations and goals. We will also provide our research questions and give a brief introduction to the methodology used in the project.

Chapter 2: Background; Covers background information about the collaboration partners. We also provide details on the technology stack for this thesis.

Chapter 3: Research Methodology; In this chapter we will discuss how we use Design Science Research during this project, and what methods we used in the evaluation.

Chapter 4: Application Design and Solution; Detailed explanation of the design and implementation of the application.

Chapter 5: Results and Discussion; Showcases the results from the evaluation and a discussion of the result.

Chapter 6: Conclusion; This chapter will conclude this thesis.

Chapter 7: Future Works; A short overview of improvements and new contents for future work.

Chapter 2

Background

This chapter we will showcase related work that the project is inspired from, information about the collaboration partners and relevant information including guidelines, tools and software. At the end of the chapter we will showcase related works and literature.

2.1 Collaborations

2.1.1 Barneposten and the Areas of Glassblokkene

These are the various locations inside of Glassblokkene, which is the main building used for treating children and adolescents. There are multiple floors, including Barneposten which is the area where children are being hospitalised, and spend a lot of their time. There are beds and play areas, including an area for table tennis etc. A floor above Barneposten is the school, where the children are able to get lessons in cooperation with their school as outlined on their website [1].

2.1.2 Control Commission

The control commission has the responsibility to ensure everyone's legal certainty in the meeting with the mental health care as provided by this page on the Helse Bergen page [9]. They are important since they checks coercive decisions, processes complaints and conducts welfare checks. The application will present the important information from the control commission to the users in the form of a list of rules that will be played to the user on an audio track.

2.1.3 Adfectus

Adfectus is a team of developers that develops ground-breaking and long-awaited communication tool for children in the healthcare system, by allowing them to access their own health status. By using gamification and illustrative elements, they strengthen the empowerment of children and young people, regardless of physical and psychological challenges [10]. Adfectus is one of our collaborators

and had the responsibility to provide the 3D models of Barneposten and the hospital school. This was done using Matterport which is explained below.

Matterport

Matterport is a platform that uses technology that allows a user to turn their 3D model into an immersive interactive 3D model, allowing things like; dollhouse view, navigation of rooms and to also share models to others via the platform. The model that this project is using is based on the 3D Matterport model of Glassblokkene which features different areas such as Barneposten and the hospital school [11].

2.1.4 Composer

Morten G. Gismervik is a composer and guitarist, who mainly has a solo artist project with a mixture of Nordic jazz and progressive rock as an expression [12]. He has been a part of this project handling the sound effect and music.

2.2 Gamification

Gamification has many characteristics that are in line with games. They are both supposed to be fun and provide some activity to perform. The idea of it is to change peoples behaviour by performing some kind of fun activity which rewards them - with some kind of score or prizes [13]. This means that it could be used with VR in order to help children get more familiar with their surroundings by collecting objects across the playable area, and by doing so earning score which allows them to purchase rewards.

2.3 Serious Game

A serious game is a software where the purpose is other than gaming, yet has a game-like structure like scoring. In this article [14], an application was built to learn laparoscopy while providing the user with training and score, it provided surgeons and medical students a useful platform for rehearsals of surgical procedures, which provides an example of the need for serious games in the medical field.

2.3.1 Guidelines for serious game development

The number of serious games is increasing rapidly, and games that allow people to produce and/or analyze scientific data. It was built a set of rules providing a guideline to create or improve serious games [15].

1. **Define a (serious) goal**
2. **Fine-tune the balance between entertainment and serious tasks**
3. **Enable the player to interact with scientific data**
4. **Promote onboarding and engagement**
5. **Manage information flow**

6. **Provide an appropriate narrative**
7. **Adapt your level design**
8. **Develop good graphics, not just for eye candy**
9. **Use all modalities, particularly sound**
10. **"Iteratively assess what works and what doesn't"**

2.4 Virtual Reality

Virtual Reality (VR) is the use of computer technology to create a simulated environment. The use of Head Mounted Displays (HMD) is the most prominent feature, which allows the user to perceive the 3D software world from their own perspective. There are different types of VR classifications: non-immersive, and fully immersive. Non immersive VR is where the user is aware of their environment and controlled by it, video games being an example, involves the use of a mouse and keyboard [16]. Fully immersive VR, while it does not exactly exist to its full capacity allows the user to experience some kind of feedback with the use of sensors An experience that has elements of immersion would include activities such as picking up objects, playing small mini games etc.

2.4.1 VR Game Development

According to an online article [17], the organization of the page gives a step by step guideline for how to develop a VR game. This guide serves as a crucial foundation for developing a VR game, and aspects used in this project were;

1. **Gameplay** Developing a fun way to play the game in VR.
2. **Optimization** Focus on having a decent frames per second (FPS).
3. **Player Mobility** Allow the player to play it both by sitting and standing.
4. **Manage Player Sickness** Prevent the player to get motion sick.

2.4.2 VR Optimization

In this online article [18], the author showcase a solution for optimization of a VR game in Unity. This guide was used in the project.

2.5 User Interface (UI) in Games

When designing a game, there are some basic UI principles that are good to know. An UI is a user interface and a GUI is a graphical user interface. Both are inter-related terms, as the UI is the set of devices that let the player interact with the game; this could mean mouse, keyboard, game controller, touch-screen etc. The GUI is the subset of the user interface that is represented by graphics; this includes on-screen buttons, drop down menus and icons as explained by the book "Mastering UI development in Unity" [19].

There are in general four types of game interfaces that the book describes and that are outlined by this figure:

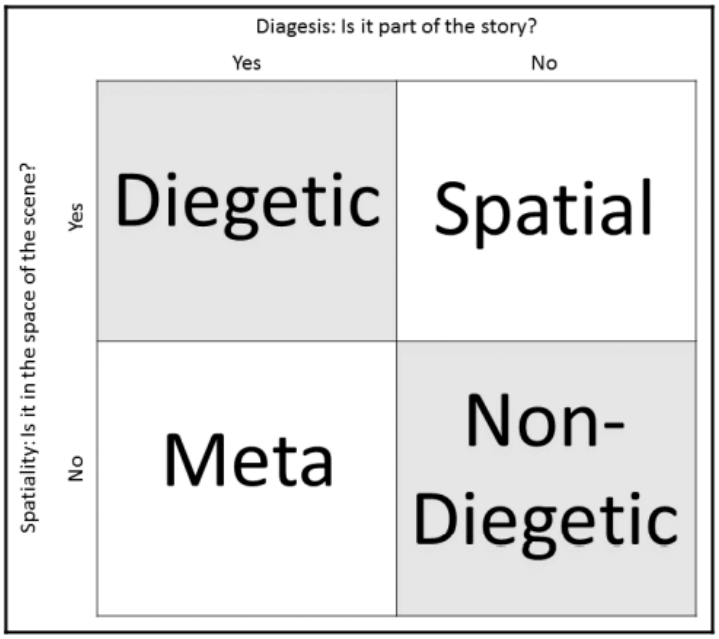

Figure 2.1: The Four Types of Interfaces [19]

The distinction is formed if the interface is part of the story or not. A **non-diegetic** is information that purely exists for the player to view, and the characters within the game are not aware of it; this can be a menu or statistics for the player. **Diegetic** is the opposite, where the interface exists within the game world, everything is displayed inside the game world in front of the playable character and it exists within the context of the game; this can be a map that one can hold in VR and interact with. **Meta** interfaces are ones that the characters in the game are aware of, but are not physically displayed within the scene, an example is a speedometer, as the player is aware of it. The last type is **spatial**, this interface exists in the scene, but the characters in the game are not aware of it. This is used to display information about items and characters in the scene [19].

For this application, a mix of diegetic and non-diegetic was used. As the application had places to indicate interaction for the player, a notification icon appeared for the player to understand that the object is interactable. The non-diegetic elements were objects like the pause menu, and the objective tab that the player views to know about their tasks to complete.

Interface Metaphors

It is common practice to use interface metaphors which are commonly recognised symbols that we are used to seeing, and are considered to be universal. In games and applications, there are three main reasons for using them:

- They are quicker to recognise than text.
- They do not clutter the UI as much as words.
- Do not have to be translated.

2.6 The Importance of Music

In an online article by Lee Holmes [20], he discuss the importance of music in video game. He discuss that the concept of music in video game lets the player know how they should be receiving the experience. For example, if it is a sports games like FIFA, then the sounds of people cheering in the arena is important in establishing the exciting environment for the player. It is noted that video games belong to epic music. It has been studied that epic soundtracks are most often used in video games with the plot of war, confrontation and battles, according to an article about the theoretical paradigm of contemporary musicology [21]. We believe that music and sound are an important aspect when developing games, and used great amount of time to create music that makes you feel like you are in safe environment.

2.7 Software and Tools

2.7.1 Game Engine

A game engine is a software framework primarily designed for the development of games and includes relevant libraries and support programs. Developers can use game engines to construct games for video game consoles and other types of computers [22]. Unity is a popular game engine used by many professional developers as well as indie developers. It supports over 25 platforms from PC to consoles and has extensive VR support. As a game engine, it provides many built-in features like physics, 3D rendering and collision detection. It makes the job of making a game much easier [23]. For functionalities Unity uses scripts to make a change to an object in-game. Those scripts are written in a programming language called C# and have an excellent documentation from the community and the owner of Unity.

The other key feature of Unity is its “Asset Store”. In the asset store creators can share their creations such as models and animations and make them available to the public [23].

2.7.2 Unity XR

Extended reality (XR) is an umbrella term that includes types of application such as virtual reality, mixed reality and augmented reality [24]. In this project

it is used as a tool to create a VR project for OpenXR and Oculus as its platform. With XR it also includes the opportunity to install a package called XR interaction toolkit. The XR Interaction Toolkit package is a high-level, component-based, interaction system for creating VR and AR experiences. It provides a framework that makes 3D and UI interactions available from Unity input events. The core of this system is a set of base Interactor and Interactable components, and an Interaction Manager that ties these two types of components together. It also contains components that you can use for locomotion and drawing visuals [25].

2.7.3 Ink

Ink is a narrative scripting language that is primarily designed for professional game development, though it can also be used to write and share choice-based interactive fiction. It is also easy to learn [26]. This was used for the dialogue system used in the application. More about the dialogue system and Ink will be explored in Section 4.6.

2.7.4 Blender

Blender is a free and open source 3D creation suite. It supports the entirety of the 3D pipeline modeling, rigging, animation, simulation, rendering, composition and motion tracking [27]. In Blender we can create 3D objects and import them in the Unity project. Models in Unity are mostly imported from Blender since you can export Blender files in FBX file format. It takes less memory space, and it is faster and more efficient because it utilizes a binary format. Also when working with textures and colors Blender is far superior to Unity.

2.7.5 ChatGPT

ChatGPT is an artificial intelligence chatbot created by OpenAI [28]. It is trained using Generated Pre-trained Transformers (GPT) language models, and can answers many different questions and topic. It also is trained to code different lines of codes depending on the input from the user. ChatGPT is a valuable tool to use when facing problems while developing the application.

2.7.6 Trello

Trello is a visual tool that empowers your team to manage any type of project, workflow, or task tracking. Add files, checklists, or even automation [29]. Trello as a tool has been used to plan every iterations in this project. In Trello we can create borders that consists of tasks. For every border we write down the period of the iteration. For every completed task we drag the task to the border of completed tasks.

2.7.7 Character Creator 4

Character Creator 4 (CC4) is a full character creation solution for designers to easily generate, import and customize stylized or realistic character assets for

use with modelling software and game engines. CC4 connects industry leading pipelines with one system for 3D character generation, animation rig, asset management, look-dev rendering, and interactive design [30]. This make the character look real and have access to animation movements such as walk and talking. The reason this software was chosen was to give the players the opportunity to interact and ask questions with a realistic human shaped character. However since the free version of the tool was used, we were limited to certain hairstyles and presets.

2.8 Related work

Search Queries: **Hospital Fear in Children, Hospital AND Fear, Hospital AND Anxiety, Serious games in healthcare.**

2.8.1 VRChat

VRChat is an online VR platform. It offers an endless collection of social VR experience by given the power of creation to its community. Whether you are looking for new VR experiences or have an idea of your own [31]. In this game you login with your own avatar and explores world created by the developers and the community. The way the community can creates world is that they downloads a software development kit (SDK) package. This package contains elements needed for both creating an avatar and a world, and add it to the game [32].

2.8.2 "HospiAvontuur: development of a serious game to help young children and their parents during the preparation for an admission at the hospital for elective surgery"

Here is a study by Jo Vrancken [33] about the creation of a serious game to help children and parents in a hospital surgery procedure. It talks about many kids experiencing pre-operative anxiety and the right of presenting information to children who are to receive the procedure in the best way possible by improving the child's understanding of the procedure. In the end, a game was developed that would prepare kids to have the procedure done, allowing them to get practical information about the operating theatre and staff etc and allowing them to play small mini games. In the end, many stakeholders such as parents approved the game, and many of the children found it to be fun and engaging. This project was also hoping to answer two questions: does the game provide information to kids in an informative way and secondly; The second goal was to investigate whether the game could also be applied as a non-pharmacological technique to reduce preoperative anxiety in comparison with a pharmacological approach like Midazolam, with the second goal undergoing a randomised control trial in a hospital.

2.9 Literature

Virtual Reality for Cultural Heritage Monuments – from 3D Data Recording to Immersive Visualisation - In this related literature carried out by [34], a workflow description is given of how something is turned in from a 3D data recording into an immersive visualisation. The examples in this papers are ancient buildings that may or may not exist, and describes the process of porting them into the Unity game engine and how reducing the number of polygons in 3D max and other modelling programs could help performance.

"Samproduksjon i psykisk helsevern for barn og unge: En studie av pasientsentrering gjennom digitale helseinnovasjoner." - In this thesis written by Randi Pedersen [2] she writes in details the challenges Barneposten faces with the children. This includes about how the children feel and what they know about Barneposten, and explores different options on what the employees can do different to prevent children being anxious about the hospital environment. It also discuss the solution of using digital gamification as a tool to prevent the anxiety of visiting the hospital.

"Measurement of Anxiety in 3-9 Year Old Children Receiving Nursing Intervention." - This study published by Cardinal FG et al [35] explains that children experience anxiety when they are away from familiar and comfortable environments, one such example was the hospital ward. There was reports that they feel threatened when encountering the health care system. The study used 266 patients of whom were both male and female to measure the levels of anxiety that they experienced when having different procedures done to them like; temperature measurements, peripheral cannula insertion etc. The levels of anxiety were measured by using the Venham picture test described in this article [36], which discovered that anxiety levels were average for a lot of patients especially between the ages of 3 and 4.

Category of the Epic as a Part of the Theoretical Paradigm of Contemporary Musicology - The article is devoted to the question of the categories of the epic as part of the theoretical paradigm of contemporary musicology. It is proven that nowadays there are many books, magazines and articles about the epic genre of music. It is noted that video games belong to epic music. It has been studied that epic soundtracks are most often used in video games with the plot of war, confrontation and battles. It is noted that Jeremy Soule, who gained fame thanks to the game series "Elder Scrolls" and "Harry Potter" is the most famous composer of orchestral music video games. The importance of music is emphasized for the video games of the famous American composer Garry Schyman [21].

"Use of perioperative dialogues with children undergoing day surgery - This study published by Wennstrom, B [4] explored what it means for children to attend hospital for day surgery. This study was carried out in 2005-2006 with 15 boys and five girls (aged 6-9) scheduled for elective day surgery. The data was collected by using tape-recordings of interviews of children including a perioperative dialogue (dialogue around time of surgery). The findings were that the main problem children have during surgery day, is that they are forced into an unpredictable and distressful situation. "Pre-operatively, the children do not know what to expect". The other additional findings showed that "they

perceive a "breaking away from daily routines" and they are "trying to gain control" over the situation". The conclusion that was drawn was that dialogue with the child by nurses helped induce a sense of security and trust.

Chapter 3

Research Methodology

The research methods in this thesis is inspired by design science research which was introduced in Section 1.6. In this chapter we will discuss how design science research was used in context of the project. We will also present development- and evaluation methodologies.

3.1 Design Science Research

Design science Research (DSR) is a problem-solving paradigm [37] that seeks to enhance human knowledge via the creation of innovative artifacts. DSR seeks to enhance technology and science knowledge bases via the creation of innovative artifacts that solve problems and improve the environment in which they are instantiated. The results of DSR include both the newly designed artifacts and design knowledge that provides an understanding via design theories of why the artifacts enhance the relevant application context. This paradigm consists of three research cycles; the relevance cycle, rigor cycle and design cycle which are seen in Figure 3.1. It also presents a framework for understanding, executing, and evaluating design science research. The environment defines the problem space in which the phenomena of interest reside. The knowledge base provides the raw materials from and through which DSR is accomplished. The knowledge base is composed of foundations and methodologies. Methodologies provide guidelines used in the evaluate phase, such as the one used in this thesis. Rigor is achieved by appropriately applying existing foundations and methodologies [37].

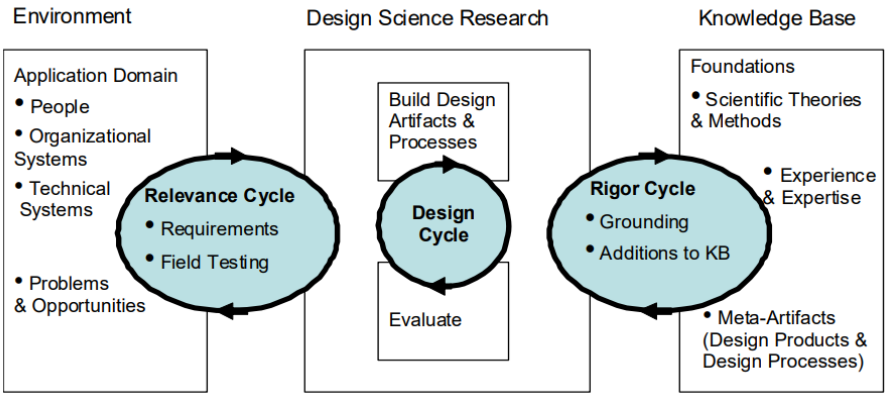

Figure 3.1: Hevners design science research cycle [38]

In the context of developing a game, we used DSR to create and test a game version that addresses a specific problem or challenge. Below are the steps we followed when using DSR in our game development project:

- Identify the problem or challenge: The first step is to identify the problem or challenge that your game is trying to address. This could be anything from improving player engagement to teaching a specific skill.
- Develop a game version: Once you have identified the problem, you can start developing a game version that addresses it. This version should be designed to test your hypothesis about the problem and the solution you have proposed.
- Evaluate the version: The next step is to evaluate the version using various methods, such as user testing, usability testing, and expert review. The goal of the evaluation is to determine if the version is effective in addressing the problem and if it meets the needs of the target audience.
- Revise and refine the version: Based on the evaluation results, you can revise and refine the version to improve its effectiveness and usability.
- Repeat the evaluation and revision process: Iterate through steps 3 and 4 until you have a version that meets the needs of the target audience and effectively addresses the problem.
- Implement and deploy the game: Once you have a refined and effective game version, you can implement and deploy it for use by the target audience.

Overall, by using DSR in this project it can help us create a game that is effective, engaging, and meets the needs of target audience. By iterating through the design, evaluation, and revision process, we can ensure that our application is continuously improving and evolving to better address the problem and challenge we have identified.

3.2 Design Science Research in the Application

The research methodology used in the project uses design science research as an inspiration. It uses the elements from Figure 3.1 and the steps explained in the last section. The project consists of a serious game and will be used as an educational game with a purpose to give children important information about Barneposten and introduce them to a safe environment. The paradigm is scaled down to fit the project since a game cannot completely cure children with anxiety, but we try to make it as a tool to make children more comfortable and with a stronger feeling of safety during the admission to Barneposten. The professional relevance was prepared in collaboration with the domain expert. The application was developed in iteration, where the developers presented new stuff and future ideas while the domain expert gave feedback and new tasks for the next iteration. Search in literature databases and research of articles gave the foundation of a knowledge base. This project gives back contribution to the knowledge base by answering the research questions presented in Section 1.3.

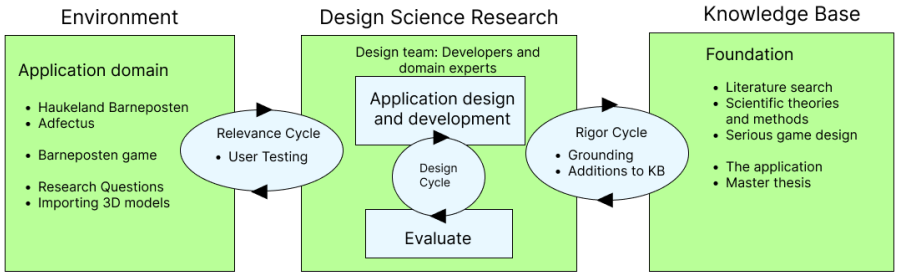

Figure 3.2: Design Science Research Framework

Figure 3.2 illustrate how the design science research paradigm is used in the project. The environment presents the collaborate partners for this project, the research questions and the 3D model created by Adfectus. This leads to Barneposten Tour game. In the design science research the application is built. The application is developed by the developers, and is evaluated in Barneposten. While the application is developing, design science research is receiving tasks from the knowledge base. The knowledge base consists of information from the literature search. This includes similar applications, research and experience. The project gives contribution back to the knowledge base through the development solution and the master thesis.

3.3 Development Methodology

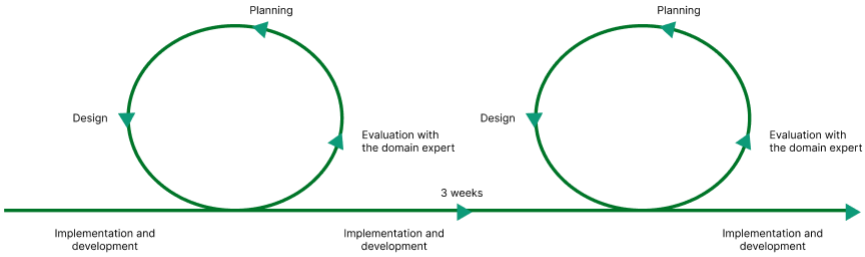

Figure 3.3: Model of the development method

As mentioned in Section 1.6.2, the development method in the project is based on an iterative approach. The method is inspired of principles from the agile methods [39]. Each iteration was an duration on 3 weeks where new functionalities and features were added. In the meeting with the domain expert the application was presented and evaluated, and a foundation for new ideas was laid. After the meeting the developers would plan the approach for the next iteration, where the work load was distributed. In Figure 3.3 shows the model of the development method to the project.

The first months of the project was mostly used to plan the project, which made it difficult to follow the development method approach. After getting the key ideas at hands, the development method was used for the remaining of the project. One big factor that affected the project was receiving the 3D model. The reason for the postponement of the 3D model was because Adfectus were not experienced in this type of work. After several months and no results, they searched for a new solution. The solution was using a third partner to create the 3D model inspired by the scans. This caused the project to stand still for a long period and made it difficult to plan the dates of the user testing phase. When receiving the first 3D model, the effectiveness of development led to major updates for the following meetings.

3.4 Evaluation Methodology

3.4.1 Research Method

In order to evaluate the project, we decided to conduct a series of questionnaires and an interview to capture the data we needed and answer specifically; primary research questions 1 and 2 (RQ1 and RQ2 defined in 1.3). We also explain the uses of each type of research methodology and how they were used in our application.

Quantitative

The system usability scale (SUS) was used as a quantitative tool. SUS is a standardized metric for measuring the usability of interactive system. It is popular

among user experience (UX) researchers for its simplicity and accuracy. SUS is a valuable quantitative tool for anyone trying to optimize the user experience. SUS uses a short, 10-item questionnaire at the end of a usability test to calculate a system's score. Users respond to each question on a 5-point scale from "Strongly disagree" to "Strongly agree". These answers are then used to generate a reliable overall usability score for a system as explained by this website [40]. This will provide an indicator of how the users found the game's core functions as well as their experience with interacting with in-game functions.

There is an article about usability in serious game [41] that states a downside of SUS; "Though it provides a set of validated measures concerning usability (SUS), it was not designed with serious games in mind, and thus it lacks greater depth that is desired". However the article follows up by stating that SUS still generates an overall usability score and quantifies how usable the serious game is overall. This means that SUS is still a viable metric for our goals of finding out if the game is playable, and useful for our selected audience.

Qualitative

Qualitative data tells a story. At the core of user experience is the subjective, emotion-based response of the individual user - the way a system makes visitors feel. Those can be positive or negative feelings depending on the users experience with the system. Listening to a user narrate their journey, hearing their reactions as they navigate a site, help to fill a gap that quantitative data can not provide as provided by this article on qualitative testing [5].

An interview is an example of one such research method that relies on asking questions in order to collect data from individuals or groups. There are a few different types of interviews; in-depth, semi-structured or unstructured. A semi-structured interview is one where the questions are preset and are open ended as described in this research paper on interviewing and observations as research methods [42]. A heavily structured interview is used to obtain a lot of quantifiable data which can be quantified (e.g. yes/no, high/medium/low). If the study is also qualitative, the interview must be flexible enough to allow for unforeseen data to be recorded as cited in this article "Guide to Advanced Empirical Software Engineering" [43]. A disadvantage that an interview may have is the problem of having to listen, and interpret what the person is saying while also trying to ask all the questions outlined in the interview as stated in this article on different interview techniques [44].

For this thesis the focus will be semi-structured interviews in order to allow us to capture the individuals exact thoughts on the questions we are looking to answer, by allowing them to answer freely. Sometimes the interviews are combined with observation, to clarify things that happened or were said during the observation.

Questionnaires are another form of qualitative research method which can be done physically by giving out a physical paper based questionnaire or by providing a link to an online form. Careful planing of the questions must be carried out in order for the data to be valid and meaningful as explained by this systematic literature review [45]. The review also states the advantages of questionnaires: they are time and cost effective, web based questionnaires do not even need the

presence of the researcher and they make it easy to collect data from a large number of users. The disadvantage is that they can be fraught with bias unless well designed, and are often criticized because of the crude level of measurement. This means it can lead to a result with inaccurate data.

For our research method we used a mix of qualitative and quantitative methods, as previously mentioned in Section 1.6. The first quantitative method is known as System Usability Scale as illustrated in Figure C.1, which tells us about the non-functional and functional characteristics of the system. It will tell us about how the system performs overall and if it is deemed satisfactory by the section leader and other staff. By allowing the section leader and other staff fill out a custom SUS questionnaire, we will be able to see what things need to be worked with, and get a better sense of what needs improved. To make full use of the SUS questionnaire, we observed the domain expert try out various iterations of the game, to see how well they managed to go through it entirely. We also had two general questionnaires that helped us answer our research questions, and two general interviews with one of the social workers of Barneposten to to try to understand what they thought of the usefulness of such a product in their work environment as well as an interview with the domain expert.

The first questionnaire that is listed in the appendix C.5 is trying to get the starting knowledge of the children about Barneposten, how they feel before their visit and after playing the game. It will use questions which use the likert scale to capture results, having scores of 1-5, and some open-ended questions that allow the user to expand on what they want to say. The second questionnaire that is referenced in this part of the appendix C.7 is trying to see if there were any changes in the results after playing the simulator and visiting the hospital. It similarly uses the same structure of the first questionnaire, and asks. It is important to see how the knowledge from playing the game has helped their visit, if they know more, and feel empowered which may lower their levels of anxiety.

3.4.2 Evaluation Plan

The application was given to the domain expert in the middle of April in a state that was ready for testing. This allowed the domain expert to fill out the first SUS questionnaire, and give the application to the other members of staff who would also fill out the rest of the SUS questionnaires online. The children who would be attending Barneposten only received the application from the start of May, allowing them to play it from their homes. Once they played the application, their parents would fill out the pre-visit questionnaire. When the dates of their arrivals at Barneposten were decided, the children had the opportunity to fill out the post-visit questionnaire that was given out by the domain expert at Barneposten.

Two interviews were held in Barneposten, where the domain expert and a social worker of Barneposten were interviewed, this took place in the middle of May once all the questionnaires had been received.

3.4.3 Limitation of the Evaluation

As explained by our domain expert, the children may not feel like playing the game. This is completely understandable and we do not have control over that decision, it completely depends on how they feel, and they may also quit the game before having finished it. This means that some data may be missing, and the results might not be as accurate as the children might not have seen all the functionalities of the application, or just haven't interacted as much with it.

The observations were not carried out on the children who played the game as there needed to be a document which allowed us to carry out the observations as there exists a law that protects confidentiality of patients [46]. In a similar setting, interviews with the children were also not possible, as this required permission from parents, which are difficult to get, and would take a lot of time as well as reduce the amount of questionnaire participants we have access to.

Due to the delays of receiving the relevant parts of the building model, the development time took longer than anticipated, which therefore caused the evaluation stage to happen much later. If this was not the cause, there could have been a more thorough evaluation with more participants and with more follow up meetings and results.

Chapter 4

Application Design and Solution

This chapter we will give a detailed description of how we implemented the different aspects of the application and discuss how it is related to the research questions. We will also include how the the support of android and virtual reality was implemented.

4.1 Software and Tools

This is a list of software and tools used while developing this game.

- Unity - Version 2021.3.8f1
- Blender 3.3.0
- Quixel Bridge - A library of realistic textures and materials
- Ink - A narrative scripting language for games

4.2 A Walkthrough of the Application

When clicking "Start" in the main menu the player will enter Barneposten. The player will be introduces by the game. The game will start and activate teddy bears. The game instructs the player to collect every teddy bears in Barneposten, see 4.4. For every teddy bear collected the player will receive information from the game about the room the teddy bear was located in. When collecting the last teddy bear the game will acknowledge it and instruct the player the new task.

The player will meet a character and be able to interact with it. Characters in this game are created by a software called Character Creator 4, see 2.7.7. The character will introduce itself as "Paul" and give the player a warm welcome to Barneposten, see 4.6. "Paul" will give the player a set of questions to ask. These questions are specific questions about what the player is allowed to do in

Barneposten. After asking all the questions the game will instruct the player to find a specific poster.

This poster is an interactable object that the player can interact with throughout the whole game. However, when the Game State is updated to "Challenge 3" the Game Manager will notice it. When interacting with the poster, the player will receive information about the control commission. This is information about children's right in Barneposten. The information is received as an audio clip that the player will listen to. When the player is finished listening to the audio clip, the game will instruct the player to take the elevator up to the next floor to meet a new character.

When taking the elevator the player will enter the hospital school and meet the character known as "Roald". The same scenario as with "Paul" will happened and when the player has asked all the questions the game will give the player the last instruction. This is another challenge where the player collect teddy bears, but in the hospital school. Completing this challenge, the player will receive a congratulation for completing all the challenges. After that the player is free to do whatever the player wishes to do.

In the next sections of this chapter we will look at the implementation of the challenges.

4.3 The Game Manager

As noted in Section 1.2, this application will consist of tasks that we call challenges. These challenges are controlled by a script called "Game Manager". The main function of the game manager is to control the flow of the challenges in the game. The game manager consist of many variables that is needed for each challenge. The important variables are:

- Instance.
- Game State.
- Action.
- Ink files for each challenge.
- Dialogue system for the challenges (see 4.6.3).

Instance is a static "Game Manager" variable that make it available to be used in every script. Reason for that is to make it easy to call the relevant functions for each script that has a responsibility for a challenge. Game State is used as an enumeration class in the game manager. An enumeration is a class that represents a group of constants. In this application the Game State represent all added challenges, the introduction of the game and the epilogue when the player has finished all challenges. The Game State will change with the help of "Action". Action is a delegate variable which are used to represent a method with no parameters and "void" as a return type. Whenever the player have completed a challenge an Action will start where the game state will change to the next state, as illustrated in Figure 4.1. The ink files are used in the game manager's Dialogue System at the beginning of each game state, read Section

4.6 for more information about the Dialogue System. In the introduction state it will give the player an introduction the game. At each challenge it will explain the player the goal of the challenge. The epilogue state will give the player a congratulation for completing the challenges.

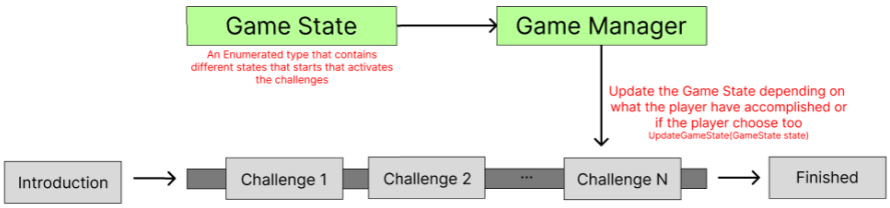

Figure 4.1: Representation of how Game State changes in the Game Manager.

Let us look at Figure 4.1. One of the challenges are "Challenge 1" and it is a task about collecting teddy bears in Barneposten. The game manager will first update the Game State from "Introduction" to "Challenge 1". The game manager will start the challenge with using the Dialogue System to explain the player about the challenge. After that the challenge will start and all the teddy bears located in Barneposten will be active, in Section 4.4 it will give more information about Teddy Bear challenge. After completing the challenge the game manager will call a function using Action to update the Game State to the next challenge.

4.4 Teddy Bear Challenge

In this application we implemented a challenge called the Teddy Bear Challenge on each available floor. The goal of this challenge is that the player will look around and search for missing teddy bears. These teddy bears are located in various rooms on each floor. Whenever a player finds a teddy bear a dialogue line will play out and give the player information about this room the player is in In Section 4.6.3 we will discuss the game dialogue. When the player has found all the teddy bears on a floor the challenge will be completed. The specific reason of collecting teddy bears was an idea from Paul Joachim Thorsen. The idea is that Barneposten has a big teddy bear that the children likes to play with, so Paul thought that motivating the children to find and collect teddy bears would be appealing for them.

4.4.1 Implementation of the challenge

The challenge will activate when the "Game State" is the Teddy Bear Challenge. The teddy bears object will then be active and visible. There is a simple solution for when the player finds a teddy bear. Both the "Player" object and "Teddy Bear" object has a component called a "Box Collider". Also the "Player" object has the tag "Player". The tag is used for specifying what type of object it is. Whenever the player collides with the "Teddy Bears" collider a function will be play out. In the script there is a variable called "challengeCount" which is the

total amount of teddy bears in the challenge. This counter will be decreased with one. A dialogue will then be played out, and then check if "challengeCount" is equal to 0. If it not the "Game State" will still be active, and if it is the "Game State" will update and the challenge will be completed. A visual description of how the Teddy Bear Challenge works can be seen in Figure 4.2.

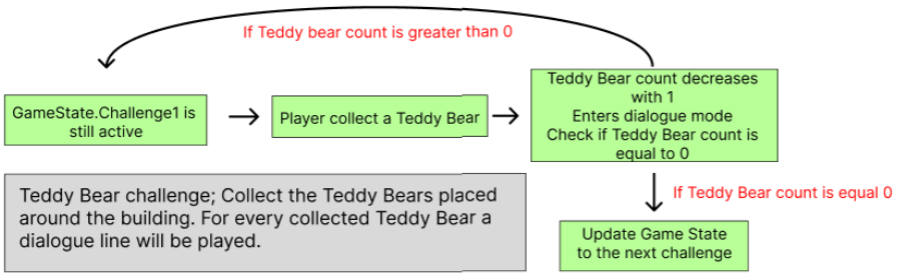

Figure 4.2: An illustration of the flow of a Teddy Bear Challenge

4.5 Information about Control Commission

As previously noted in Section 2.1.2, this section provides valuable insight into the role of the control commission and highlights the crucial importance of their involvement. The issue we were facing during the development was how the control commission should be represented. After a discussion with the domain expert it was concluded that we use a poster created by the domain expert. When the player interact with the poster, an audio clip will play. The audio clip was recorded by the leader of the control commission. It contains essential information about who the control commission is, what their role is, and that you (the player) can contact them whenever you want. This information is important because it gives the player information about their rights in Barneposten. The poster will be active to interact with during the whole playthrough of the game. However, when the "Game State" is set to "Challenge 3", the challenge "What is Control Commission" will be active. After the player has interacted with the poster, the "Game Manager" will acknowledge it and update the state to the next challenge. The challenge itself is not really a challenge, but an informative section of the game. The reason for this approach was that the domain expert wanted to include the control commission, but not let them be an essential part of the game.

Figure 4.3: In-game illustration of the poster of Control Commission

4.6 Dialogue System

One of the challenges for the children was about giving them the option to ask questions. The solution for this challenge was implementing a dialogue system where the player get to interact with a Non-playable character (NPC) and choose different questions and get the information they need. Ink was used to write the dialogue, as previously noted in Section 2.7.3.

The way it worked was that the player could go to a NPC which has an ink JSON file attached to them. The NPC has also a box collider, and by entering its range the player can interact with it. By interacting with the NPC a dialogue panel will enter the scene and reveal the ink JSON file from it. This is handled by a C# script called the Dialogue Manager. It is a singleton class which means there can only be one of them in the scene. The Dialogue Manager will take the ink JSON file and turn it into a story object. The story object can then be displayed in a panel using the unity UI objects tools. The Dialogue Manager also keeps track on whether a dialogue currently is playing. Other scripts can reference that information and behave accordingly. For example the Character Controller will freeze the player movement if the dialogue is playing. By exiting the dialogue the player movement will unfreeze. This is a pattern called Singleton Pattern Design which is a software design pattern that restricts the instantiation of a class to a singular instance, and is illustrated in Figure 4.4.

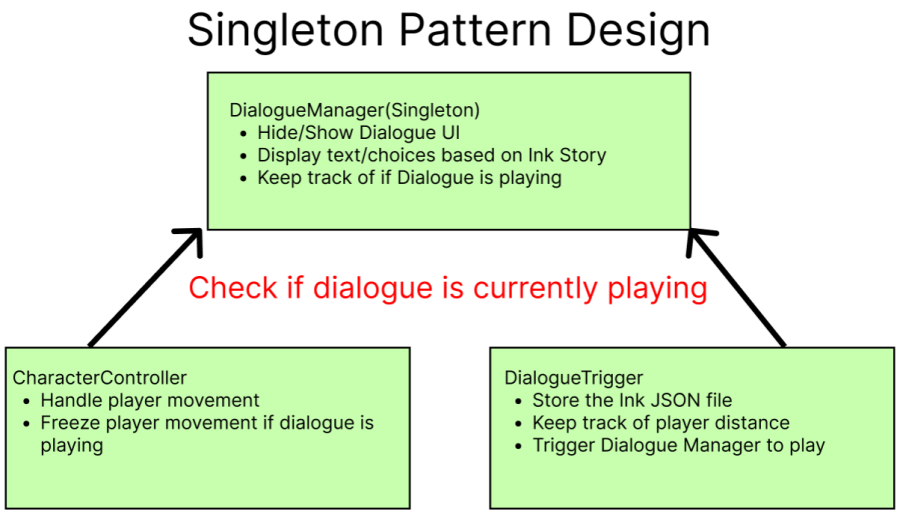

Figure 4.4: Singleton Pattern Design

4.6.1 Representing metadata from ink file

In the ink files we used tags to add metadata to any line of dialogue. Each tag got read into unity as a string. A solution to structure them in the script was to set them up in key-value pairs where key represent the action that we wanted to perform in the C# code for that line of dialogue, and the value which represented the data used for this action. As seen in Figure 4.5 we can have a dialogue line "Hello there!" with the tag "speaker:Bob". The tag will be read into Unity and get parsed into a key-value pair. The key would be "speaker" and the Value would be "Bob". The key in this example represent the name holder of the person who is speaking and the value is the name of the person. The dialogue panel displays the line of the dialogue and the name of the speaker. In this project we used tags such as "speaker", "audio" and specific tags for when a challenge was completed like "challengeCompleted".

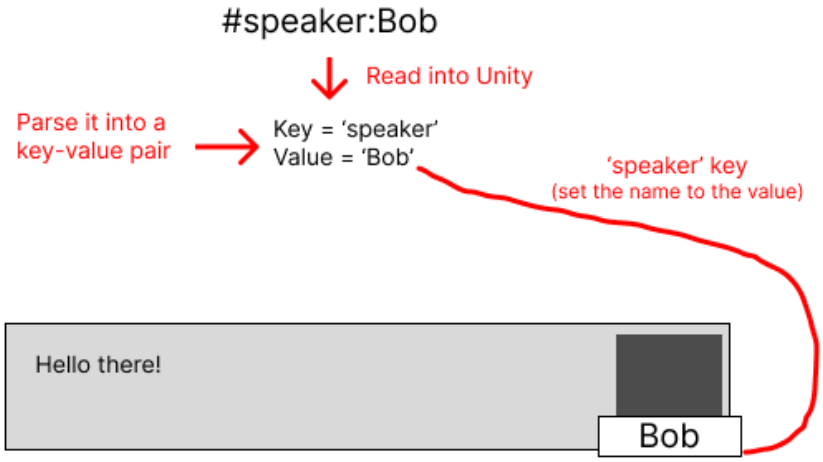

Figure 4.5: An example of how we can structure the tags from an ink file

4.6.2 Audio System - Giving the dialogue system voice clips

The age of children who get hospitalized in Barneposten are between 5-13 year. This means that there are a good chance that some of the children can not read. To make sure every children understands the dialogue, we implemented an audio system inside the Dialogue Manager script that plays audio clips depending on which line is displayed in the panel.

The audio clips used in the dialogue is stored in different scriptable objects. Scriptable object is a data container that you can use to save large amounts of data, independent of class instances. It helps to save and store data during an editor session, and saving data as an asset in your project to use at run time[47]. These objects includes an Id and a Name. When a specific line of dialogue is played the Dialogue Manager script receives the audio tag from the ink file. With the information from the tag the Dialogue Manager knows which scriptable object to use, and plays the audio clip.

Figure 4.6: Showing how an audio clip is chosen for a dialogue line

A visual description can been seen in Figure 4.6. For each line the "Dialogue Manager" will check a line for tags. There are two tags "speaker:Roald" and "audio:intro1_R". The first tag defines the person who are speaking and the second tag is the audio tag. The audio tag contains the value "intro1_R" and the "Dialogue Manager" will take that information and search through a list of scriptable objects until it finds an id which is equal to the value. When the scriptable object is found the audio file for that object will be played once.

4.6.3 Game Dialogue

In this application the dialogue system will be used when the player interact with a non-playable character (NPC). However, there are parts in the application where a dialogue panel will appear when the application tells the player what to do or when the player receive a dialogue line when interacting with teddy bears. This is called the Game Dialogue. The Game Dialogue is similar to the dialogue system. The motive with the Game Dialogue is to tell the player about the current challenge and give information. The player movement will not be freeze like it does in the Dialogue System. This is because we want the player to move freely while receiving the dialogue line and not force the player to stand still like in the Dialogue System. The Game Dialogue is implemented in the "Game Manager" script, see Section 4.3.

4.7 User Interface

In this section, we will explore the user interface (UI) design choices we made for our application, and how they enhance the user experience. As previous discussed in Section 2.5 we used a mix of diegetic and non-diegetic interfaces in the application depending on what device the application is used on. If it is a VR device the application will sole use non-diegetic interface. The use of UI in VR will be discussed more in Section 4.9.2. In this application we created various UI elements that we will explain in the next sections.

4.7.1 Main Menu

When the game is opened the player will enter the main menu. The main menu, as illustrated in Figure 4.7, is a simple scene with an image, the title of the game, a panel that stores two buttons. The purpose of this menu was to give the player a quite place to be before starting the game. The options in this scene is either click "Start", which starts the game, or "Avslutt", which quits the application.

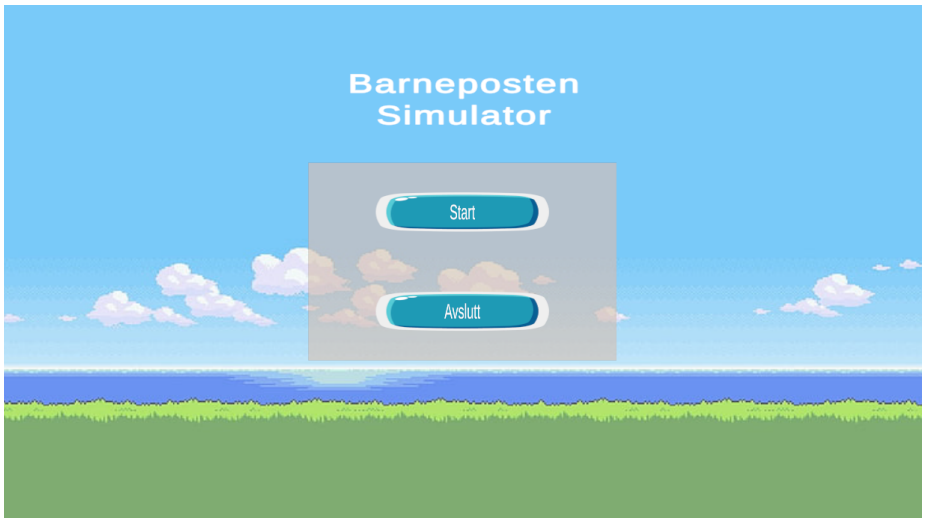

Figure 4.7: The main menu of the game

4.7.2 Dialogue Panel

In this game we developed two dialogue panels, that we explained in Section 4.6. The idea of these two dialogue panel was to showcase the dialogue to the player. When the dialogue panels get active it will cover the space of the screen. UI such like this is an example of diegetic interface. We wanted to design the panels so it did not take unnecessary space. The solution for this, which are illustrated in Figure 4.8 and 4.9 was to make the panels and the questions box transparent. To make an UI element transparent means that the player can see through the UI element which mean that the player is still able to see what is in the scene. We also placed the dialogue panel in the lower screen and the question box on the right side. The name tag above the dialogue panel in Figure 4.8 was not transparent. The reason for that was to make it clear to the player who they interacted with.

Figure 4.8: Illustration of the Dialogue Panel with questions

Figure 4.9: Illustration of the Game Dialogue Panel

4.7.3 Pause Menu

The purpose of the pause menu was to give the player options to take a break from the gameplay and access information of the game. The pause menu consists of three panels, which are illustrated in Figure 4.10; pause menu, option and journal. The pause menu are also diegetic interface. The player can access the panels with the buttons upper left in each panels. Compared to the dialogue panels the pause menu covers nearly the whole screen and are not transparent. This was to give the player a break from the gameplay as mentioned at the start of this section, and to set the focus on the UI panel. The first panel (pause menu) consists of a title indicating that it is a pause menu and two buttons. One of the buttons resume the game, while the other button quits the game and send the player to the main menu.

The purpose of the option panel was to give the player the control to adjust the volume of the application. There was added three volume sliders; master volume, music volume, sound effect volume. The first slider adjust the master volume. The master volume include all audio sources. The second slider adjust the music volume, which is the background music in the application. The last slider adjust the sound effect. In the application there was added a sound effect which played everytime the player collected a teddy bear in the Teddy Bear Challenge.

The Journal was added to give the player an overview over the challenges in

the application. It consists of buttons on the right side in the panel with each of the challenges name. When the player hovers over one the buttons it will display the title of the challenge and a description of the challenge. This will give information of what to do on each challenge. Above the buttons there are red text. The red text indicates that when the player has finished all the challenge the player will be able to select one of the challenges and start it.

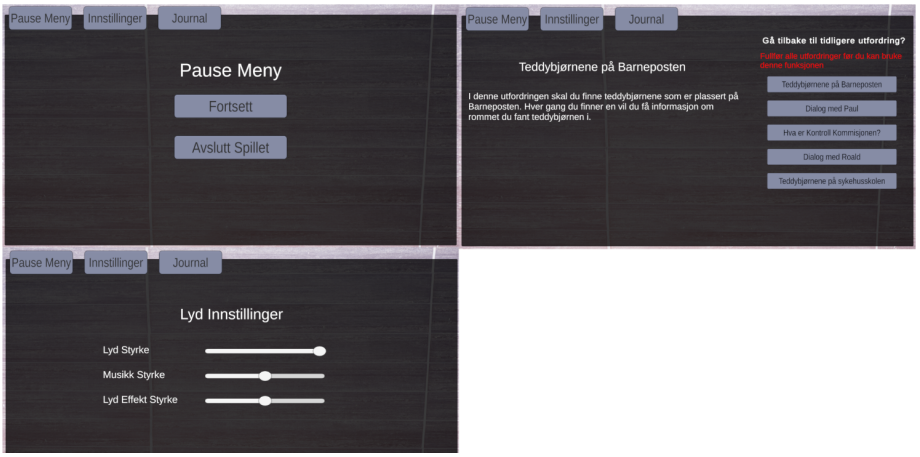

Figure 4.10: 3 panels of the pause menu including pause, option and journal

4.7.4 Teddy Bear Panel

In section 4.4 we explained the challenge Teddy Bear Challenge. In this challenge the objective to the player was to collect teddy bears and receive information about its location from the game dialogue. To give the player an overview of the different locations of the teddy bears in the area we designed diegetic UI elements for each floor. In Figure 4.11 showcases the UI panel which includes the objective written as "Finn teddybjørnene", and green boxes with the location name inside. One of the panels is for Barneposten (left side) and for Hospital School (right side). There is one box that is red. This is an indication that the teddy bear for the specific location is already collected. This was done to help the player keep track of their progress in the Teddy Bear Challenge and to provide a clear indication of which locations they still needed to search. The use of color-coding also made it easier for the player to quickly identify the status of each location without having to read through a lot of text. The placement of the panel was positioned in the upper-right of the screen. The placement made sure that it did not take to much space on the screen and that it did not overlap with the dialogue panel.

Figure 4.11: UI panel from the Teddy Bear Challenge

4.8 Implementation of the game for Android

To extend the reach of our game and bring its captivating gameplay to the world of mobile devices, we embarked on the task of implementing it for Android, specifically targeting phones and tablets. During the last development phase, the domain expert expressed the need for a tablet version of the game, particularly because Barneposten had several Android tablets available for children to use. Adapting the application for Android devices would facilitate their access to the game. With the basis of the game already established, there were only a few key points to address in order to accomplish this objective.

The initial step involved integrating a virtual joystick. To achieve this, we incorporated the "Joystick Pack" package from the asset store, which provided a collection of buttons and joysticks designed as a starter pack for mobile game developers. The package offered a joystick object with preexisting scripts, enabling us to use it seamlessly. By simply moving the joystick a few millimeters from its original position using an index finger, players could control the game.

Subsequently, we developed a new player movement script, similar to the original script designed for Windows users, with the exception of replacing keyboard and mouse inputs with the virtual joystick and touchscreen controls. To manage the camera angle, we implemented a class called "MobileInput" that detects touch events on the right side of the screen. When the screen is touched on the right side, camera movement is activated. We limited the camera angle change to the right side of the screen to prevent conflicts with joystick usage. Additionally, the player movement script detects touchscreen input using the "MobileInput" script, receiving the position and direction of the player's finger. For the player movement component, the script interprets the inputs for horizontal and vertical movement from the joystick.

Figure 4.12 provides a visual representation of the user interface (UI) for the Android version. As previously mentioned, the joystick, situated in the lower left corner, has been strategically placed for ease of use with the thumb, resembling

a console controller layout found in popular gaming consoles like PlayStation, Xbox, and Nintendo. In the upper left corner, we implemented a button labeled "Hovedmeny" which pauses the game and activates the pause menu. The last UI element introduced for this version was a button in the lower right corner of the screen, enabling interaction with non-playable characters (NPCs) and posters from the control commission challenge. When players interact with an NPC, they can skip dialogue simply by touching the screen. By accomplishing these steps, we successfully made the game playable on Android phones, expanding its accessibility and enhancing the overall user experience.

Figure 4.12: Illustration of the android version of the game using a simulated tablet

4.9 Implementation of the game for VR devices

As discussed in the introduction of this thesis we will develop a game with VR support. The player will have the opportunity to connect a VR device to a computer, but also the opportunity to export the game and install it on their VR device. As previously noted, Section 2.4 provides brief information about the technology of virtual reality. During the development of the game we used Meta's Meta Quest 2 to test the VR functionalities. The goal with the implementation of VR during the development was creating an immersive and user friendly gameplay. To complete this goal we followed the guideline previously mentioned in Section 2.4.1.

4.9.1 Technical Implementation

Section 2.7.2 explained briefly about what extended reality (XR) is. When developing a VR application we followed a step by step guide to include the important aspects. At the start of the project we installed XR Plugin Management. This plug-in based approach improves Unity's ability to make quick bug fixes, distribute SDK updates from platform partners, and to support new XR devices and runtimes without having to modify the core engine [24]. This plugin was installed in the "Project settings" in the editor which can be seen in Figure 4.13.

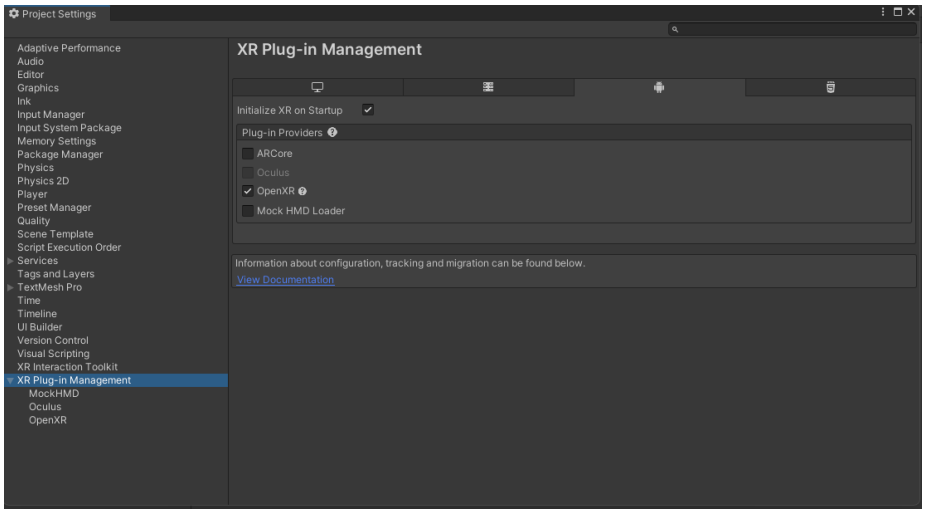

Figure 4.13: Overview of the project setting highlighting XR Plug-in Management

The next step was to add a package called XR Interaction Toolkit. It was added by going to the Package Manager in the editor and adding it by writing the package name *com.unity.xr.interaction.toolkit*. After that, an asset from this package called "Starter Assets" was imported. This asset consisted of input action and presets for default movement, which are illustrated in Figure 4.14. By doing this, access was obtained to a game object with the component called "XR Origin". This component included the game object itself, a camera offset, the camera, and a tracking origin mode where height mode could be chosen. It also created the camera offset and camera game objects.

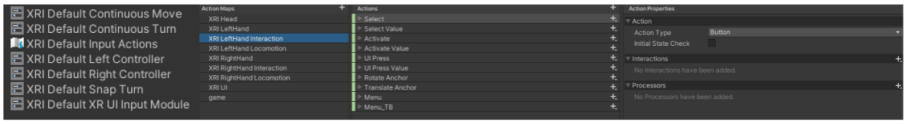

Figure 4.14: Left side shows a list of presets and input action and the right side shows the list of all input actions

To get hands, two game objects were added and put in as children for the camera offset. For both objects, a component called "XR Controller" was added. This component consists of input actions for every action for the VR controller. By using the preset from the toolkit, the default input actions for the left hand and the right hand were obtained. The last step that was done for this to work was to add a component for the "XR Origin" object called "Input Action" and select the input action from XR toolkit. After all these steps were completed, it created the foundation to walk and turn around in the application in VR. The

hand model used in this project was Oculus hand package.

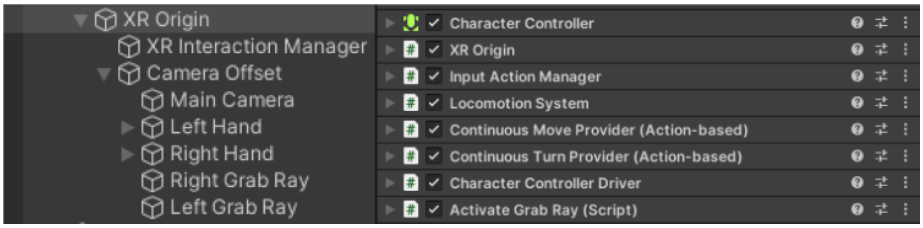

Figure 4.15: Illustration of the children game objects and XR Origins components

In the "XR Origin" object, we added the "Locomotion System" component to control access to the XR Origin, which gave the player access to movement and turning around. There were several components to choose from, and we used the "Continuous Move Provider" and "Continuous Turn Provider" components in this project. We also added the "Character Controller" component, which allowed us to do movement constrained by collisions. After completing all these steps, we were able to move and turn in the VR application. Figure 4.15 illustrates the components of XR Origin used in the final build.

The final objects we added was our solution for interaction with the environment. As seen in Figure 4.15 there are two objects called "Right Grab Ray" and "Left Grab Ray". These two game objects was created by adding a XR object called "Ray Interactor (Action-Based)" that created a game object with the components "XR Controller", "XR Interactor Line Visual", "Line Renderer" and "XR Ray Interactor". These components was used as a helping tool to give the player indication for when it is possible to interact with an object or canvas. It indicates with a green line pointing at the object, as illustrated in Figure 4.17. To make it possible to interact with objects in VR we added components for the object we wanted to interact with. For physical objects we added the component "XR Grab Interatable" and "Tracked Device Graphic Raycaster" for canvas.

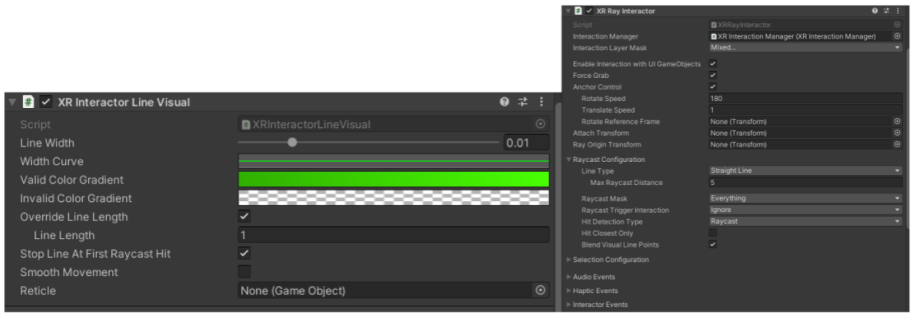

Figure 4.16: Two components in Left- and Right Grab Ray game objects

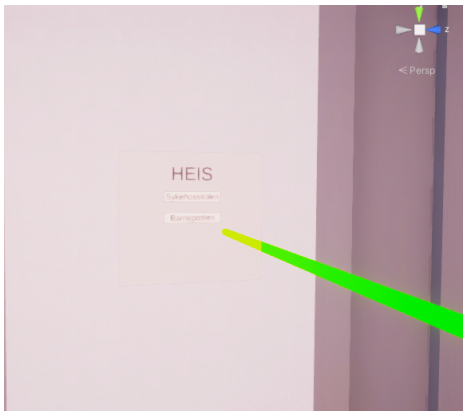

Figure 4.17: Illustration of the line renderer in play when interacting with a canvas in "world space" mode

4.9.2 VR Design

The challenges we faced during the development of the VR functionalities were how to fix the UI elements. In Unity there are three different render mode for canvases. First of all, a canvas is the area where all the UI elements are put in. The three different render mode are "Screen Space - Overlay", "Screen Space - Camera" and "World Space". As preciously noted in Section 4.7 the canvas used for the pause menu, dialogue panel etc are rendered in "Screen Space - Overlay". However, in VR this is not possible to do. This is because the only render mode available for VR devices is "World Space". Like the elevator panel, the canvas has to be in the scene.

After many iterations the approach chosen was putting the canvas as part of the left hand. As illustrated in Figure 4.18 and 4.19 the canvas with its UI elements are over the left hand. The canvas object was set as a child object of the left hand. This means the canvas will follow the position to the left hand. Rotating the hand will also make the canvas rotate. This approach made it easier to read and look at the canvas since the player can use the canvas as a tablet. Figure 4.14 illustrates the input actions. We added our own input actions for activating the UI elements. For example we made an input action called "Menu" which uses the left hand's primary button. By adding the input action to the "Game Menu Manager" script it made it possible to open the pause menu with a VR Controller.

Figure 4.18: The pause menu used in VR

Figure 4.19: The dialogue panel used in VR

4.10 The idea of choosing a stage

As previously noted in Section 1.5, we wanted to create an interface where the player can teleport between scenes. What is mean is that the player can select what we call a stage from a list in the menu. The idea was later abandoned because of the work load. However, a dummy version of this interface was made.

Figure 4.20 illustrates the design of the interface. It is a simple interface with a title and a panel that includes the list. Every items in the list contains a name. We can look at the code in Figure 4.21 how the list was made. We searched through a list of every unity scenes in the project, and for every enabled scenes we did the following:

1. Found the name of the scene using the scene path and edit it with Regex.

2. Checked if it was not the Main Menu or Hub World.
3. Created a button by using a button template.
4. Gave the text component of the button the name of the stage.
5. Added a on click event to the button using the method "AddEventListener"

When finished searching through the list, the button template was destroyed. This happens every time the application starts. To test the interface we used "EditorBuildSettingsScene" library which gives us the list of scenes. However, this only works in edit mode and not when building the game. The approach that was planned, was to connect the application to a database. In the code illustrated in 4.21 we would replace "EditorBuildSeetingsScene" with the database.

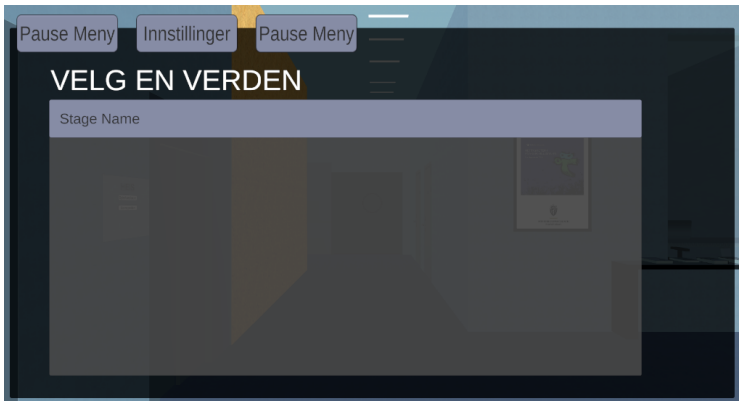

Figure 4.20: Early version of the choose a stage menu

```
public static class ButtonExtension
{
    public static void AddEventListener<T>(this Button button, T param, Action<T> OnClick)
    {
        button.onClick.AddListener(delegate() {
            OnClick(param);
        });
    }
}
void Start()
{
    GameObject buttonTemplate = transform.GetChild(0).gameObject;
    GameObject g;

    foreach(EditorBuildSettingsScene scene in EditorBuildSettings.scenes)
    {
        if(scene.enabled)
        {
            string stage = RegexThisPath(scene.path);

            if (stage != "HubWorld" && stage != "MainMenu")
            {
                g = Instantiate(buttonTemplate, transform);
                g.transform.GetChild(0).GetComponent<TMP_Text>().text = stage;
                //g.GetComponent<Button>().AddEventListener(stage, ChooseStage);
            }
        }
    }

    Destroy(buttonTemplate);
}
```

Figure 4.21: The code used for the list of stages

Chapter 5

Results and Discussion

This chapter will contain the methodology used for the evaluation, the presentation of evaluation results, a comprehensive discussion on the results and lastly the summary of the results.

5.1 Methodology

As previously discussed in Section 3.4, we used a series of questionnaires and an interview to capture the data we needed to answer the research questions. When the application was completed, we let the domain expert and the therapists to try it as our first set of participants. After playing through the game, the participants were handed the System Usability Scale (SUS) questionnaire. This questionnaire was not intended to answer the research questions, but to gather data to know if the application was playable.

The children would play through the game and answer questionnaires with their parents beside them. For this set of participants we made two set of questionnaires, one before they visit Barneposten and one after they have visit Barneposten. The intention of these questionnaire was to answer the primary research questions. After the user testing we arranged a meeting with one of the therapist for an interview and also an interview with the domain expert.

5.2 The Results of Evaluation

5.2.1 SUS Questionnaire Results and SUS Score

The SUS questionnaire can be viewed in the appendix C

The SUS evaluation consisted of 4 participants that were all staff members of Barneposten in Haukeland. In order to calculate the SUS score which is a general score for all the questions, it is necessary to perform a series of calculations that are described in this article about measuring and interpreting the SUS score [48]. The scores are rated out of 100, an average score meaning 50% is said to be 68 out of 100, and therefore that is the score to beat in order for the

application to be considered usable. The diagram below shows the rating in relation to score. In our case, a higher score than 68 is preferred in order to consider the system to be completely usable.

SUS Score	Grade	Adjective Rating
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

Figure 5.1: Results grading table [49]

The scores of the SUS evaluation are shown by the table below. Each participant is labelled ”p1”, ”p2” and so on. We can see that the first participant scored 65, which is regarded as below the average , while the others scored above 70 and even above 80. This is a good indication that the application works as intended. Looking at the lowest SUS score, the user thought that the game was slightly more difficult to use than the rest and they indicated that they would need a bit more technical help with playing the game.

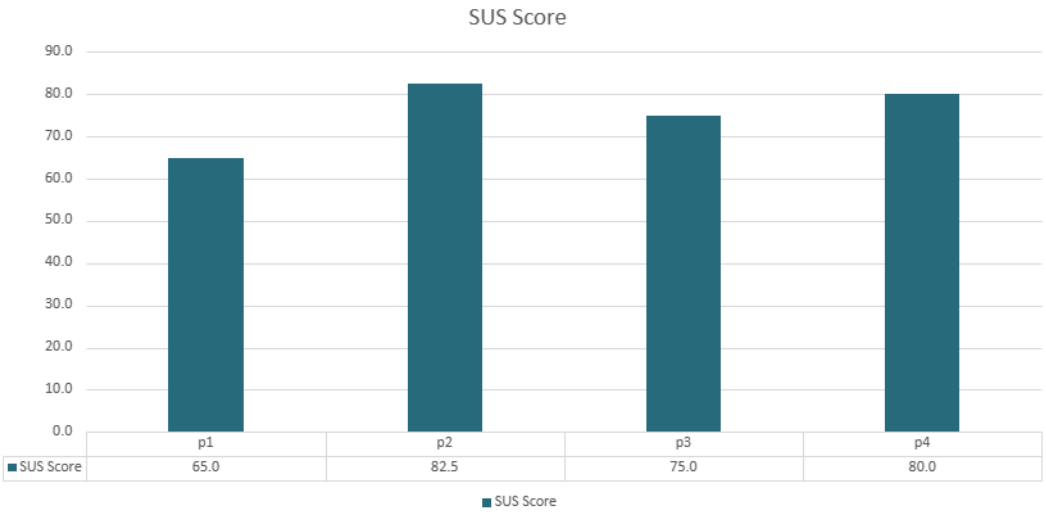

Figure 5.2: SUS scoring table

In addition to the questionnaire, the team at Barneposten also left some feed-

back in the form of an email. This was not part of the SUS questionnaire but in any case it is something that we could consider. The feedback received from the staff can be seen below.

1. "The rooms were nice and easy to move around in when you know what to press".
2. "The characters/persons you meet are not very friendly, they could be shorter so as it does not look like they are looking down at the child - makes it look like a "top-down attitude". They should sit down and face the child, smile.
3. "Have a speech bubble?".
4. "Have a smaller rubric around text when information comes in?".

5.2.2 Custom Questionnaire Results

The results for the custom questionnaires can be viewed in the appendix C

Participants

The number of patients who received both the pre and post visit questionnaires was 3, giving a total of 6 filled out questionnaires. It has been noted that participant 3 (as we will call them from now on) has not played the Barneskolen level, and has also played the older version of the game which was released around the start of April, the other players played the more recent release of the game.

Results of the Custom Questionnaires

Pre-visit Questionnaire

1. **Føler barnet ditt nervøst for besøk/opphold i Barneposten? (Did your children feel nervous before the visit/stay in Barneposten?)** In the first question the first patient scored a 1, signifying they were not nervous at all, the other two patients scored 2 and 4 respectively.
2. **Etter å ha spilt ≪Barneposten Simulator≫, føler barnet ditt at de har fått mer informasjon om Barneposten enn før?(After playing the game "Barneposten Simulator", did your child feel that they found out more about Barneposten than before?** The 2nd and 3rd child reported that the game gave them more information than before, scoring 4 and 5 respectively, while the first user reported that the game did not give them any new information, scoring only a 1.
3. **Var ≪Barneposten Simulator≫ gøy? (Was "Barneposten Simulator" fun?** All of the children reported the game to be fun, scoring 4 and 5.
4. **Hva har barnet ditt lært om Barneposten etter å har spilt "Barneposten Simulator"? (What did your child learn about Barneposten after having played "Barneposten Simulator")** For this question there were no replies.
5. **Hvilken utfordinger fullførte barnet ditt? (What levels did your child complete?)** All the children ticked both boxes.
6. **Er det noe som manglet eller noe som du ville ønsket var lagt til i spillet? (Is there anything missing or anything which you want added to the game)** One user reported wanting to add a treasure chest once the game was complete. Another one said that "it looks strange".

Post-visit Questionnaire

1. **Visste pasienten hva han kunne forvente på Barneposten etter å ha spilt spillet ≪Barneposten Simulator≫? (Did the patient know what they can expect in Barneposten after playing Barneposten Simulator?)** This question had scores of 4 for two children and a score of 3 for another child.

2. **Har spille ≪Barneposten Simulator≫ gjort pasienten mindre nervøs for å være i Barneposten? (Has the game "Barneposten Simulator" made the patient less nervous to be in Barneposten?)** In this question all the children reported a score of 4.

3. **Stillte pasienten mange spørsmål om hvor de var? (Did the patient ask many questions about where they were)** All the children gave a score of 4, indicating that they had many questions.

4. **Følte pasienten at simuleringen hjalp dem å navigere seg på Barneposten?(Did the patient feel that the simulation helped them navigate around Barneposten?)** Two children gave a score of 5 indicating that it helped a lot, and one child gave a score of 3.

5. **Gjorde ≪Barneposten Simulator≫ at pasienten ønsket å utforske Barneposten?(Did the simulator make the patient want to explore Barneposten?)** For this question, all the children gave a score of 5, showing that they wanted to explore Barneposten.

6. **Noe spesielt som pasienten lærte at de ikke gjorde før?(Did the patient learn anything special that they did not before?)** This was an open question, and there were no replies left.

7. **Spørte pasientent noe relaterbart til hvorfor de oppholde seg på Barneposten?(Did the patient ask anything related to why they are held in Barneposten?)** There were two answers to the question, however what was answered had no relation to the question.

8. **Noe de ikke likte med ≪Barneposten Simulator≫ nå som de har besøkt det virkelige bygget?(Anything the patient did not like about Barneposten Simulator now that they have visited the real building?** This was an open question, and only two children answered. One of the children said that there should be more people to talk to, more things and children playing. Another child said that there should be stairs, and other rooms like the "security room" and "other parts of the building".

5.3 Interview with Social Worker from Barneposten

The interview took place in the end of May, and it was a short 15 minute semi-structured interview.

1. **Have you played the game?**
   The interviewee said that they played the game on laptop.

2. **Do you think a game like this is useful for children? Does it have a purpose in its current form?**
   The interviewee said that this is very useful for children, and many of them have anxiety in relation to coming into new environments. It was also stated that it catches the attention of children much better than information presented from parents, and from websites. The game in its current form is a good starting point, as the children get familiarised

with the building, and the people they could possibly encounter. It is informative, and easy for older children to play.

3. **Did the kids find it fun?**
   The interviewee mentioned that one child that she saw play the game said that it was "fun enough".
4. **What are the biggest issues that children face coming into Barneposten?**
   The interviewee said that the environment for the children is unfamiliar, it is difficult to visualise what they will experience.
5. **What other tasks should be in the game?**
   The interviewee responded that there should be more elements that will keep children coming back. Also children with ADHD need more stimulation to remain interested.

5.4 Interview with Domain Expert

1. **How has the game contributed in giving information?**
   They answered: One gets the feeling of how it looks, the adults (the NPCs) provide answers to questions. Information about admission, the hopsital school and the control commission.
2. **What made the game fun?**
   It was fun exploring and it was fun playing the instruments.

The domain expert also expressed additional feedback about the game: "It can reduce stress and anxiety for the children if they can play it ahead of the admission". "Input from the patient is that it should have been shown that there is a lift up in the department, not just to the school (for those with a fear of lifts)".

5.5 Discussion

5.5.1 Discussing SUS

The results of the SUS questionnaire that were filled out by 4 hospital staff were positive, and the SUS score that was derived from them scored very high except for one of the testers who thought that the game was a bit more difficult and needed some technical assistance with using it. This can be attributed to some people being unfamiliar with using mouse and keyboard layout for playing games, as this was tested on a laptop. This finding is not prevalent in any of the other 3 participants. The questionnaire allowed us to know how children would be able to perform in the game, and if they would be able to fluently use the controls, which is important for the experience of the game. The results also showed high scores in functionality and integration of the application, which means that features such as challenges were well implemented. An issue of SUS is that certain scores that are given by a test-participant cannot be completely explained unless there are some follow up evaluation methods to get a more of a qualitative analysis. After our SUS questionnaires, we did receive an informal feedback from the test-participants about the game, however nothing regarding

as to why certain scores were given by certain participants. But this feedback was still useful in giving a better overall understanding.

5.5.2 Discussing the Questionnaires

The pre-visit questionnaire has given us insight into how the children felt before their visit to Barneposten, this gives us insight into their state of being. For the first question two of the children experienced a low to moderate amount of nervousness going into Barneposten and one of the children did not experience any nervousness as they scored only a 1. This shows that children may feel some kind of unease, while others may not feel any at all. The feeling of unease when going into a hospital environment is reflected in other studies done by Jo Vrancken et al [33], which explained that children experienced pre-operative stress (stress experienced before operation day at a hospital). This also coincides with the findings by Wennström, Berith [4] as he mentioned that children experience some kind of anxiety from the fear of the unknown and of not having knowledge of what would happen to them.

The second question was generally asking if the child received more information than before after playing the game; the scores showed that the game gave two children much more information while another child received seemingly no new information. This large discrepancy is difficult to explain, and a more thorough evaluation would be needed. This result shows that the children that scored higher in the first question, also scored higher in this question; therefore it can be said that the game provided more information to these children. However, a separate evaluation would be needed to understand if the information they received helped them ease their nervousness. The questions that they got to ask and the answers that they received were formulated by our domain expert.

In relation to this being a serious game project, the aspect of gamification and fun is important for the children to absorb information, as mentioned in the guidelines for creating and improving serious games in game development [15], it was necessary to create a balance between the entertainment aspect and serious tasks. The last question that asked "how fun the users found the game to be" gave very high scores, this highlights that fun elements were present in the game.

The first question of the post-visit questionnaire had two of the children give a score of 4 and one give a score of 3, which showed that all of them thought that the game has gave them lasting information about Barneposten. In the second question, it asked if playing the game made the children feel much less nervous about being in Barneposten, and everyone responded positively giving a score of 4. The results provide an indication that the game has helped the children in some way. This score is also surprising, as one of the children claimed to not experience any nervousness or anxiety towards going into Barneposten based on the previous questionnaire in question 1, yet in this question of the second questionnaire they experienced a lot less nervousness, this remains to be an unexplained inconsistency with the results.

The third question also received a score of 4 from all the children which showed they had many questions about Barneposten, it was important to ask this question to see if the children responded to their surroundings after playing

Barneposten Simulator, and showed interest in its exploration. The fifth question asked about if the simulation helped them navigate Barneposten, in this question two children scored 5 and one scored 3. This meant that the game was in some way helpful in guiding the child around the area, which seems to have helped in navigating the real life version of the building. In the fifth question, we asked if the game made the child want to explore more of Barneposten, and this was answered positively by all of the children. This showed that the game provided the children with confidence to explore an area that they felt anxious about visiting.

In the open ended questions, most of the children answered questions 7 and 8 of the post-visit questionnaire, for question 7, one of the children mentioned that "it looks different" meaning Barneposten, it is difficult to understand what was meant exactly by this; as they could have meant the textures, or the fact that it was not entirely a one to one reconstruction of Barneposten. For question 8, there was a lot of feedback left by two children; one of them mentioned that there should be more people, more things, more children playing and the other mentioned that there should be stairs in the recreation, also more rooms such as; security room and other parts of the house - which was not entirely clear, as there was no "house".

5.5.3 Discussing the Interviews

Both interviews provided important background and additional information about the game that they noticed themselves. Both of the interviewees expressed opinions that children seemed to find the game fun, and that they themselves believed it also. Both of the interviewees believe that this can have use-cases in their current environment, by helping to relieve their anxiety towards hospitalisation.

5.6 Summary

The results of the SUS questionnaire explain to us that the game is fully playable and is viable to be used by the public, one test-participant found that they needed more technical assistance while playing, and it is unclear if this is attributed to a need for a more complex tutorial system; a separate evaluation interviewing the participants could highlight what the application is lacking.

Children who were being admitted to Barneposten claimed to have some sort of nervousness in relation to going there, except for one child who claimed not to have any; while the evaluation only approached this question very broadly, it would have been of use to ask what makes them nervous specifically; however this was not part of the scope of this thesis. The pre-visit questionnaire found that most of the children received some sort of new information; it may have been good to define what the new information was.

Based on the pre-visit and post-visit questionnaires, a lot of the children knew what to expect in Barneposten once they got there, and that playing the game made them less nervous than before judging by the results. The use of serious games guidelines in this setting has demonstrated to be quite effective, as it provided them information and helped them enjoy the game. Also the fact

that most of them rated the game to be fun and enjoyable. It was reported that all but one child played through all the levels, which is a good indication that it occupied them well, however more interesting mechanics would help replayability especially for children who have ADHD disorder as mentioned by one of the interviewees.

Other questions in the post-visit questionnaire tried to see how empowered the children were, and if they were confident in exploring their surroundings. Our domain expert said, it is important that the children feel empowered, and we gave them that ability of freedom and exploration. We asked if they wanted to explore Barneposten, and all of them answered positively, claiming that they did.

Overall, the SUS testing showed that even for less technical people, the game was still fine, and was easy enough to pick-up as seen from the score of the third SUS question C.12 and worked without problems, giving it the possibility to be used in practice. The questionnaire returned positive results, but would need more user feedback and different evaluations to see to what extent the game helps children. As this project has already ended, there is still going to be further testing at Barneposten on the 25th of May, which shows that this seems to be a promising tool for the staff of Barneposten.

Chapter 6

Conclusion

In this thesis, the primary goal was to develop a game with android and virtual reality support, taking inspiration from the models used in Barneposten and Hospital School. Additionally, the objective was to incorporate interactive tasks within the game to provide information about Barneposten. Upon examining the results presented in Section 5.2.2, it can be concluded that we have completed these goals.

Furthermore, we added sub-goals for this thesis, which involved implementing a database with multiple stages that players could choose from. As explained in Section 4.10, a rudimentary version of stage selection was developed and demonstrated to be functional. However, due to constraints such as limited evaluation and incomplete work, further progress on this aspect was not accomplished.

The primary research question for this thesis were;

1. How can we design a game that will provide interactive information about Barneposten and its experience?
2. How can we optimized the application making it entertaining and serious?

To answer these two research questions we made an application with Android and Virtual Reality support. After developing the game, the children got to try the application. According to the results from the questionnaires in Section 5.2.2 and the discussion in Section 5.5.2, we received great feedback from the children. There were some criticisms and wishes in the feedback that should be focused on. Specific criticisms and wishes from the feedback are discussed in Chapter 7. Answering research question 1, we made an interactable game where the player could go around in Barneposten and Hospital School doing challenges and exploration. After playing the game, the majority of the children felt that they received new information about Barneposten. This gives us data on how to create an informative game. The second research question aimed to explore how the game could strike a balance between entertainment and educational value. According to the results obtained from the interviews conducted in Section 5.3 and 5.4, the participants expressed positive feedback regarding the game's ability to be both engaging and informative.

While we mainly focused on the primary questions, we also had a set of secondary research questions.

1. How can we develop a scalable framework where the client can request a 3D model from a server that will consist of a library of 3D models with levels and tasks?
2. If added multiplayer, how can it we make the players interact with each others?

The first research question was inspired by the idea from the domain expert. The ambition of this idea was to create a social platform were users could upload their 3D scanned model and share it with the community. While we had a solution for player to choose a stage, we did not implement a database to use. Due to the workload we did not manage to research this further. This application is a single player experience, but we looked at the potential to make it a multiplayer experience too. We did not test the application for multiplayer testing, but according to a feedback we received from a participant it was stated that the participant wished to see other children play and interact with them. This feedback expands the idea of an application with multiplayer and mini games that two or more players could attend.

The application was primarily evaluated for its usability by children aged between 5 and 13 years who visit Barneposten. The domain expert involved in the evaluation expressed satisfaction with the application and expressed enthusiasm about continue the work in the future. This project holds relevance for professionals working in the digital healthcare sector, specifically those focused on disseminating information effectively.

In conclusion, this thesis successfully accomplished its primary goals of developing a game with android and virtual reality support inspired by Barneposten and Hospital School models, as well as answering the primary research questions. The positive evaluation feedback from the questionnaires validates the potential utility of this application in the context of digital healthcare. However, we need to be critical and ask the question; Do we have enough data to have an accurate result? We only had a few participants in the evaluation, which means we cannot say for sure if the results of the project are accurate. Moving forward, it is recommended to conduct further evaluations and expand the functionalities to fully realize the envisioned objectives. This research contributes to the growing field of digital health care and lays the foundation for future investigations in improving dissemination of information to children.

Chapter 7

Further Work

We managed to deliver a fully functional application. However, there is more content that could be added to make the game more fun and more informative. Also not every goals were completed. In this last section we will give an overview over content that can be added in the future.

7.1 Improvements and further development

7.1.1 Remaking the Audio System in the Dialogue Manager

In Section 4.6.2 we explain how we store audio clips in scriptable objects. When a dialogue line is playing, the Dialogue Manager will receive the id for the scriptable object. This solutions works well enough, but a scriptable object can only store one audio clip. This is not a reliable solution because it means that we need a scriptable object for each dialogue line. To make the audio system better it should be a scriptable object for each NPC.

7.1.2 Dialogue Panel

In Section 4.6 we mentioned that there are two dialogue panels, the one that is active when interacting with a NPC and the game dialogue panel. One mistake made while developing this was that both panels can be active at the same time. The issue occurred when the player has finished talking with a NPC and not exiting the dialogue, the game dialogue will be active and overlap the other dialogue panel. Another part that could further improve the dialogue panel is its design. One of the feedback from Section 5.2.1 the participants talks about resizing the panel depended on how much words that are used and using a speech bubble.

7.1.3 Making the environment more immersive

One part of the game that felt empty was the availability to interact with objects. A small goal that can be explored further is to add new furniture and expand

on the current one and make it interactable. One example can be about making the billiard board and the table tennis playable for the player. There are also the possibilities for small contents such as turning the light switch on or off or picking up toys.

7.1.4 Character models

As previously noted in Section 5.2.1 we received feedback from the participants. One of the feedback was about the characters looking unfriendly. For the character models we used a software called Character Creator 4, as mentioned in Section 2.7.7. An improvement for this game would be to create characters from scratch. By doing this it would be also easier to add simple animations.

7.2 Enter a 3D world selected from a database

In the planning phase with discussed the approach of the project with the domain expert. One essential part the domain expert wanted was a solution for users to upload their own 3D scanned building. In Section 2.8.1 we showcased a game that do exactly that using their own software development kit (SDK). This idea was later abandoned because of the time limit. For future work this idea can again be researched on and developed to expand this project.

List of Figures

List of Tables

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Appendix A

Software

A.1 Software

This is the software used in the development of Barneposten Tour.

- Unity - Version 2021.3.8f1
  - TextMeshPro - Unity's built in text solution. Used as text in the dialogue system.
  - Input system - used to register inputs from the keyboard and controller
  - XR Plug-in Management - enables provider plug-ins for the VR devices
  - XR Interaction Toolkit - used to make it easier to develop VR application

A.2 Third party software

- INK - a narrative scripting language that is primarily designed for professional game development.
- Character Creator 4 - a full character creation solution for designers to create realistic characters.

Appendix B

Gantt Schema

Hospital Tour VR Project Schedule

Gantt Chart Template © 2006-2018 by Vertex42.com.

Project Start Date: 10/2/2022 (Sunday) | Display Week: 4 | Project Lead:

WBS	TASK	LEAD	START	END	DAYS	% DONE	WORK DAYS
1	**[Upload Model In Unity]**		Sun 10/02/22	Tue 11/29/22			42
1.1	Rough Model in Unity		Sun 10/02/22	Mon 10/17/22			
1.2	Implement and Test Partial Features		Tue 11/01/22	Wed 11/30/22			
1.3	Complete The Intro + Backrounund of Thesis		Sun 10/02/22	Tue 12/20/22			
2	**[Main Game Features]**		Thu 12/01/22	Mon 1/30/23			
2.1							
2.2							
2.3							
2.4							
2.5							
3	**Test And Evaluation**		Mon 1/02/23	Tue 1/31/23			
3.1							
3.2							
3.3							
3.4							
3.5							
4	**Final Polish of Project**		Wed 3/01/23	Fri 3/31/23			
4.1							
4.2							
4.3							
4.4							
4.5							
5	**Thesis Completion and Wor**		Sat 4/01/23	Tue 5/30/23			
5.1							
5.2							
5.3							
5.4							
5.5							
							-
							-

Week 4 24 Oct 2022 | Week 5 31 Oct 2022 | Week 6 7 Nov 2022 | Week 7 14 Nov 2022 | Week 8 21 Nov 2022 | Week 9 28 Nov 2022 | Week 10 5 Dec 2022 | Week 11 12 Dec 2022

Table B.1: Gantt Schema

The Gannt chart shows the rough outline of the project. Some of the key periods for the project as shown by the chart are: 4 sprints lasting 3 weeks each until December to create the project prototype, the testing and evaluation phase by mid January, and the overall polish phase by march if there is still time.

B.1 Iteration Cycles

In order to create the prototype, we decided to work in iteration cycles lasting 3 weeks long. It was decided that there should be 4 iterations cycles the first

half of the project.

Iteration 1: 17/10/22 - 04/11/22

Iteration 1 is mainly used for coming up with ideas and a plan on how to tackle the task. We contacted Paul Joachim, our stakeholder and inquired about the project in detail, and what he wants implemented. Using that, we came up with activities that we could perform.

Activities	**Description**
Import the model of Glassblokkene	Correct model imported into unity without bugs.
Implement UI elements	—
Add database for users	—
Add important items into the game	—
Create a hub world	A place where the user can connect to the game instance.

Iteration 2: 07/11/22 - 25/11/22

Iteration 2 was used to finish any unfinished features of iteration 1, such as importing the model and experimenting other features. In this iteration, we moved away from trying to set-up a database and focused on the functional elements.

Activities	**Description**
Import the model of Glassblokkene	Keep in contact with Adfectus about the new model, as the previous model was too big in size and had many bugs. —
Continue working on the editor	The editor would be a complex system of creating challenges.—
Finish challenge 1	Create the basic functionality of the first challenge.—
Add menu for different stages	Added a menu that displays the scenes in the unity build.—

Iteration 3: 28/11/22 - 16/12/22

Iteration 3 was used to continue working on previous sprints as well as updating the UI so far.

Activities	**Description**
Fix the player object so it is easier to interact with objects	
Add background sound to the hub world	—
Update main menu	—
Solution to play either VR or non-VR.	—

Iteration 4: 2/1/23 - 21/1/23

Iteration 4 was used to create the Dialogue System and the Main Menu as well as updating the Teddy Bear Challenge and the UI.

Activities	Description
Implement the Dialogue system	A system where the player can interact with a NPC read/listen to its dialogue lines and ask questions
Implement the Main Menu	When running the game the player will start at the main menu where the player can start the game.
Implement a sound manager	The player wish to have a soundtrack playing in the background
Add UI panels for the dialogue system	To read the dialogue line and choose a question to ask the player need UI elements for that

Development Phase: 23/1/23 - 5/5/23

This section includes iterations over several months.

Activities	Description
Add the model of the Hospital school	We wish to expand the game to include another important area and give relevant information about it to the player
Decorate the models with textures and furniture	We want the model to look alive, realistic and rememberable for the player
Implement a Game Dialogue System	We wish for a separate Dialogue System to play out when the player needs instruction for the challenges
Write dialogues	The Game Dialogue System needs dialogue lines
Fix bugs in Challenge 2	In the dialogue system there is a bug where dialogue line would not be received
Finnish CH1 Teddy Bear challenge	With the dialogue line, final 3D model of Teddy Bear and a fitting locations we want to set a finishing touch for this challenge
Create 3D avatars of the leaders of Barneposten and Hospital school	We wish that the player interact with a realistic human model
Update the player movement script	At a demo we experience bad player movement after export the project and running it on another computer. We need to fix that
Implement a function to teleport between each floor	We wish for an easy solution to navigate between Barneposten and Hospital School
Create a transition when using the elevator	We wish to have a smooth transition when navigating between floors
Challenge 4, write dialogue for the hospital school leader	We wish for the player to interact with the hospital school leader
Challenge 5, add a Teddy Bear challenge for hospital school area	We want the player to explore the different rooms in the Hospital School
Challenge 3, Control Commission	We wish to give the player information about the guidelines from the Control Commission
Add a tutorial area	We wish to give the player instruction on how to play the game
Update the new features with VR too	—
Create a Journal which contains an overview of the challenges	We wish that the player should have access to information about the challenges, and choose to redo them with a click of a button

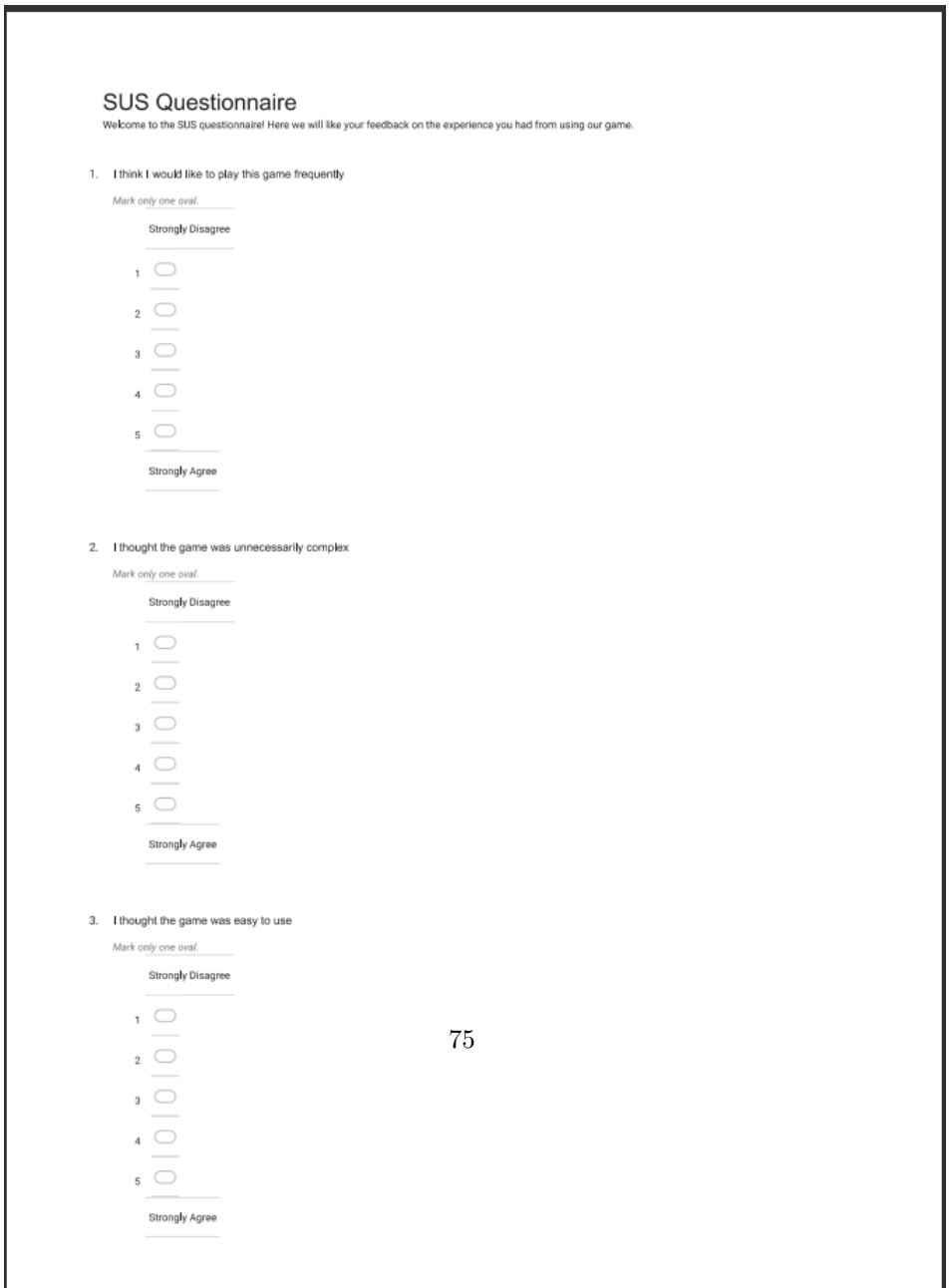
This table includes fun to have activities.

Activities	**Description**
Implement a function to open doors	Make the player to open specific doors
Add a cursor	Help the player pointing at buttons
Create buildings/structures	Make the scene feel more alive instead of an empty scene
Add terrain	Make the scene feel more alive instead of an empty scene
Make the game playable on tablets and phones	Expand the project so it works with other units such as tablets and phones

Appendix C

Questionnaires

C.0.1 SUS Questionnaire, Pre-Visit Questionnaire and Post-Visit Questionnaire



SUS Questionnaire

Welcome to the SUS questionnaire! Here we will like your feedback on the experience you had from using our game.

1. I think I would like to play this game frequently

Mark only one oval.

Strongly Disagree

1 ○
2 ○
3 ○
4 ○
5 ○

Strongly Agree

2. I thought the game was unnecessarily complex

Mark only one oval.

Strongly Disagree

1 ○
2 ○
3 ○
4 ○
5 ○

Strongly Agree

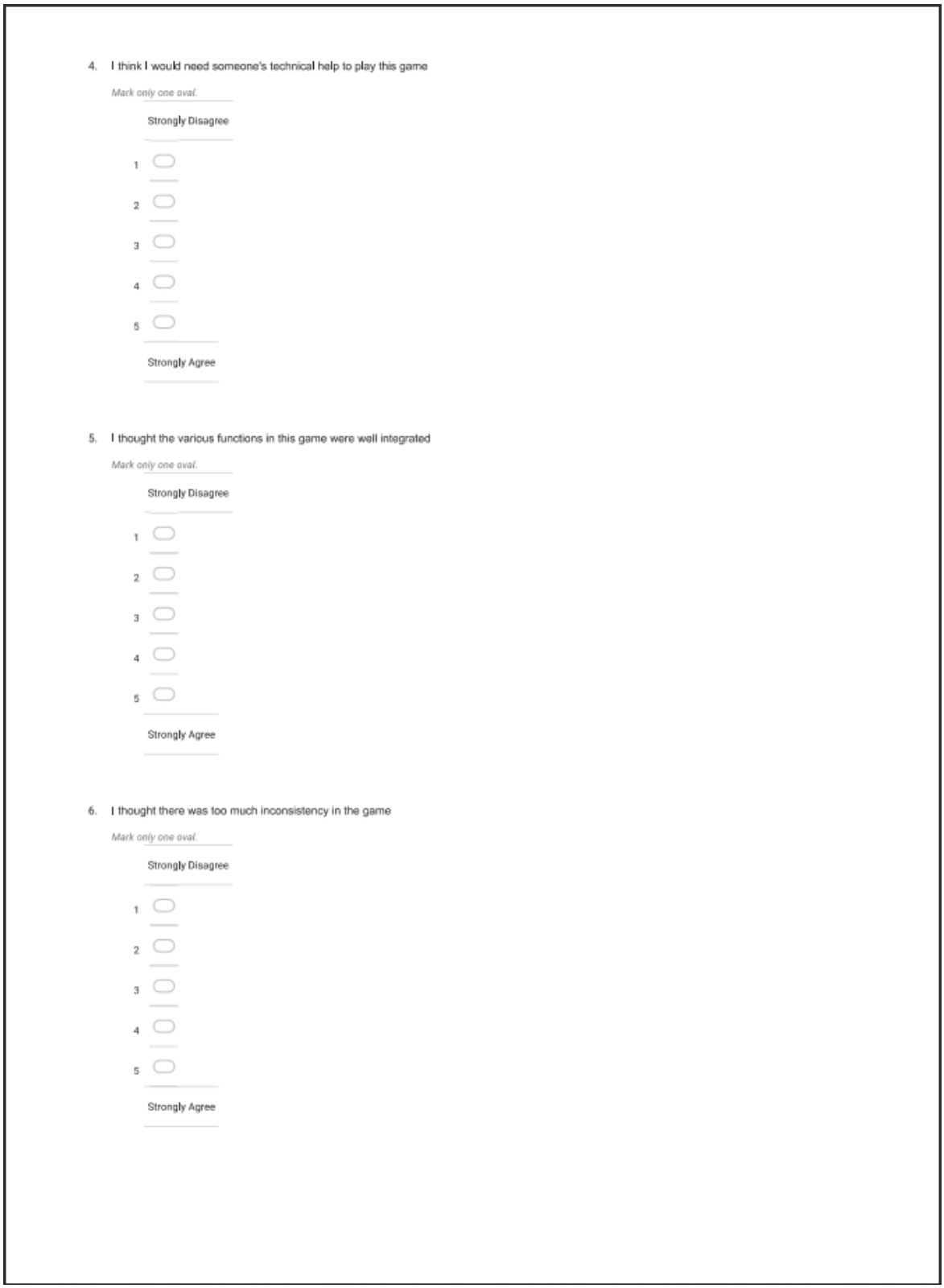
3. I thought the game was easy to use

Mark only one oval.

Strongly Disagree

1 ○
2 ○
3 ○
4 ○
5 ○

Strongly Agree



4. I think I would need someone's technical help to play this game

Mark only one oval.

Strongly Disagree

1 ○
2 ○
3 ○
4 ○
5 ○

Strongly Agree

5. I thought the various functions in this game were well integrated

Mark only one oval.

Strongly Disagree

1 ○
2 ○
3 ○
4 ○
5 ○

Strongly Agree

6. I thought there was too much inconsistency in the game

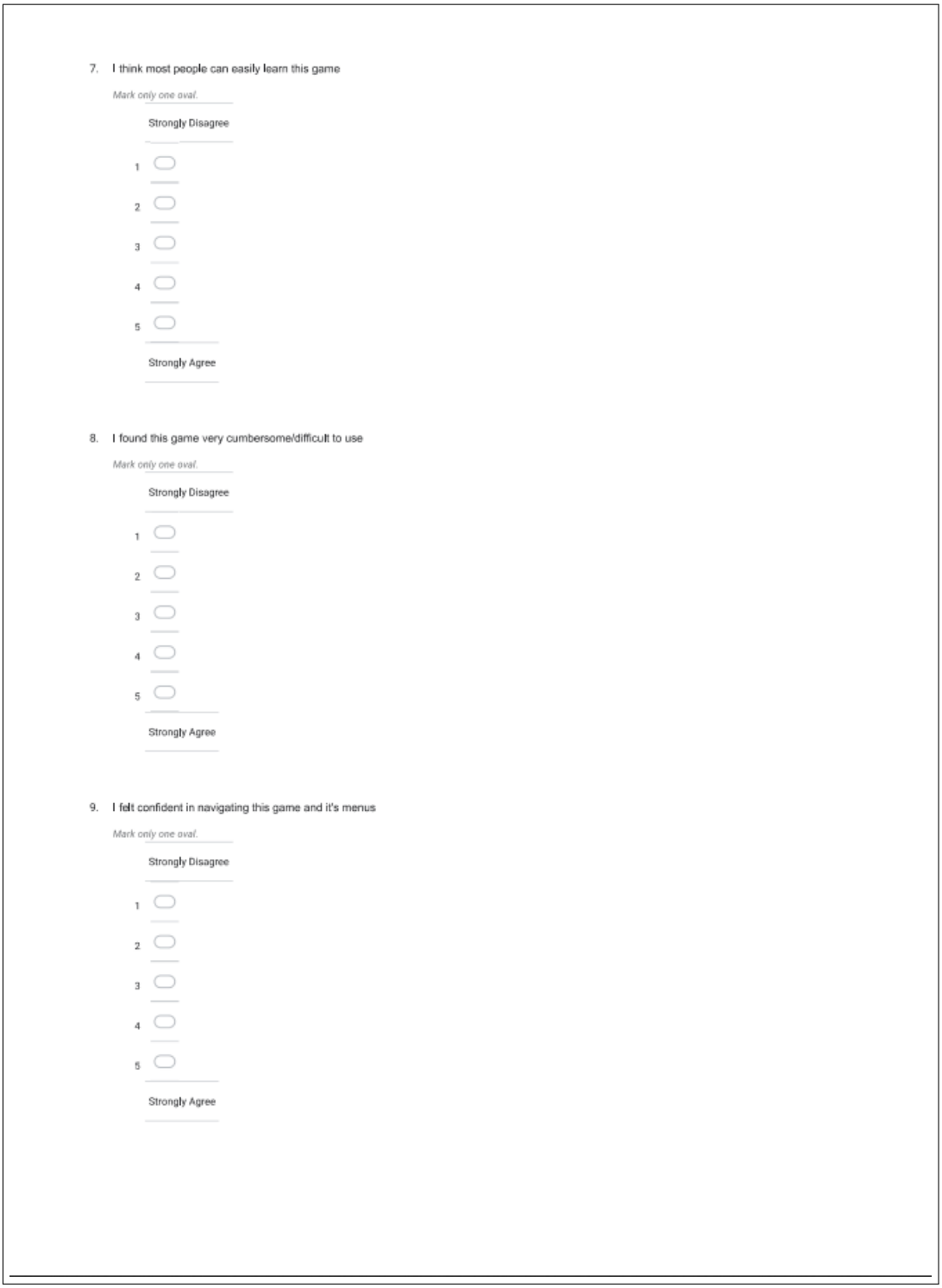
Mark only one oval.

Strongly Disagree

1 ○
2 ○
3 ○
4 ○
5 ○

Strongly Agree

Figure C.2: Page 2 of SUS Questionnaire


7. I think most people can easily learn this game

Mark only one oval.

Strongly Disagree

1 ○

2 ○

3 ○

4 ○

5 ○

Strongly Agree

8. I found this game very cumbersome/difficult to use

Mark only one oval.

Strongly Disagree

1 ○

2 ○

3 ○

4 ○

5 ○

Strongly Agree

9. I felt confident in navigating this game and it's menus

Mark only one oval.

Strongly Disagree

1 ○

2 ○

3 ○

4 ○

5 ○

Strongly Agree

Figure C.3: Page 3 of SUS Questionnaire

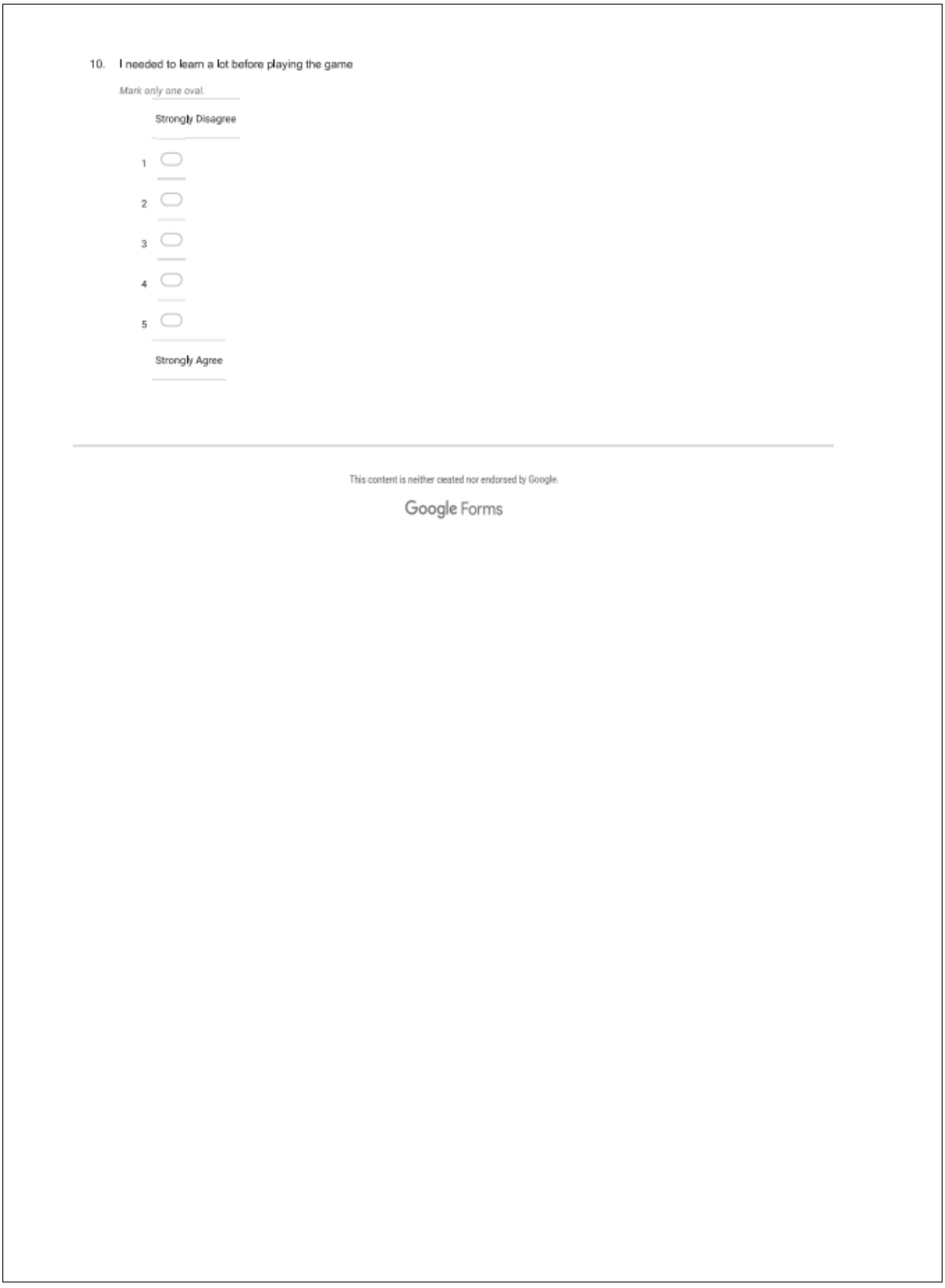
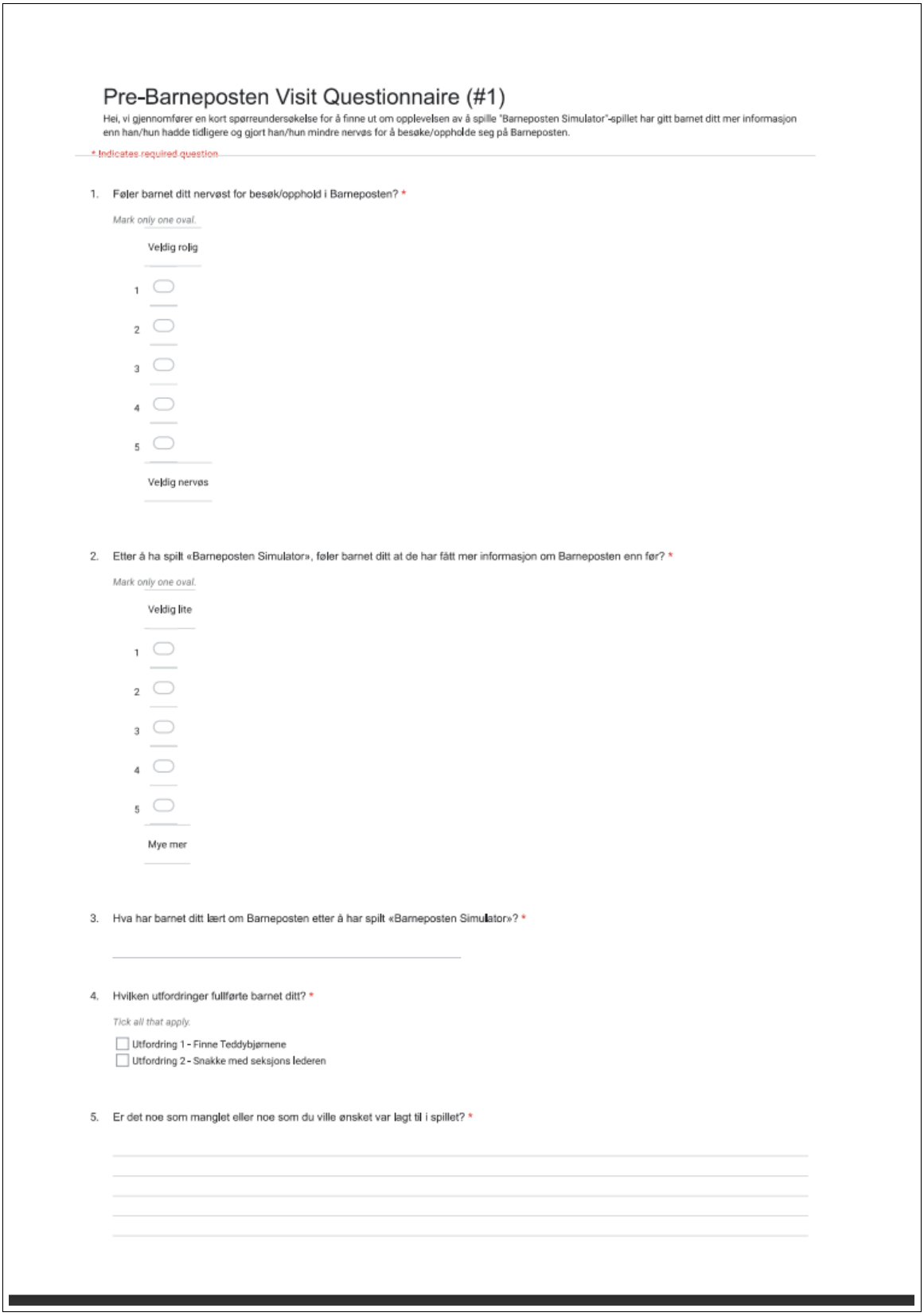


Figure C.4: Page 4 of SUS Questionnaire



Pre-Barneposten Visit Questionnaire (#1)

Hei, vi gjennomfører en kort spørreundersøkelse for å finne ut om opplevelsen av å spille "Barneposten Simulator"-spillet har gitt barnet ditt mer informasjon enn han/hun hadde tidligere og gjort han/hun mindre nervøs for å besøke/oppholde seg på Barneposten.

* Indicates required question

1. Føler barnet ditt nervøst for besøk/opphold i Barneposten? *

Mark only one oval.

Veldig rolig

1 ◯
2 ◯
3 ◯
4 ◯
5 ◯

Veldig nervøs

2. Etter å ha spilt «Barneposten Simulator», føler barnet ditt at de har fått mer informasjon om Barneposten enn før? *

Mark only one oval.

Veldig lite

1 ◯
2 ◯
3 ◯
4 ◯
5 ◯

Mye mer

3. Hva har barnet ditt lært om Barneposten etter å har spilt «Barneposten Simulator»? *

4. Hvilken utfordringer fullførte barnet ditt? *

Tick all that apply.

☐ Utfordring 1 - Finne Teddybjørnene
☐ Utfordring 2 - Snakke med seksjons lederen

5. Er det noe som manglet eller noe som du ville ønsket var lagt til i spillet? *

Figure C.5: Page 1 of Pre-Visit Questionnaire

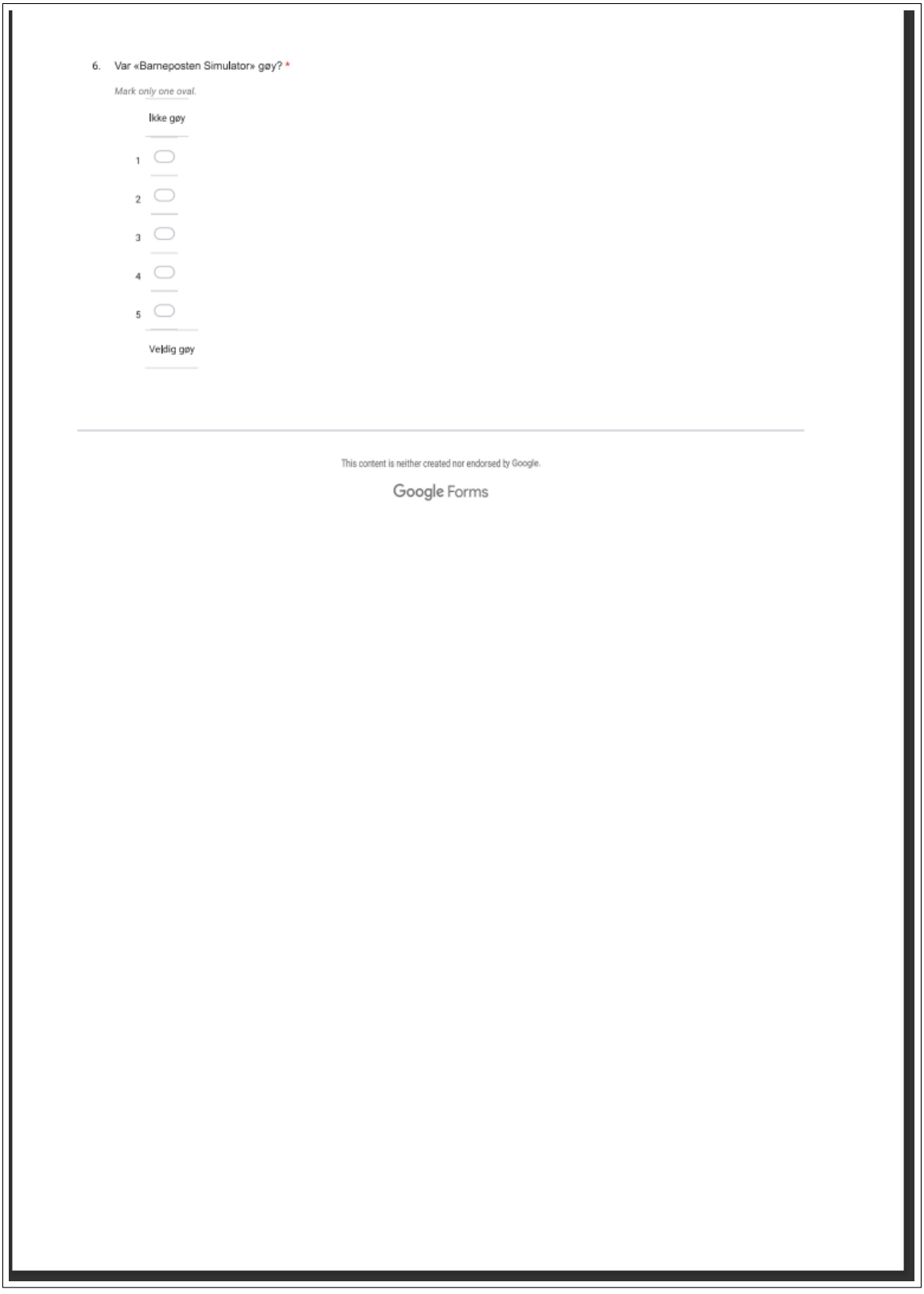
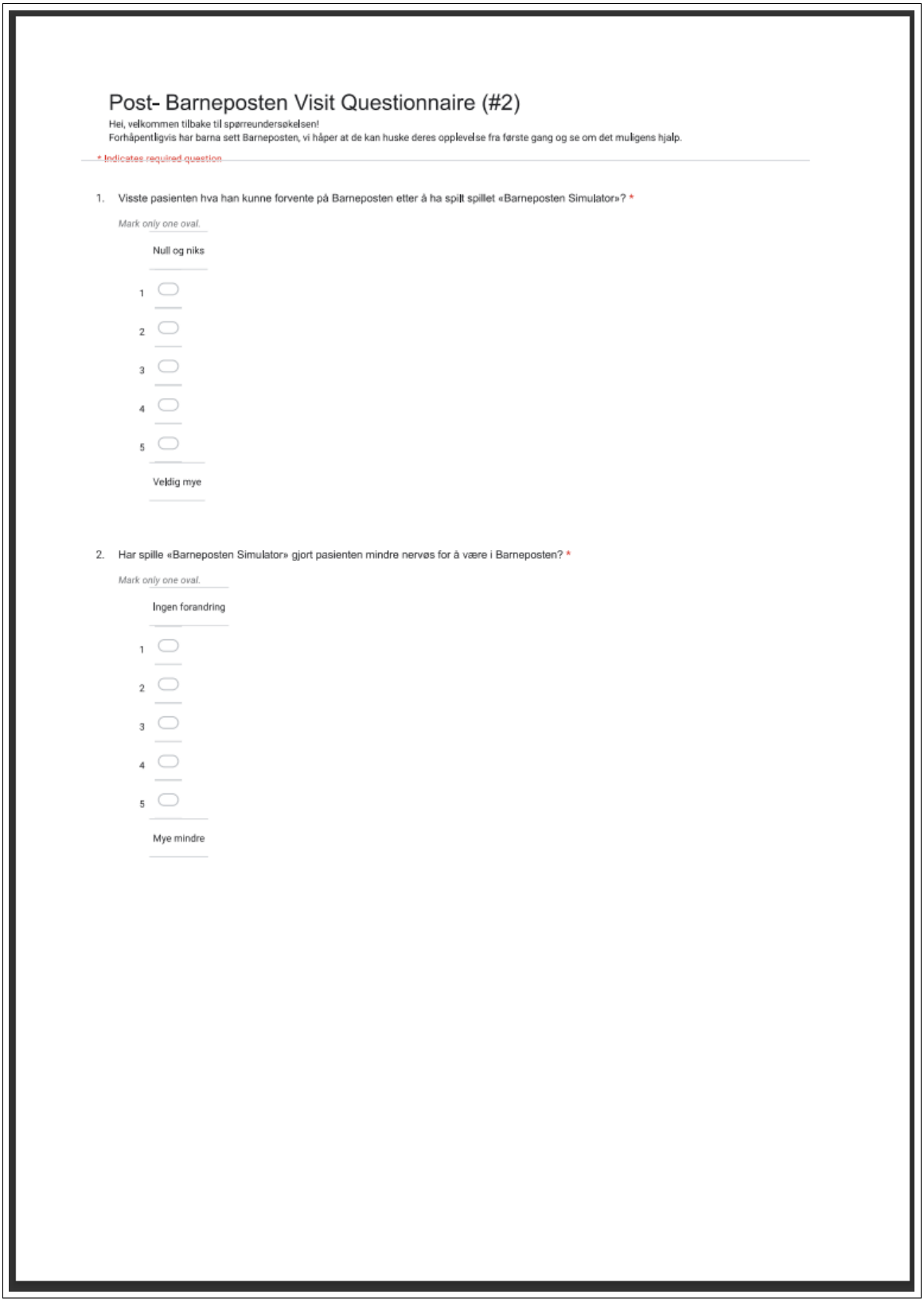


Figure C.6: Page 2 of Pre-Visit Questionnaire



Post- Barneposten Visit Questionnaire (#2)

Hei, velkommen tilbake til spørreundersøkelsen!
Forhåpentligvis har barna sett Barneposten, vi håper at de kan huske deres opplevelse fra første gang og se om det muligens hjalp.

* Indicates required question

1. Visste pasienten hva han kunne forvente på Barneposten etter å ha spilt spillet «Barneposten Simulator»? *

Mark only one oval.

Null og niks

1 ◯
2 ◯
3 ◯
4 ◯
5 ◯

Veldig mye

2. Har spille «Barneposten Simulator» gjort pasienten mindre nervøs for å være i Barneposten? *

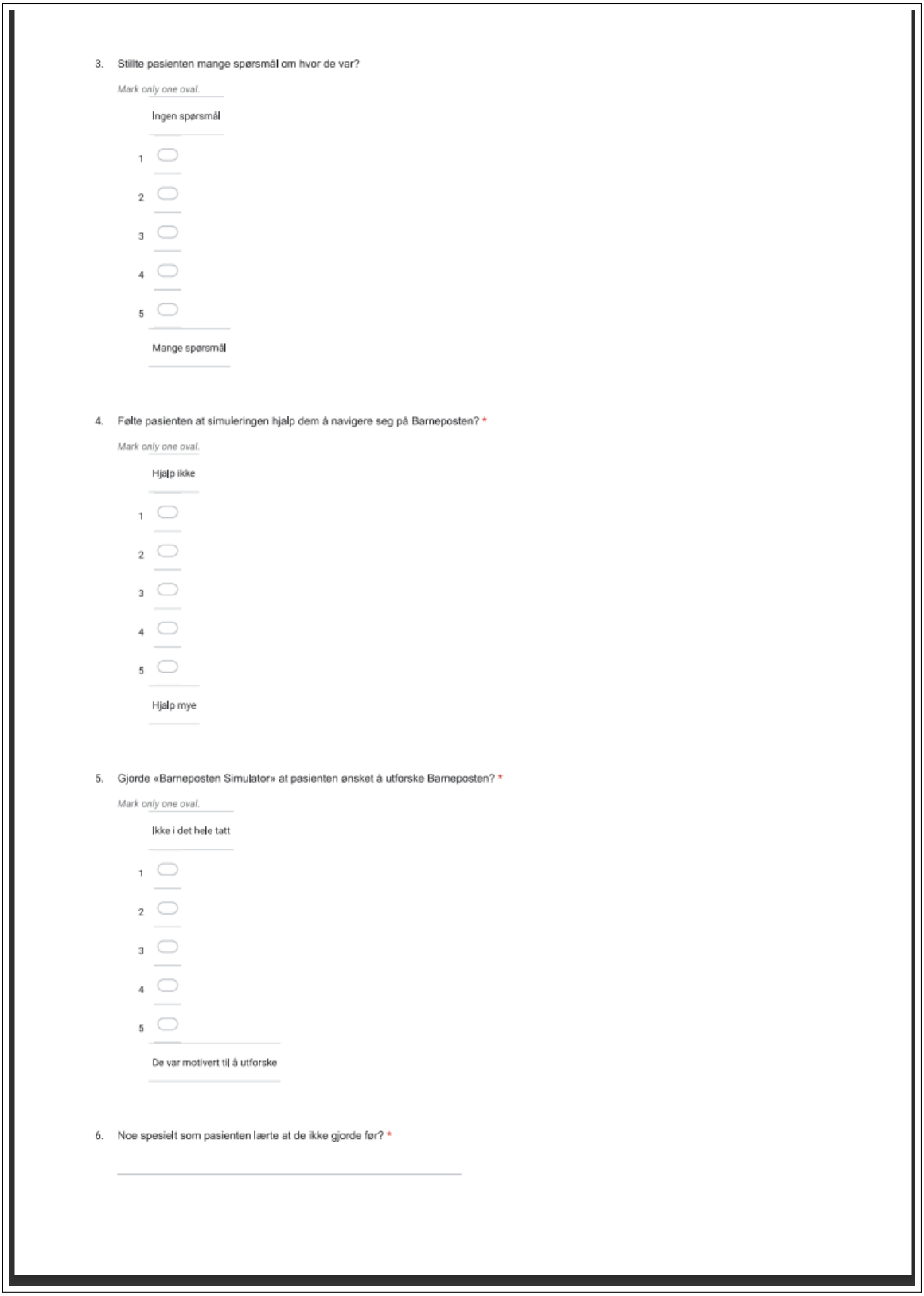
Mark only one oval.

Ingen forandring

1 ◯
2 ◯
3 ◯
4 ◯
5 ◯

Mye mindre

Figure C.7: Page 1 of Post-Visit Questionnaire



3. Stillte pasienten mange spørsmål om hvor de var?

Mark only one oval.

Ingen spørsmål

1 ○
2 ○
3 ○
4 ○
5 ○

Mange spørsmål

4. Følte pasienten at simuleringen hjalp dem å navigere seg på Barneposten? *

Mark only one oval.

Hjalp ikke

1 ○
2 ○
3 ○
4 ○
5 ○

Hjalp mye

5. Gjorde «Barneposten Simulator» at pasienten ønsket å utforske Barneposten? *

Mark only one oval.

Ikke i det hele tatt

1 ○
2 ○
3 ○
4 ○
5 ○

De var motivert til å utforske

6. Noe spesielt som pasienten lærte at de ikke gjorde før? *

Figure C.8: Page 2 of Post-Visit Questionnaire

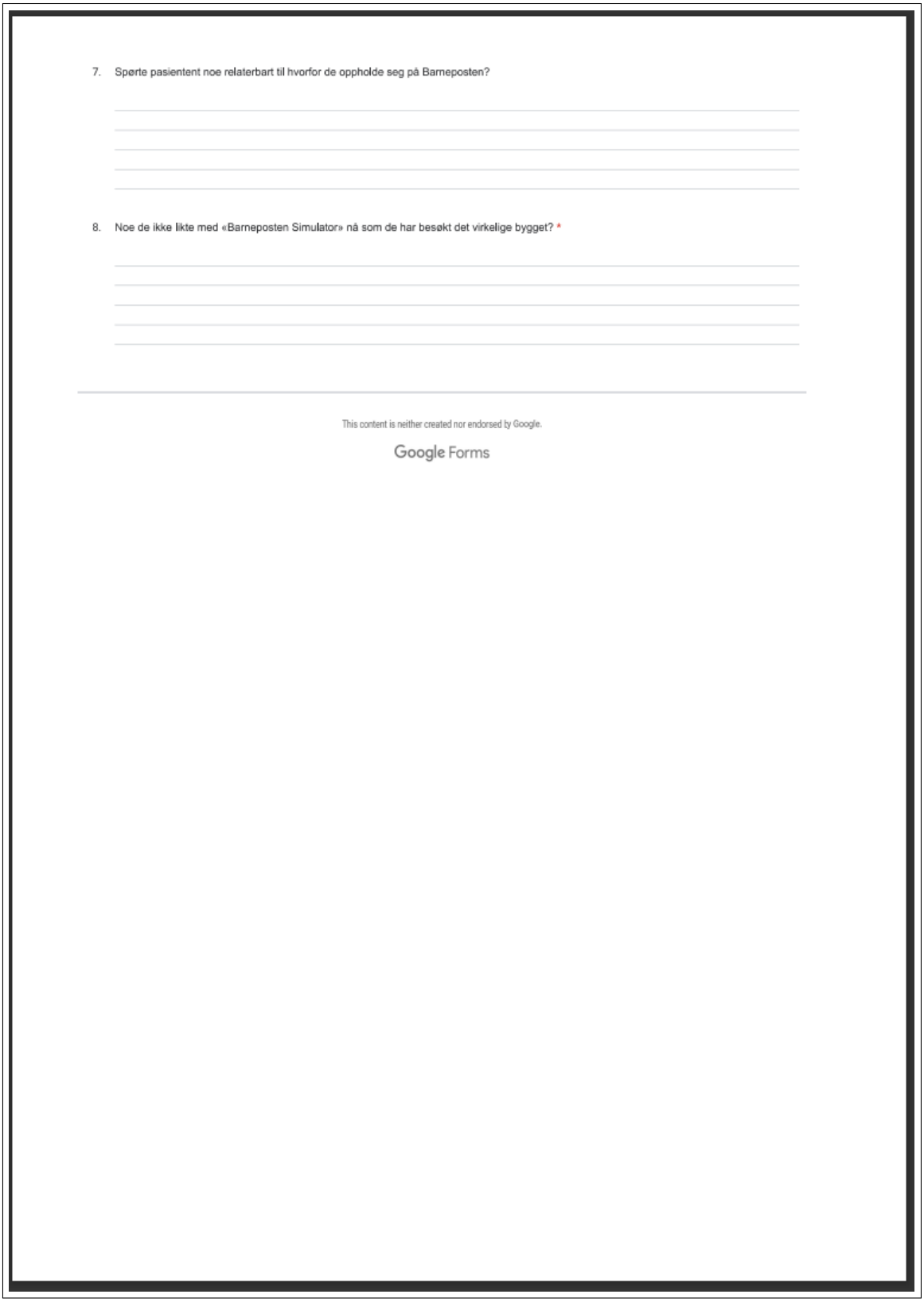


Figure C.9: Page 3 of Post-Visit Questionnaire

C.0.2 SUS Questionnaire Answers

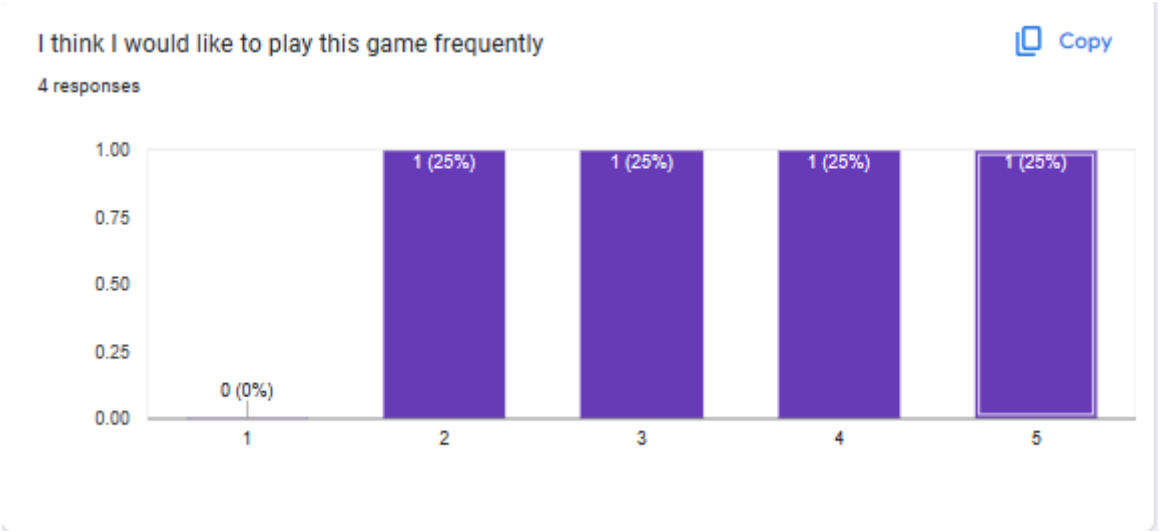


Figure C.10: Question 1

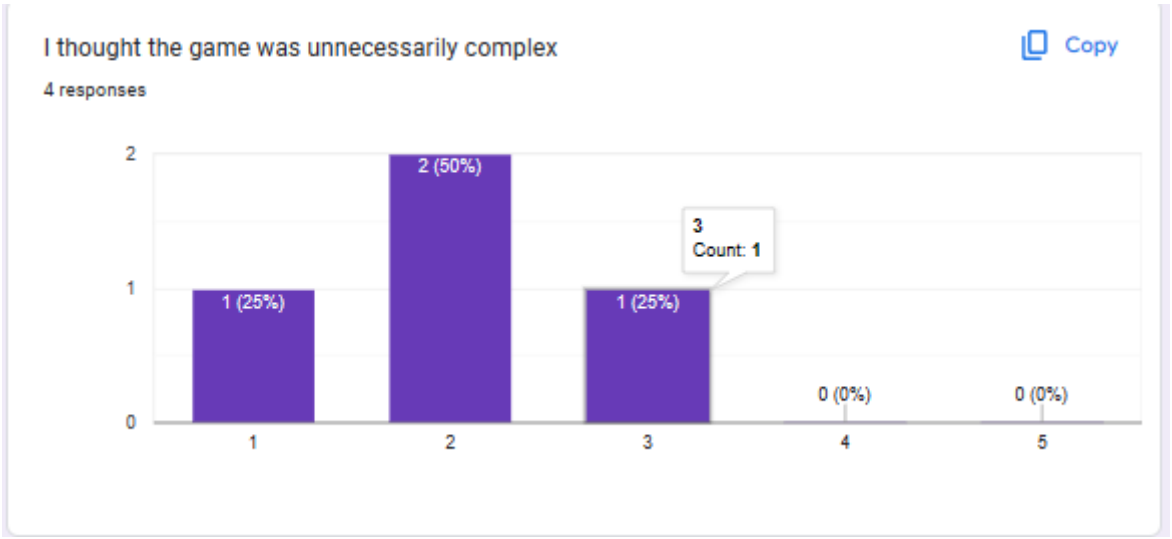


Figure C.11: Question 2

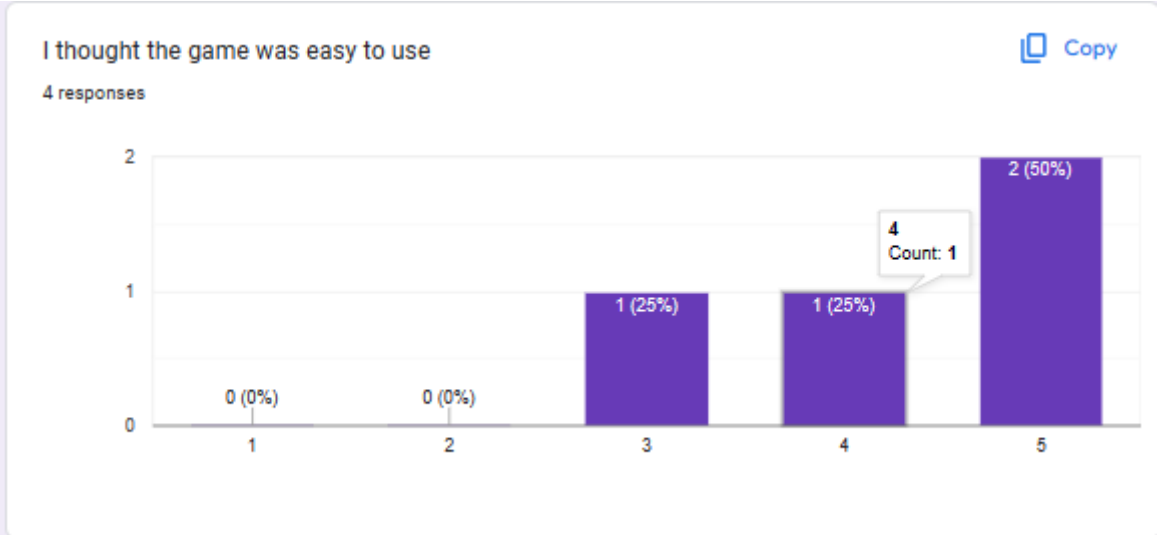


Figure C.12: Question 3

Figure C.13: Question 4

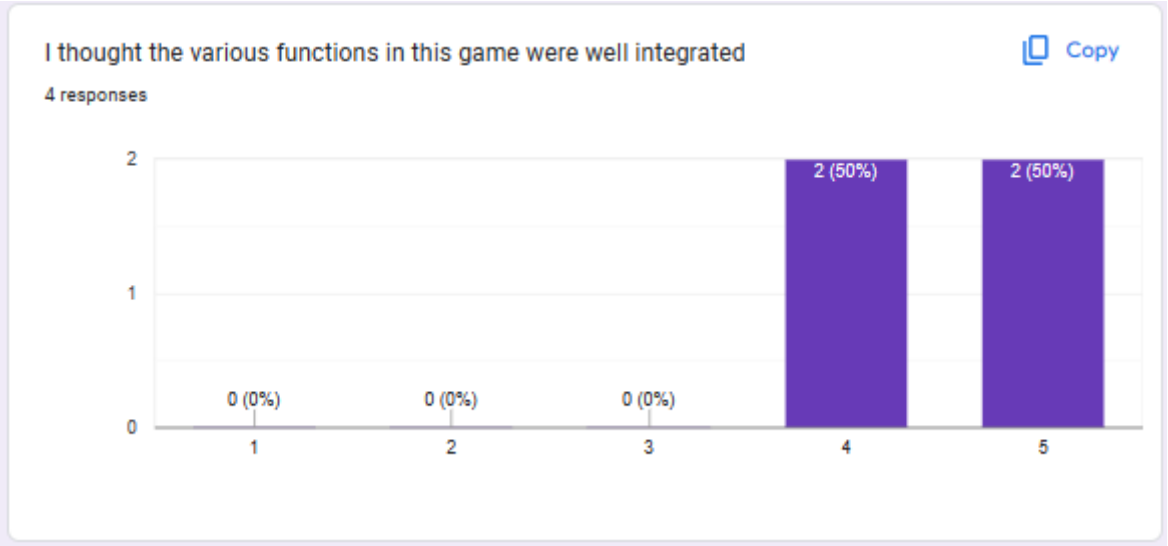


Figure C.14: Question 5

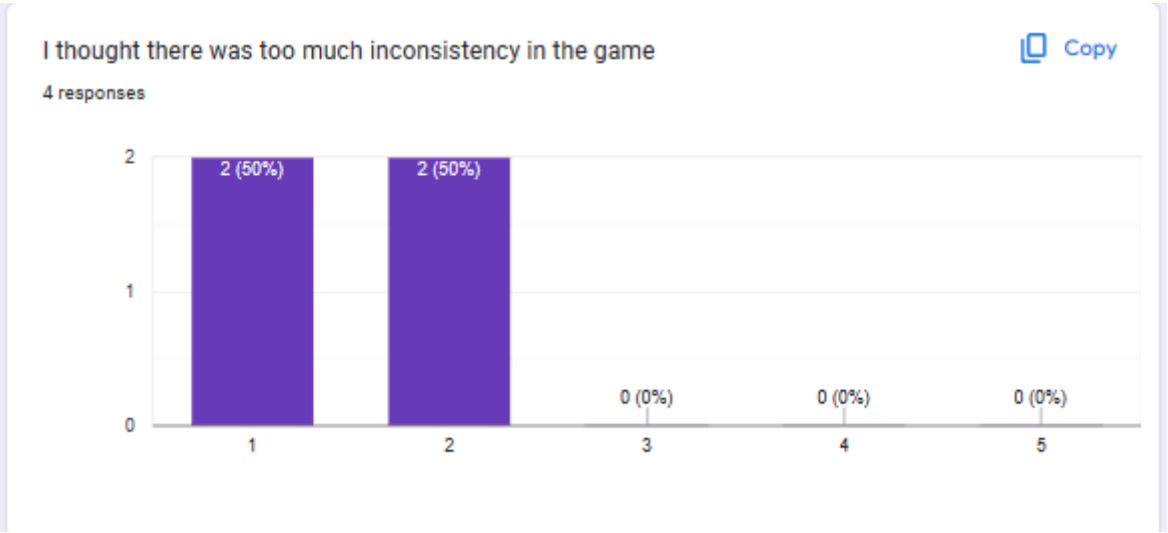


Figure C.15: Question 6

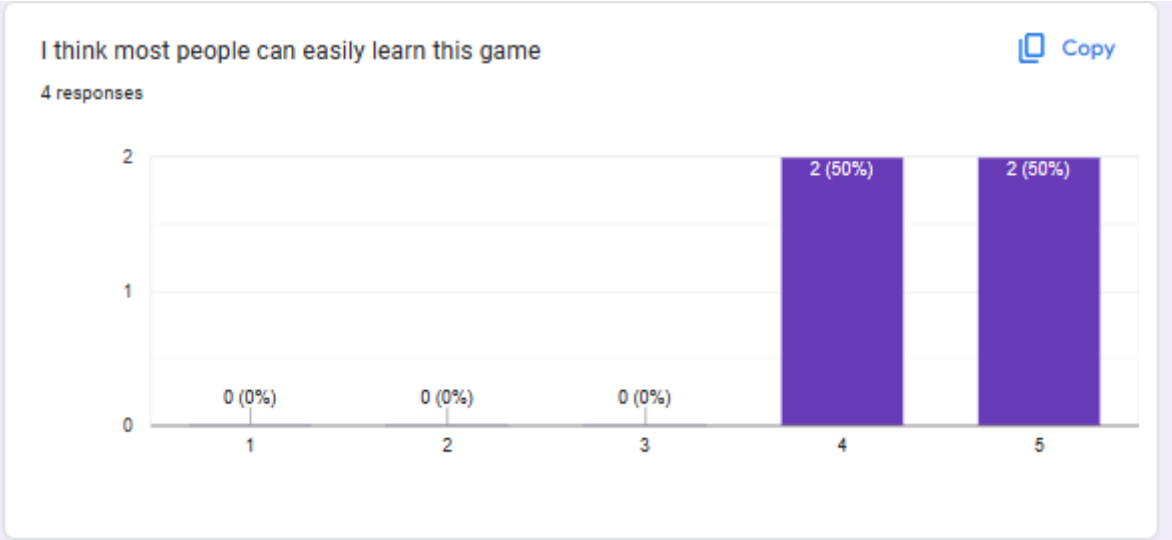


Figure C.16: Question 7

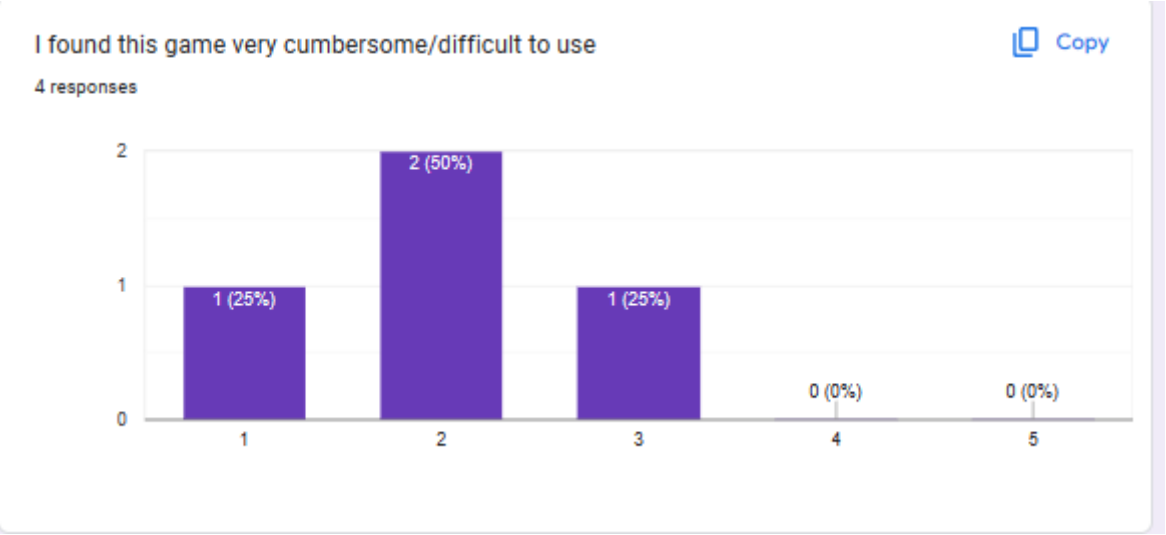


Figure C.17: Question 8

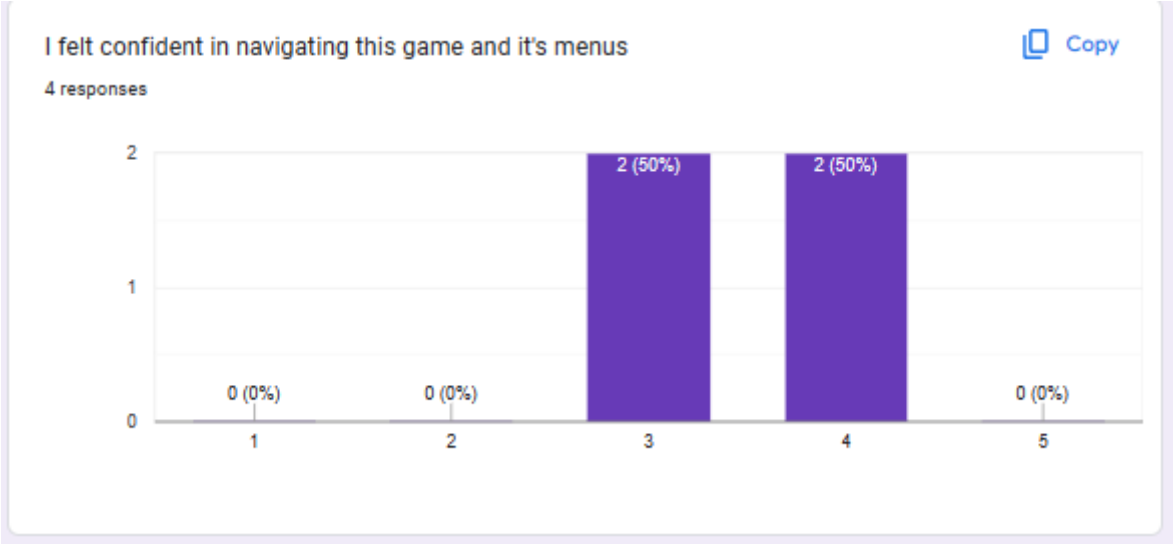


Figure C.18: Question 9

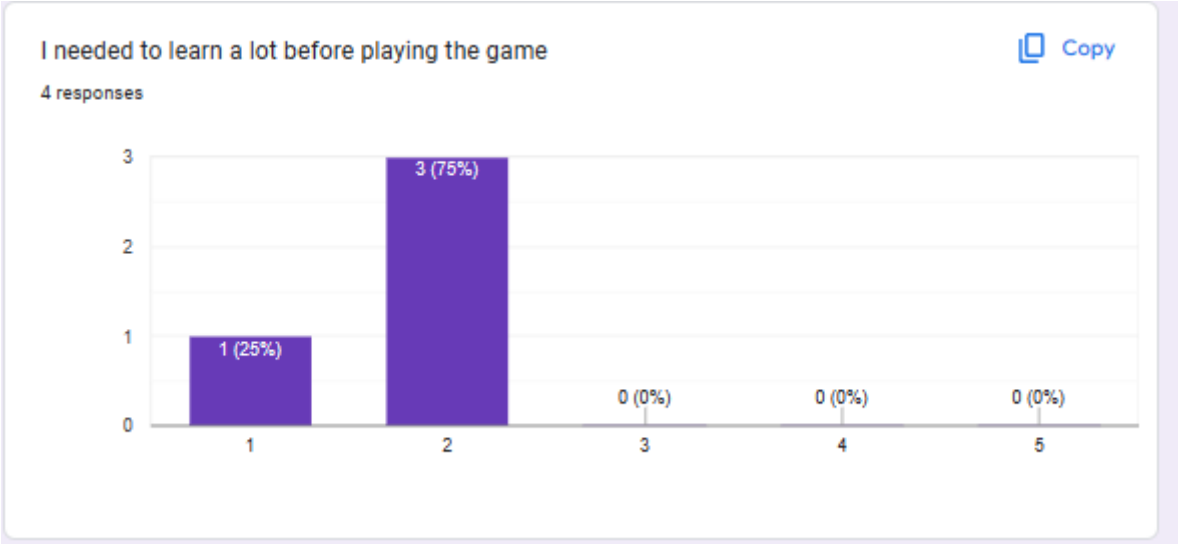
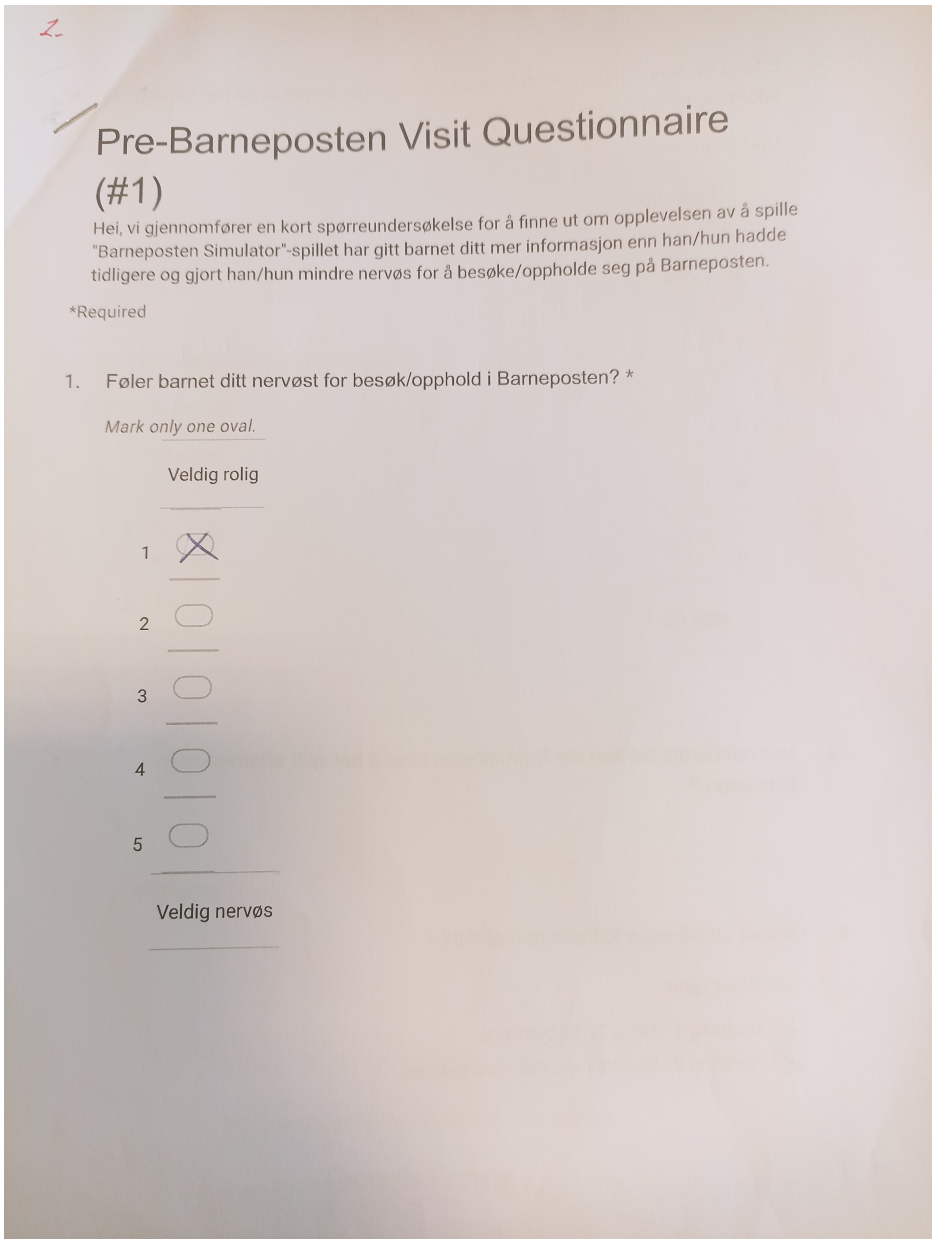


Figure C.19: Question 10

C.0.3 Questionnaire Results

Pre-Visit Results



Pre-Barneposten Visit Questionnaire (#1)

Hei, vi gjennomfører en kort spørreundersøkelse for å finne ut om opplevelsen av å spille "Barneposten Simulator"-spillet har gitt barnet ditt mer informasjon enn han/hun hadde tidligere og gjort han/hun mindre nervøs for å besøke/oppholde seg på Barneposten.

*Required

1. Føler barnet ditt nervøst for besøk/opphold i Barneposten? *

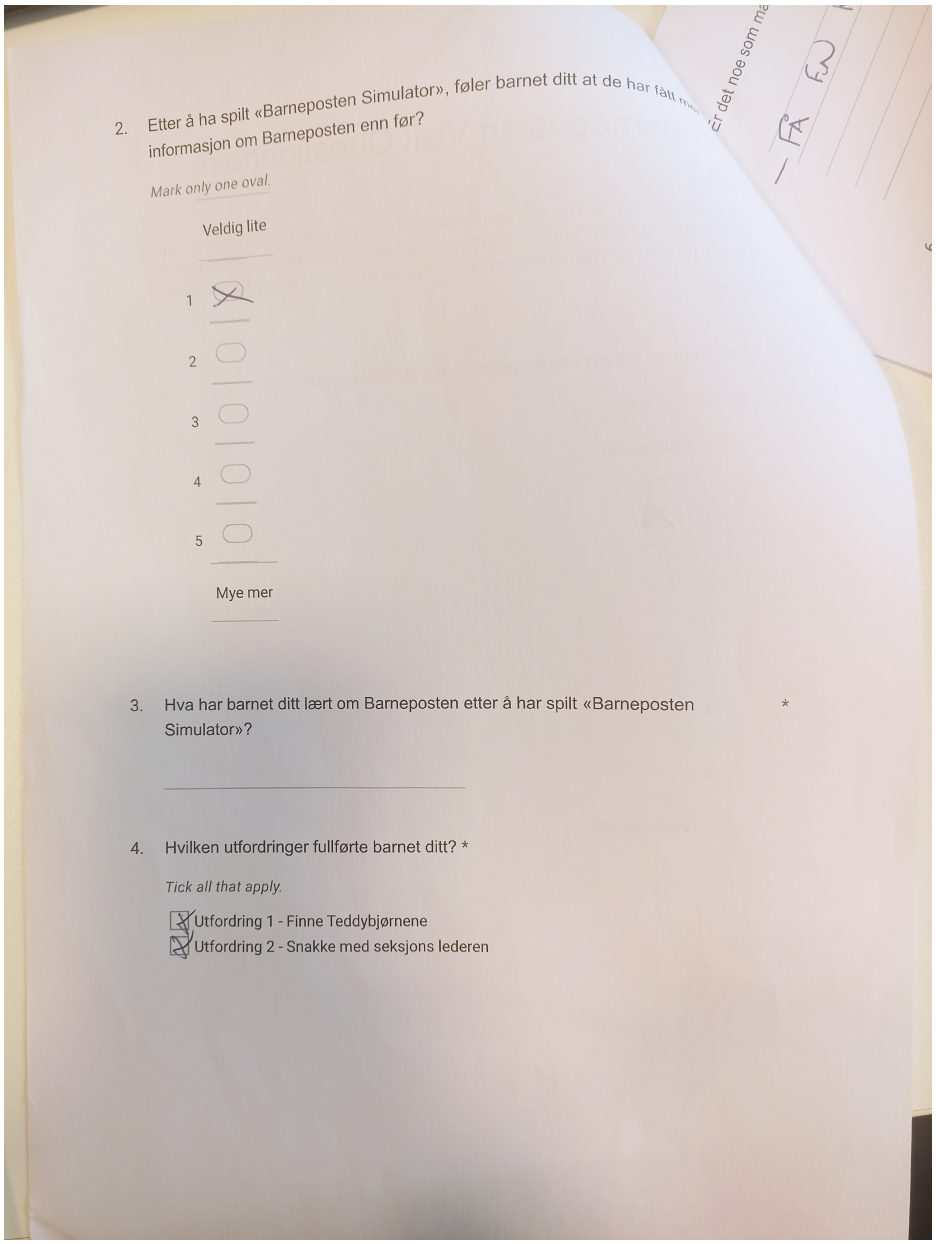
Mark only one oval.

Veldig rolig

1 (X)
2 ( )
3 ( )
4 ( )
5 ( )

Veldig nervøs

Figure C.20: Participant 1: Page 1



2. Etter å ha spilt «Barneposten Simulator», føler barnet ditt at de har fått mer informasjon om Barneposten enn før?

Mark only one oval.

Veldig lite
1 X
2 O
3 O
4 O
5 O
Mye mer

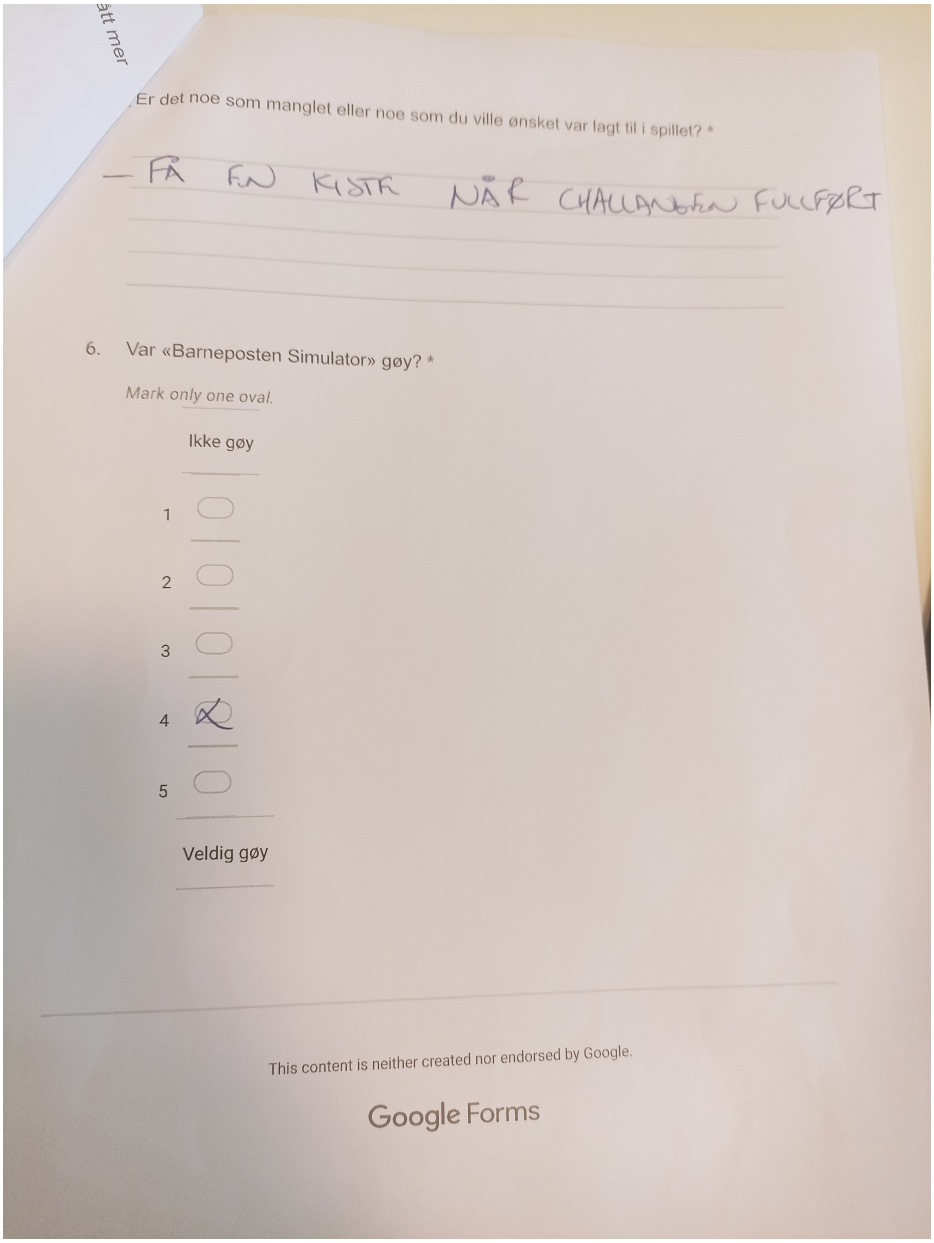
3. Hva har barnet ditt lært om Barneposten etter å har spilt «Barneposten Simulator»? *

4. Hvilken utfordringer fullførte barnet ditt? *

Tick all that apply.

- [x] Utfordring 1 - Finne Teddybjørnene
- [x] Utfordring 2 - Snakke med seksjons lederen

Figure C.21: Participant 1: Page 2



ått mer

Er det noe som manglet eller noe som du ville ønsket var lagt til i spillet? *

— FÅ FÅ KISTE NÅR CHALLANGEN FULLFØRT

6. Var «Barneposten Simulator» gøy? *

Mark only one oval.

Ikke gøy

1

2

3

4

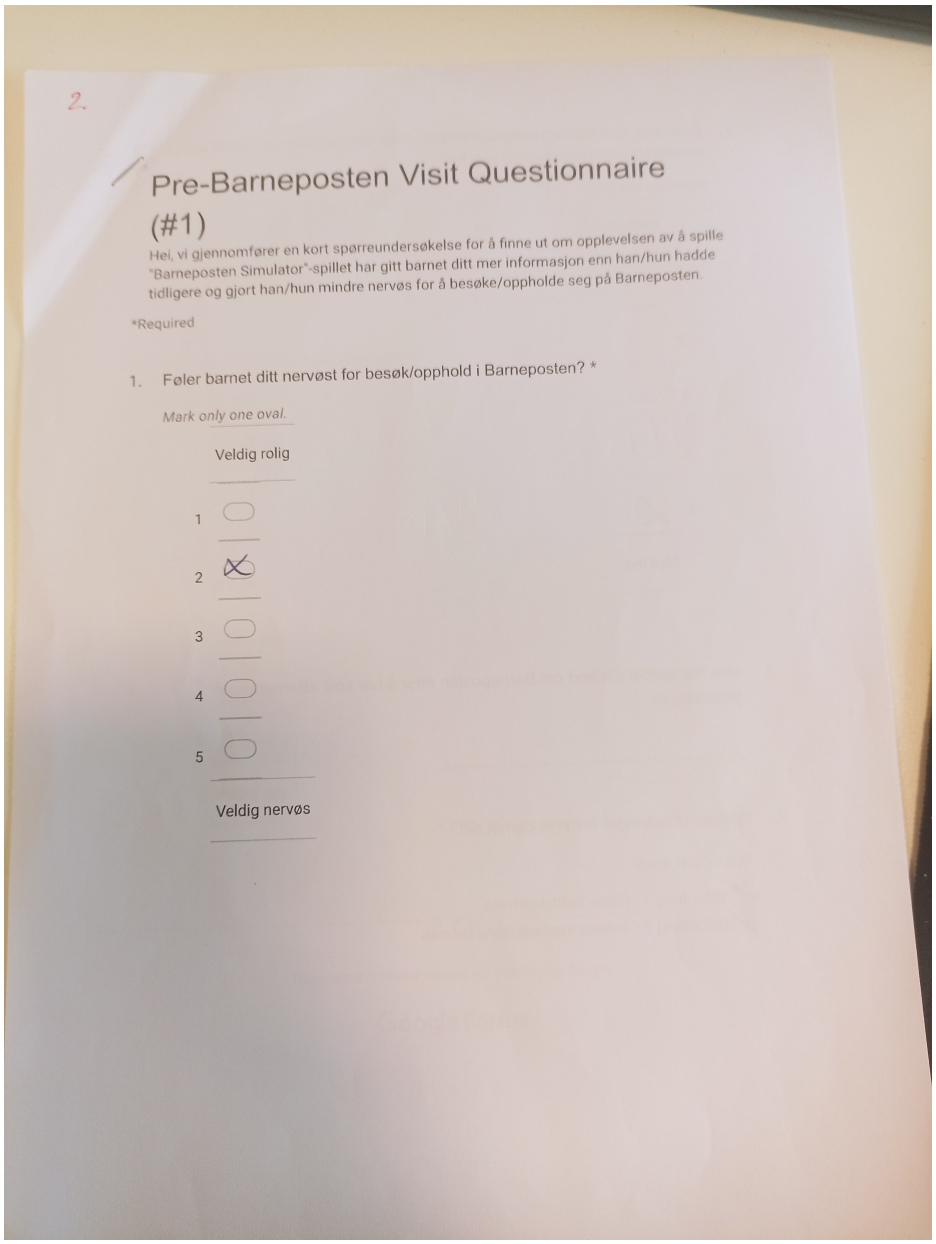
5

Veldig gøy

This content is neither created nor endorsed by Google.

Google Forms

Figure C.22: Participant 1: Page 3



2.

Pre-Barneposten Visit Questionnaire (#1)

Hei, vi gjennomfører en kort spørreundersøkelse for å finne ut om opplevelsen av å spille "Barneposten Simulator"-spillet har gitt barnet ditt mer informasjon enn han/hun hadde tidligere og gjort han/hun mindre nervøs for å besøke/oppholde seg på Barneposten.

*Required

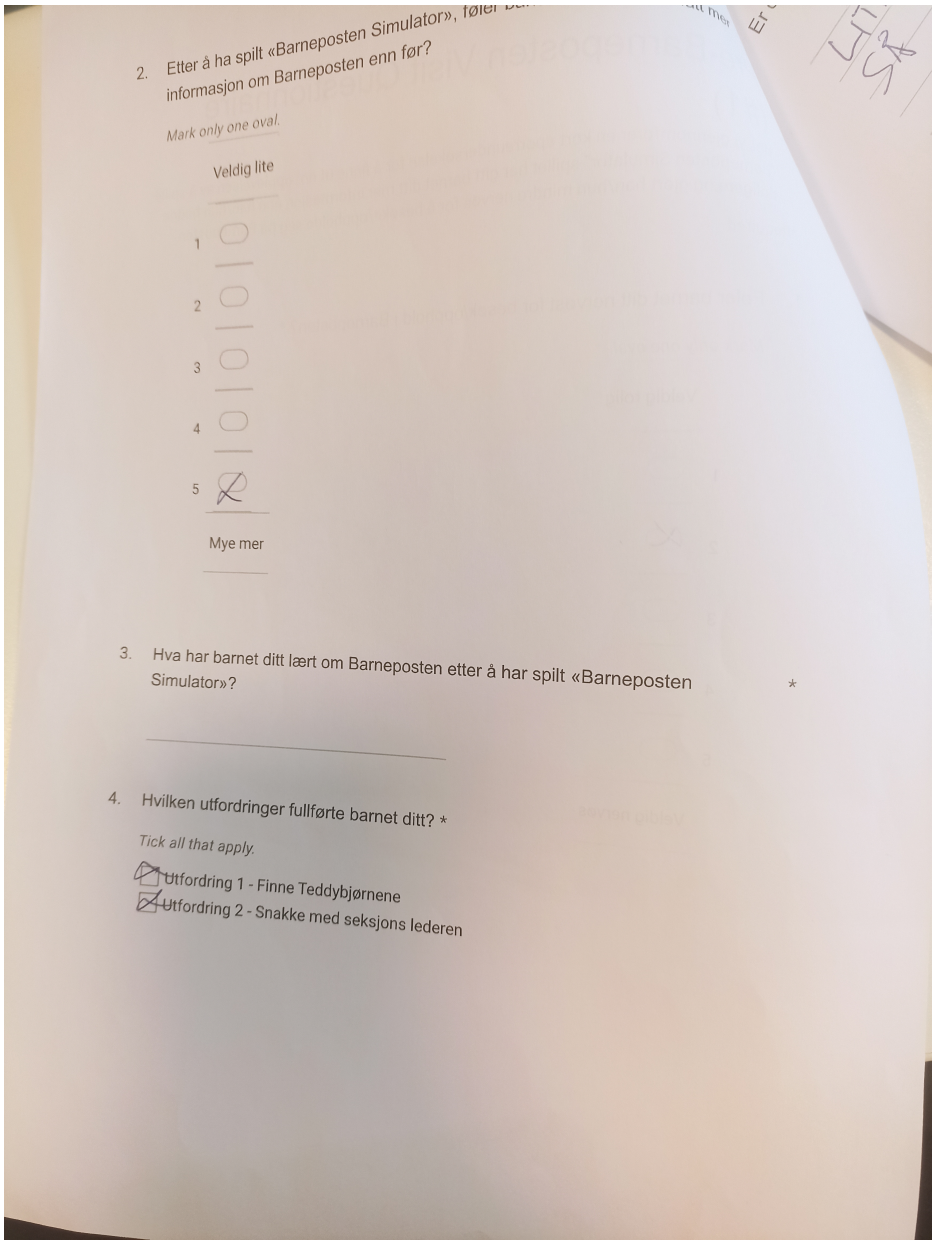
1. Føler barnet ditt nervøst for besøk/opphold i Barneposten? *

Mark only one oval.

Veldig rolig

1 ○
2 ☒
3 ○
4 ○
5 ○

Veldig nervøs



2. Etter å ha spilt «Barneposten Simulator», føler ... informasjon om Barneposten enn før?

Mark only one oval.

Veldig lite

1 ○
2 ○
3 ○
4 ○
5 ✓

Mye mer

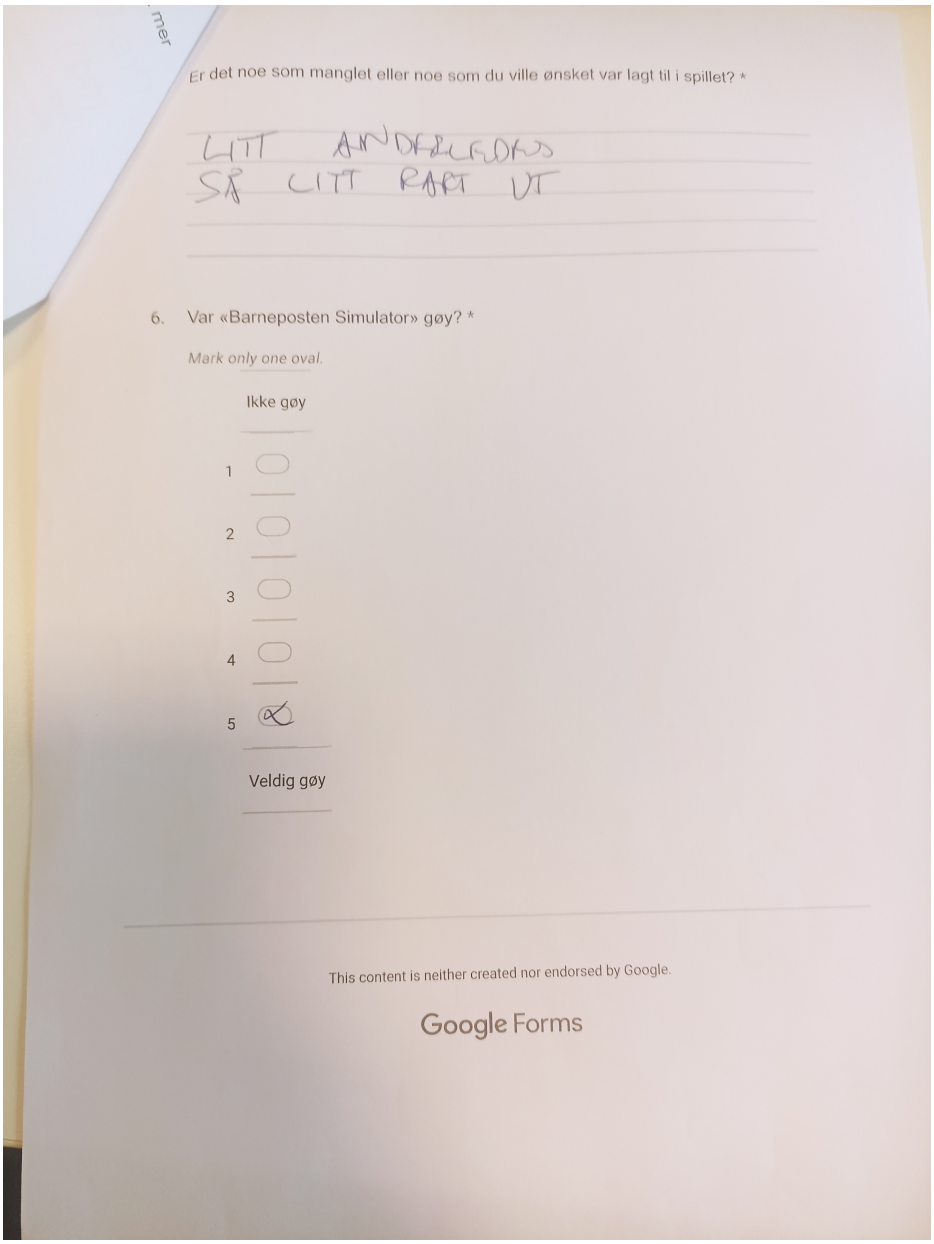
3. Hva har barnet ditt lært om Barneposten etter å har spilt «Barneposten Simulator»? *

4. Hvilken utfordringer fullførte barnet ditt? *

Tick all that apply.

☐ Utfordring 1 - Finne Teddybjørnene
☑ Utfordring 2 - Snakke med seksjons lederen

Figure C.24: Participant 2: Page 2



Er det noe som manglet eller noe som du ville ønsket var lagt til i spillet? *

LITT ANDRELUDS
SÅ LITT RART UT

6. Var «Barneposten Simulator» gøy? *

Mark only one oval.

Ikke gøy

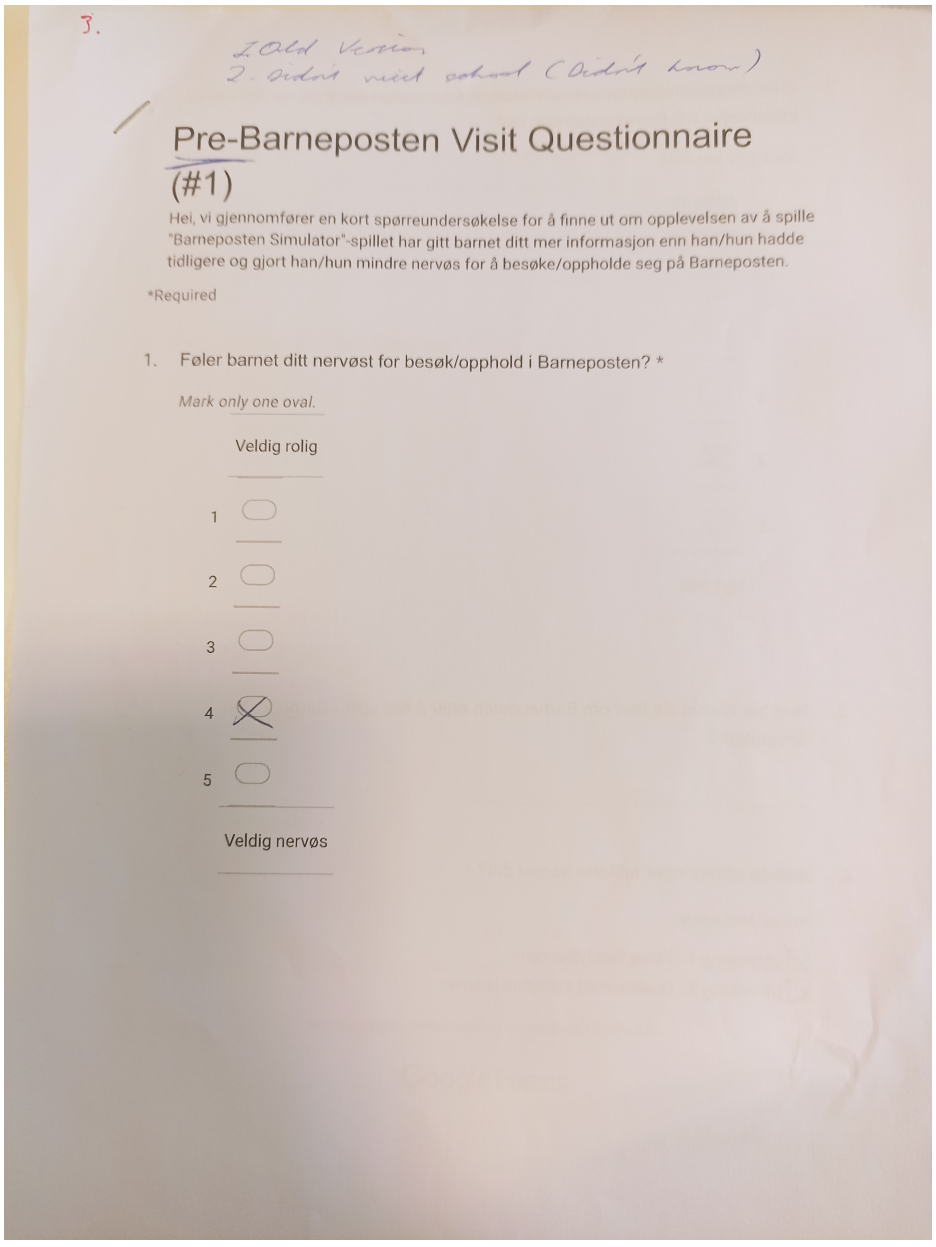
1
2
3
4
5

Veldig gøy

This content is neither created nor endorsed by Google.

Google Forms

Figure C.25: Participant 2: Page 3



3.

2. Old Version
2. didnt visit school (didn't know)

Pre-Barneposten Visit Questionnaire (#1)

Hei, vi gjennomfører en kort spørreundersøkelse for å finne ut om opplevelsen av å spille "Barneposten Simulator"-spillet har gitt barnet ditt mer informasjon enn han/hun hadde tidligere og gjort han/hun mindre nervøs for å besøke/oppholde seg på Barneposten.

*Required

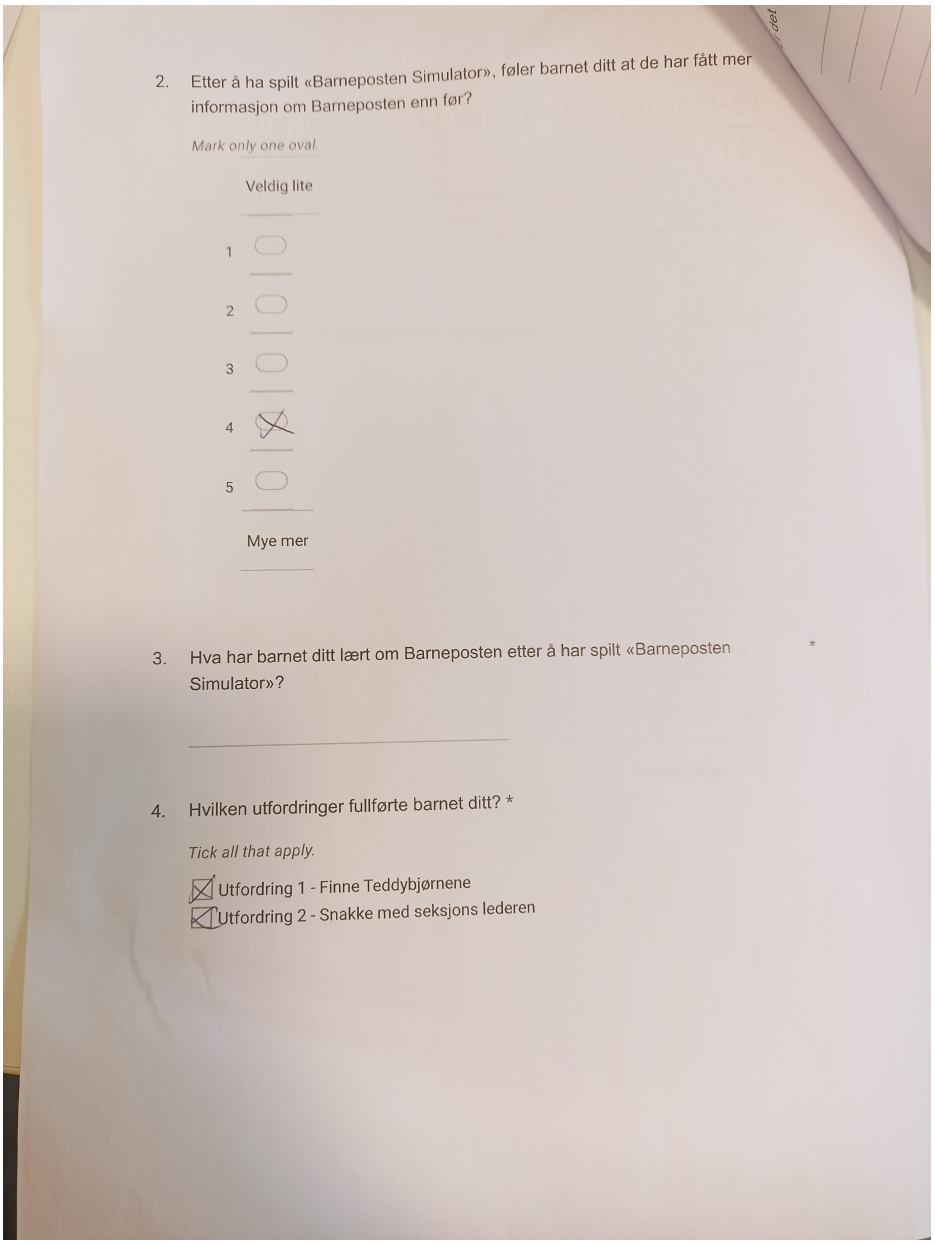
1. Føler barnet ditt nervøst for besøk/opphold i Barneposten? *

Mark only one oval.

Veldig rolig

1 ○
2 ○
3 ○
4 ⊗
5 ○

Veldig nervøs



2. Etter å ha spilt «Barneposten Simulator», føler barnet ditt at de har fått mer informasjon om Barneposten enn før?

Mark only one oval.

Veldig lite

1 ◯

2 ◯

3 ◯

4 ⊗

5 ◯

Mye mer

3. Hva har barnet ditt lært om Barneposten etter å har spilt «Barneposten Simulator»? *

4. Hvilken utfordringer fullførte barnet ditt? *

Tick all that apply.

☒ Utfordring 1 - Finne Teddybjørnene
☒ Utfordring 2 - Snakke med seksjons lederen

Figure C.27: Participant 3: Page 2

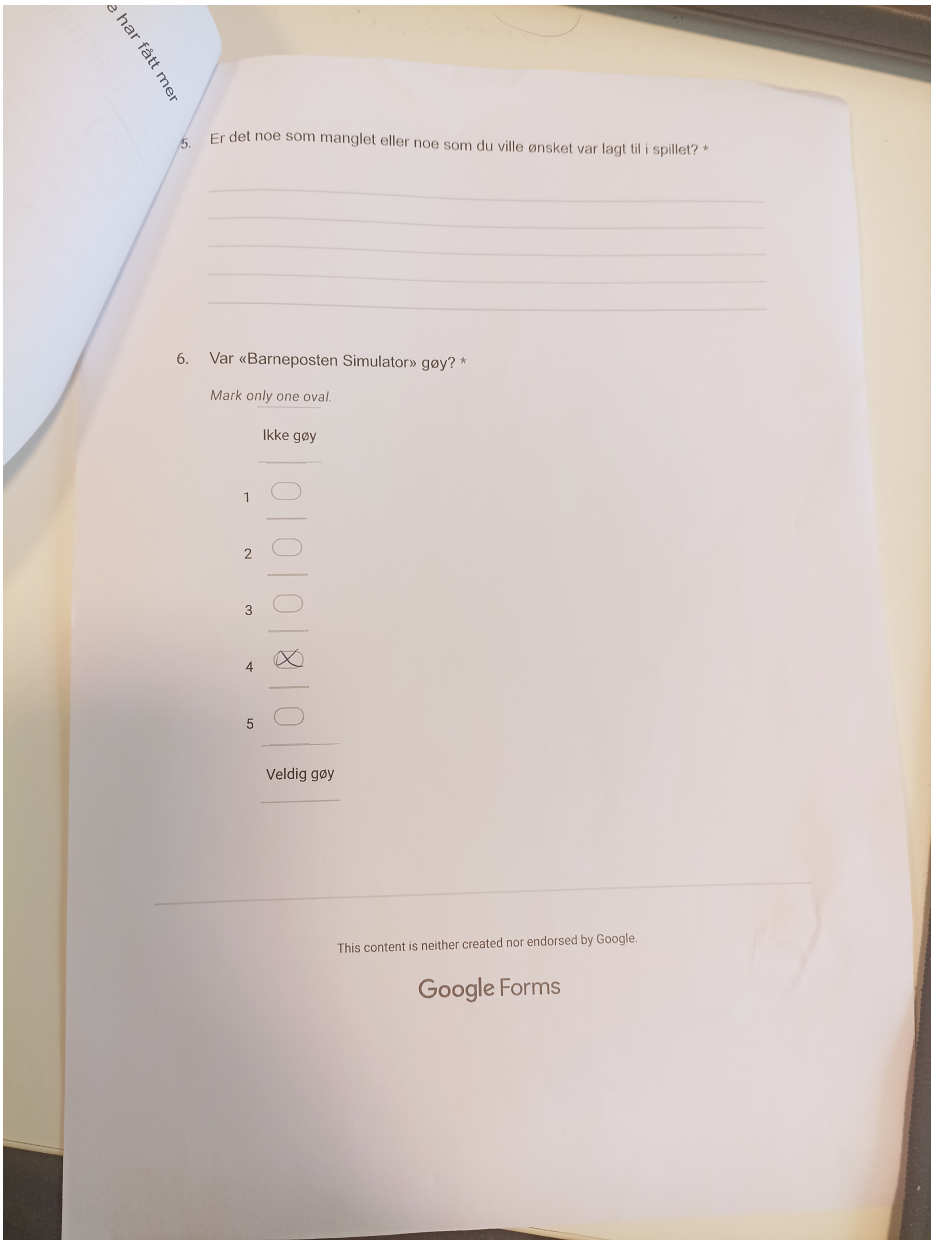
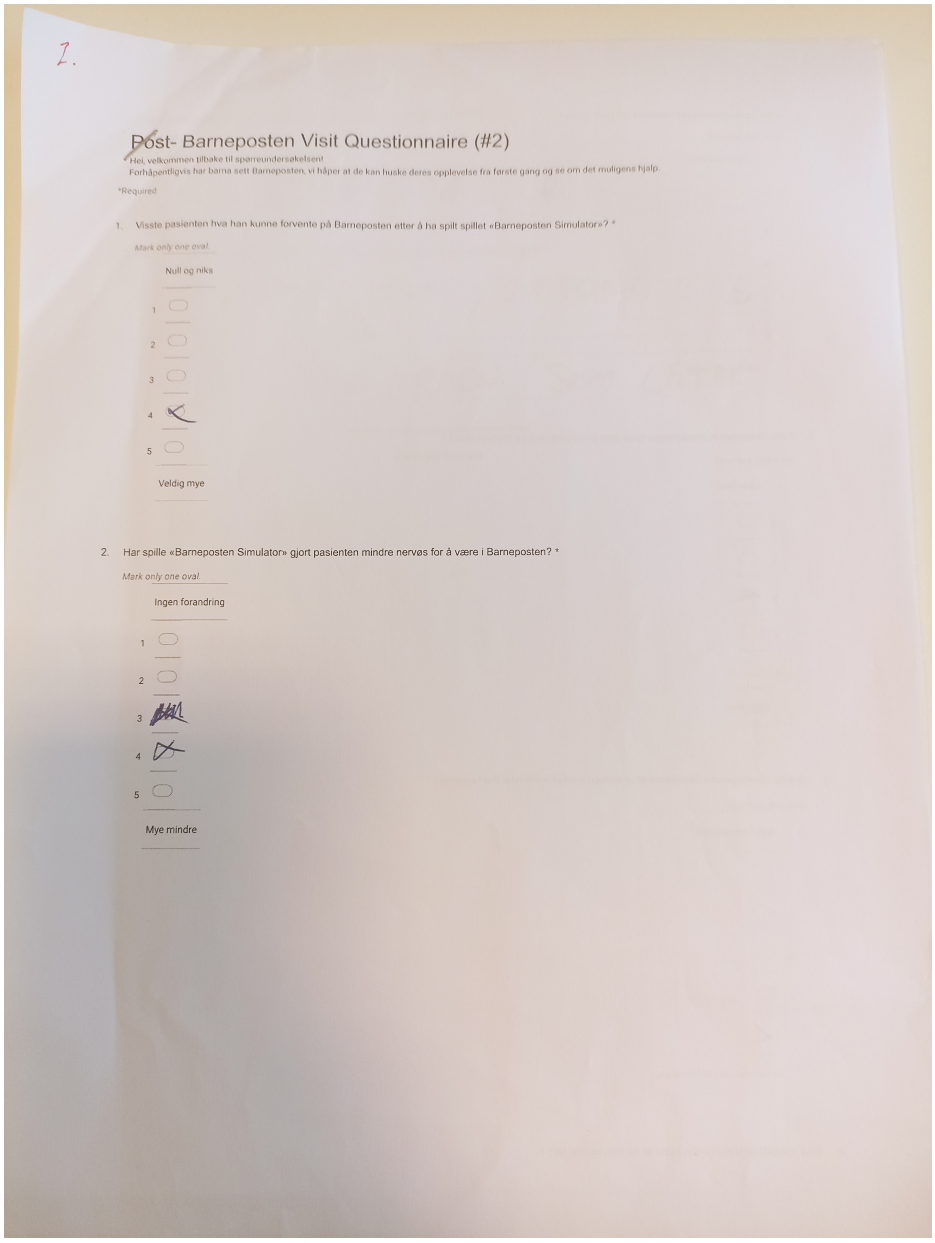


Figure C.28: Participant 3: Page 3

Results of Post-Visit Questionnaire



1.

Post- Barneposten Visit Questionnaire (#2)

Hei, velkommen tilbake til spørreundersøkelsen!
Forhåpentligvis har barna sett Barneposten, vi håper at de kan huske deres opplevelse fra første gang og se om det muligens hjalp.

*Required

1. Visste pasienten hva han kunne forvente på Barneposten etter å ha spilt spillet «Barneposten Simulator»? *

Mark only one oval.

Null og niks

1 ○
2 ○
3 ○
4 ✓
5 ○

Veldig mye

2. Har spille «Barneposten Simulator» gjort pasienten mindre nervøs for å være i Barneposten? *

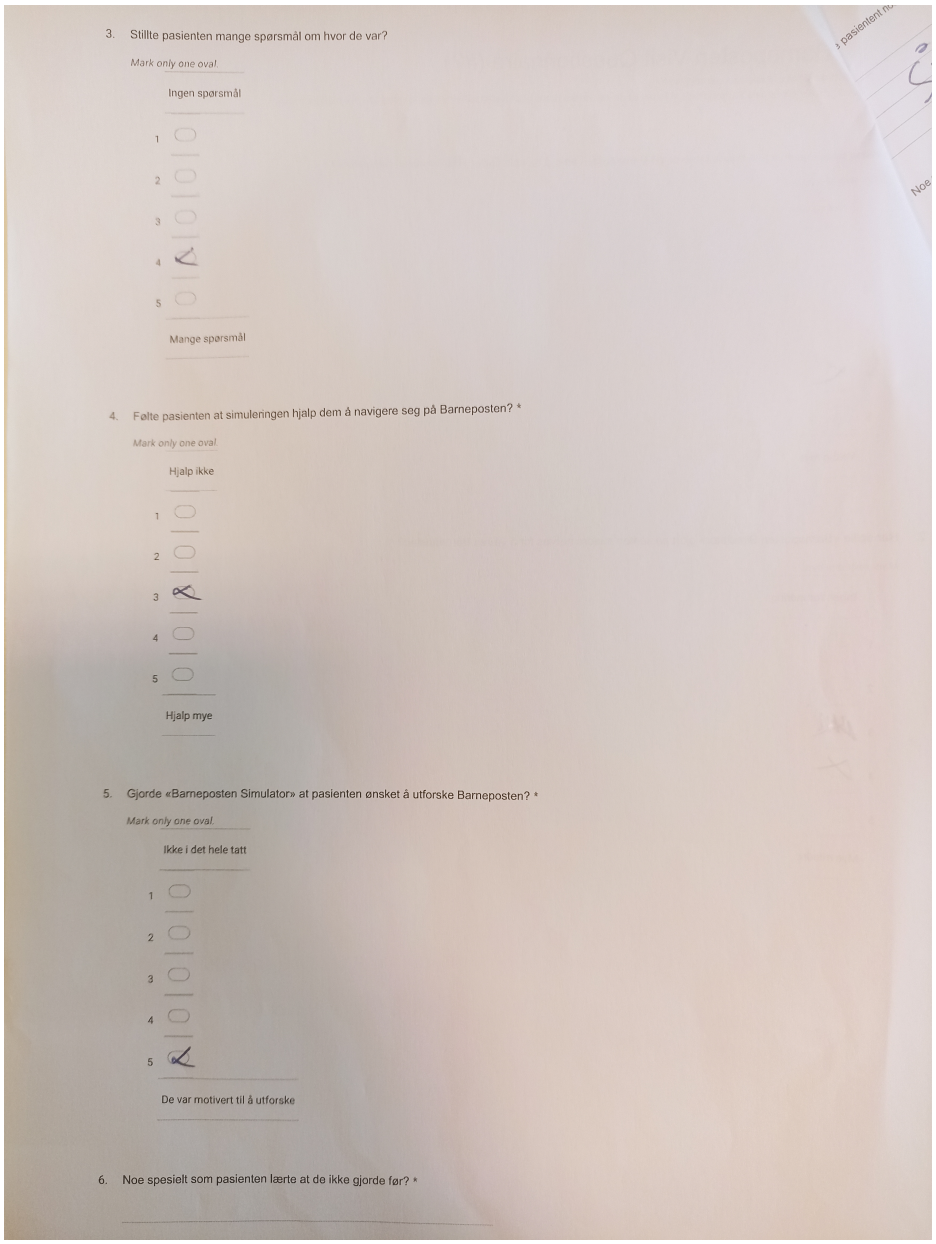
Mark only one oval.

Ingen forandring

1 ○
2 ○
3 ○
4 ○
5 ○

Mye mindre

Figure C.29: Participant 1: Page 1



3. Stillte pasienten mange spørsmål om hvor de var?

Mark only one oval.

Ingen spørsmål

1 ○
2 ○
3 ○
4 ✓
5 ○

Mange spørsmål

4. Følte pasienten at simuleringen hjalp dem å navigere seg på Barneposten? *

Mark only one oval.

Hjalp ikke

1 ○
2 ○
3 ✓
4 ○
5 ○

Hjalp mye

5. Gjorde «Barneposten Simulator» at pasienten ønsket å utforske Barneposten? *

Mark only one oval.

Ikke i det hele tatt

1 ○
2 ○
3 ○
4 ○
5 ✓

De var motivert til å utforske

6. Noe spesielt som pasienten lærte at de ikke gjorde før? *

Figure C.30: Participant 1: Page 2

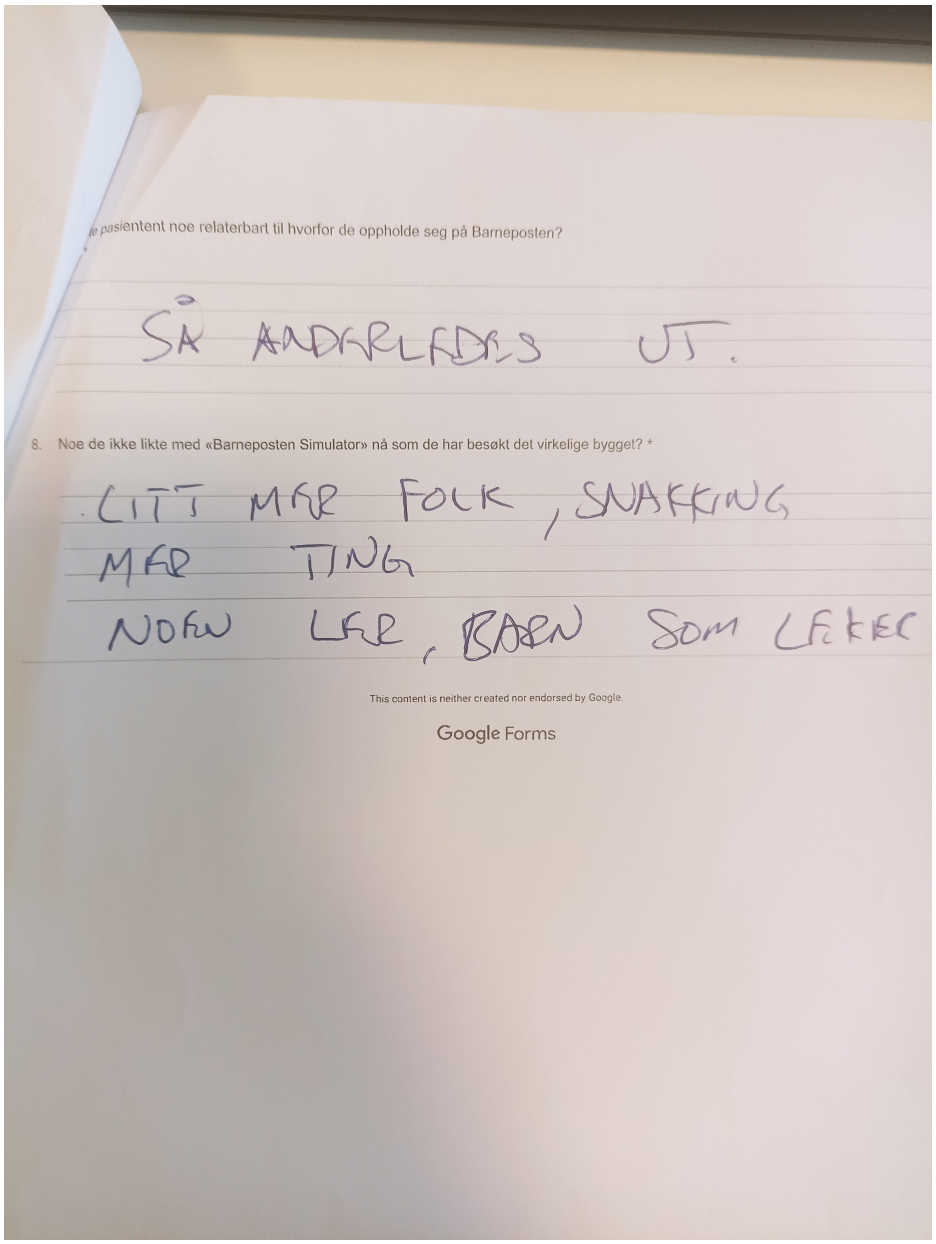
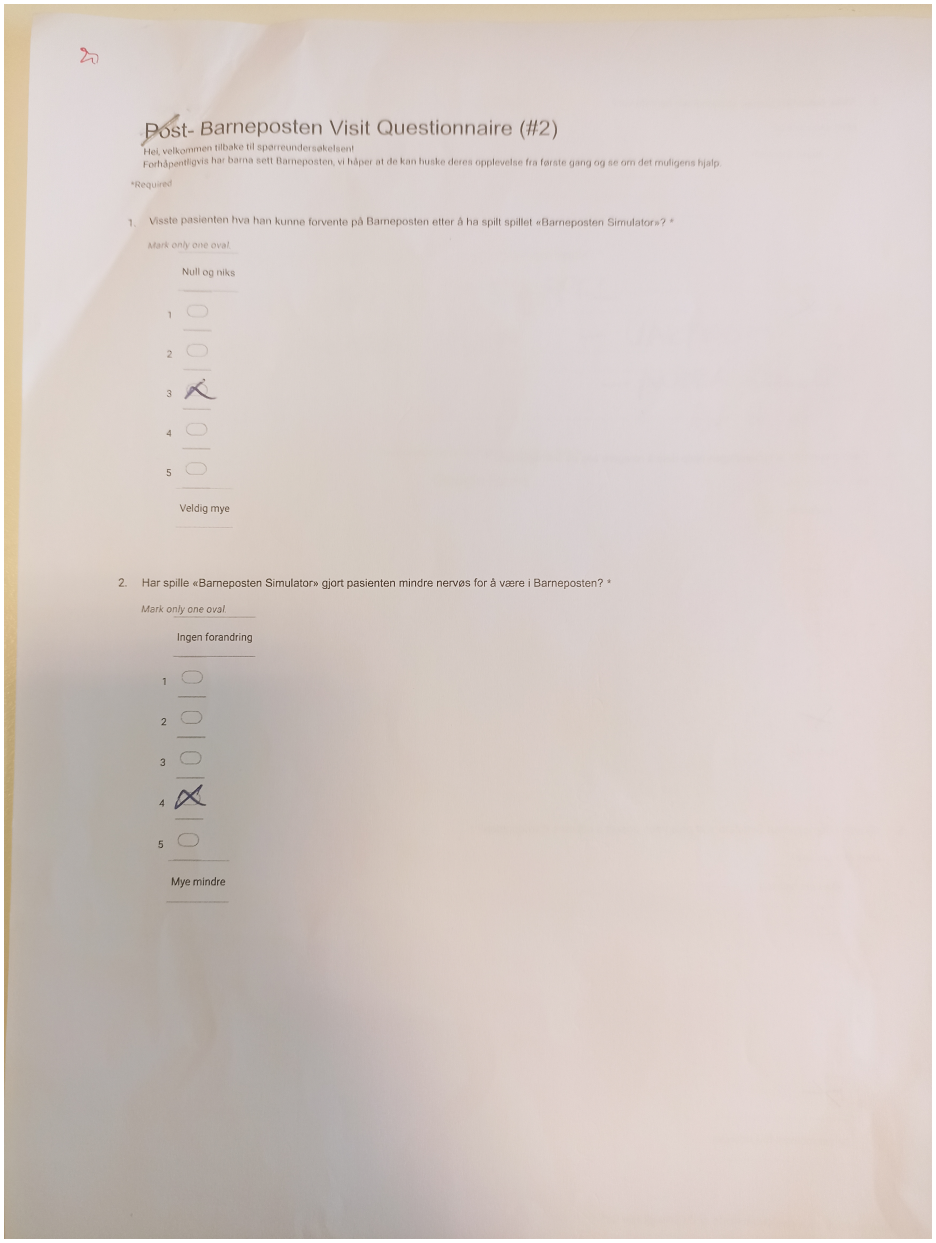


Figure C.31: Participant 1: Page 3



Post- Barneposten Visit Questionnaire (#2)

Hei, velkommen tilbake til spørreundersøkelsen!
Forhåpentligvis har barna sett Barneposten, vi håper at de kan huske deres opplevelse fra første gang og se om det muligens hjalp.

*Required

1. Visste pasienten hva han kunne forvente på Barneposten etter å ha spilt spillet «Barneposten Simulator»? *

Mark only one oval.

Null og niks

1 ◯
2 ◯
3 ✓
4 ◯
5 ◯

Veldig mye

2. Har spille «Barneposten Simulator» gjort pasienten mindre nervøs for å være i Barneposten? *

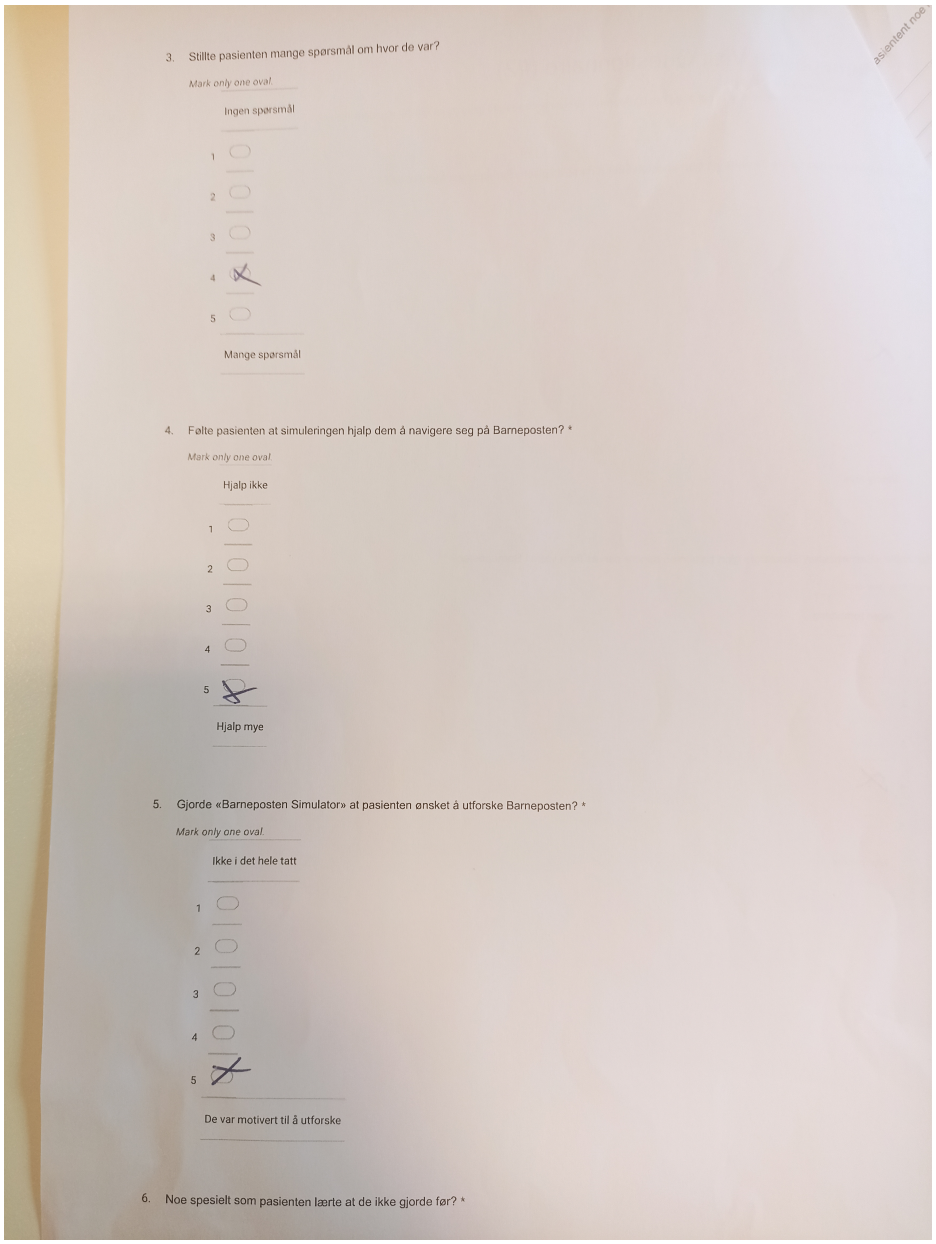
Mark only one oval.

Ingen forandring

1 ◯
2 ◯
3 ◯
4 ✓
5 ◯

Mye mindre

Figure C.32: Participant 2: Page 1



3. Stillte pasienten mange spørsmål om hvor de var?

Mark only one oval.

Ingen spørsmål

1
2
3
4
5

Mange spørsmål

4. Følte pasienten at simuleringen hjalp dem å navigere seg på Barneposten? *

Mark only one oval.

Hjalp ikke

1
2
3
4
5

Hjalp mye

5. Gjorde «Barneposten Simulator» at pasienten ønsket å utforske Barneposten? *

Mark only one oval.

Ikke i det hele tatt

1
2
3
4
5

De var motivert til å utforske

6. Noe spesielt som pasienten lærte at de ikke gjorde før? *

Figure C.33: Participant 2: Page 2

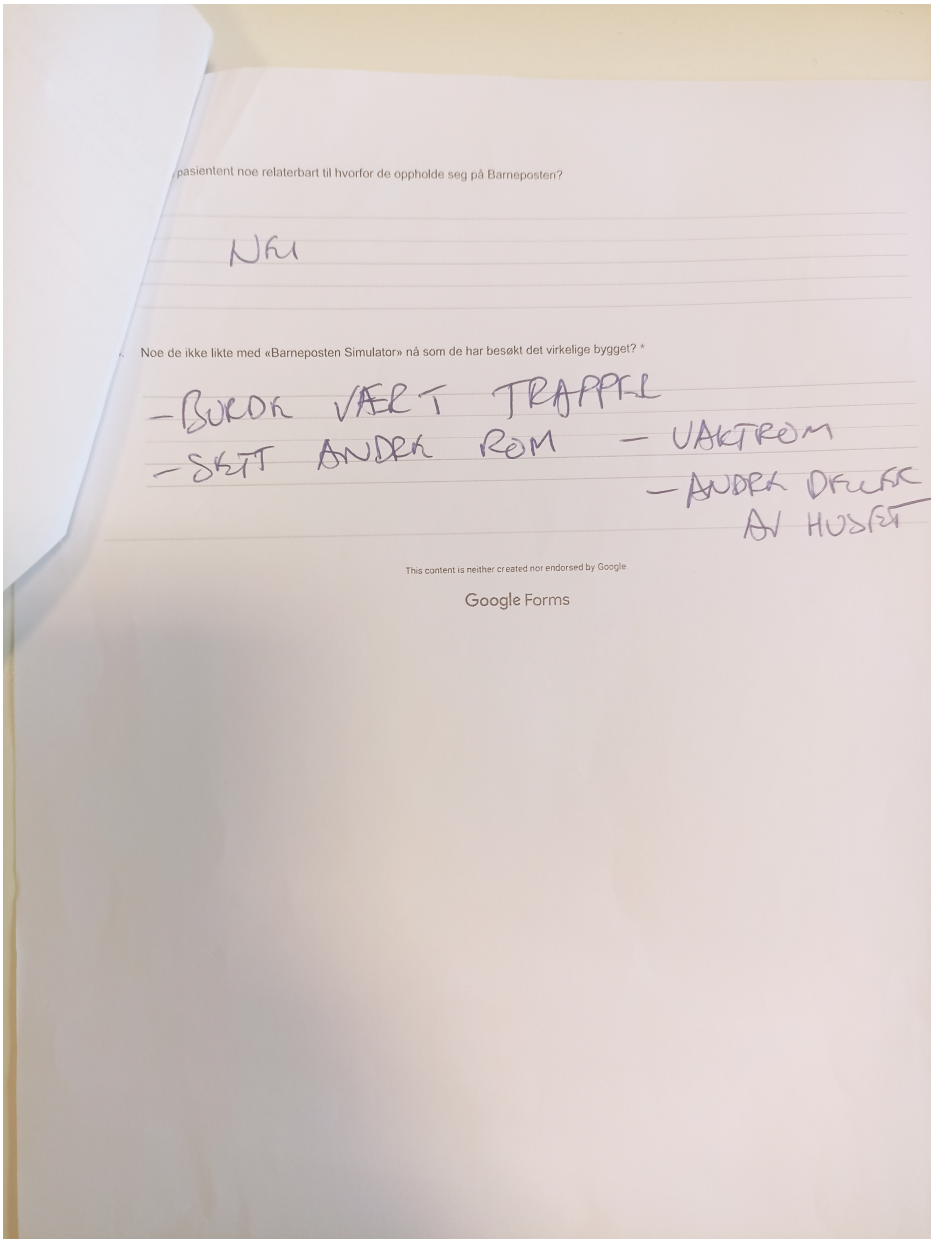
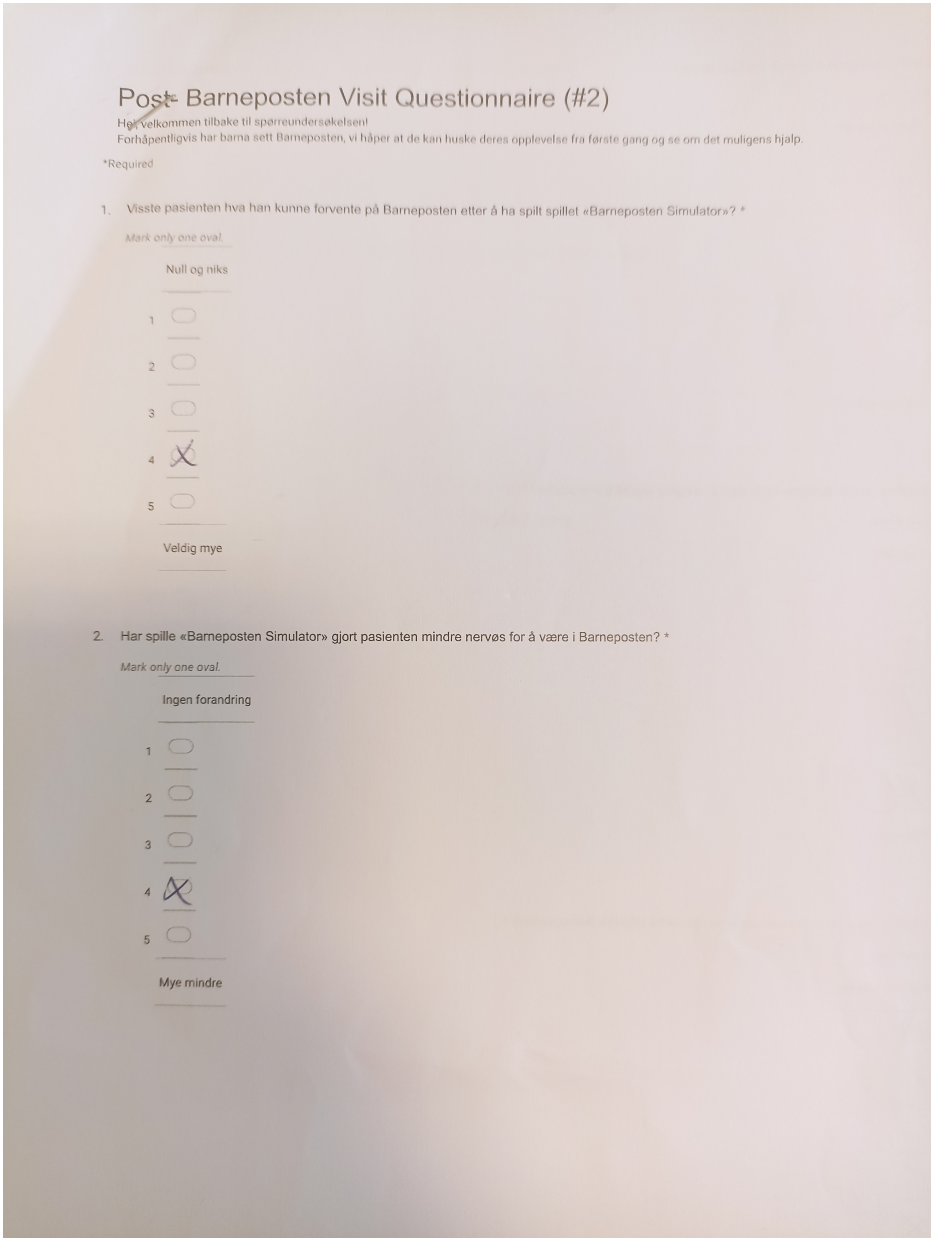


Figure C.34: Participant 2: Page 3



Post- Barneposten Visit Questionnaire (#2)

Hei velkommen tilbake til spørreundersøkelsen!
Forhåpentligvis har barna sett Barneposten, vi håper at de kan huske deres opplevelse fra første gang og se om det muligens hjalp.

*Required

1. Visste pasienten hva han kunne forvente på Barneposten etter å ha spilt spillet «Barneposten Simulator»? *

Mark only one oval.

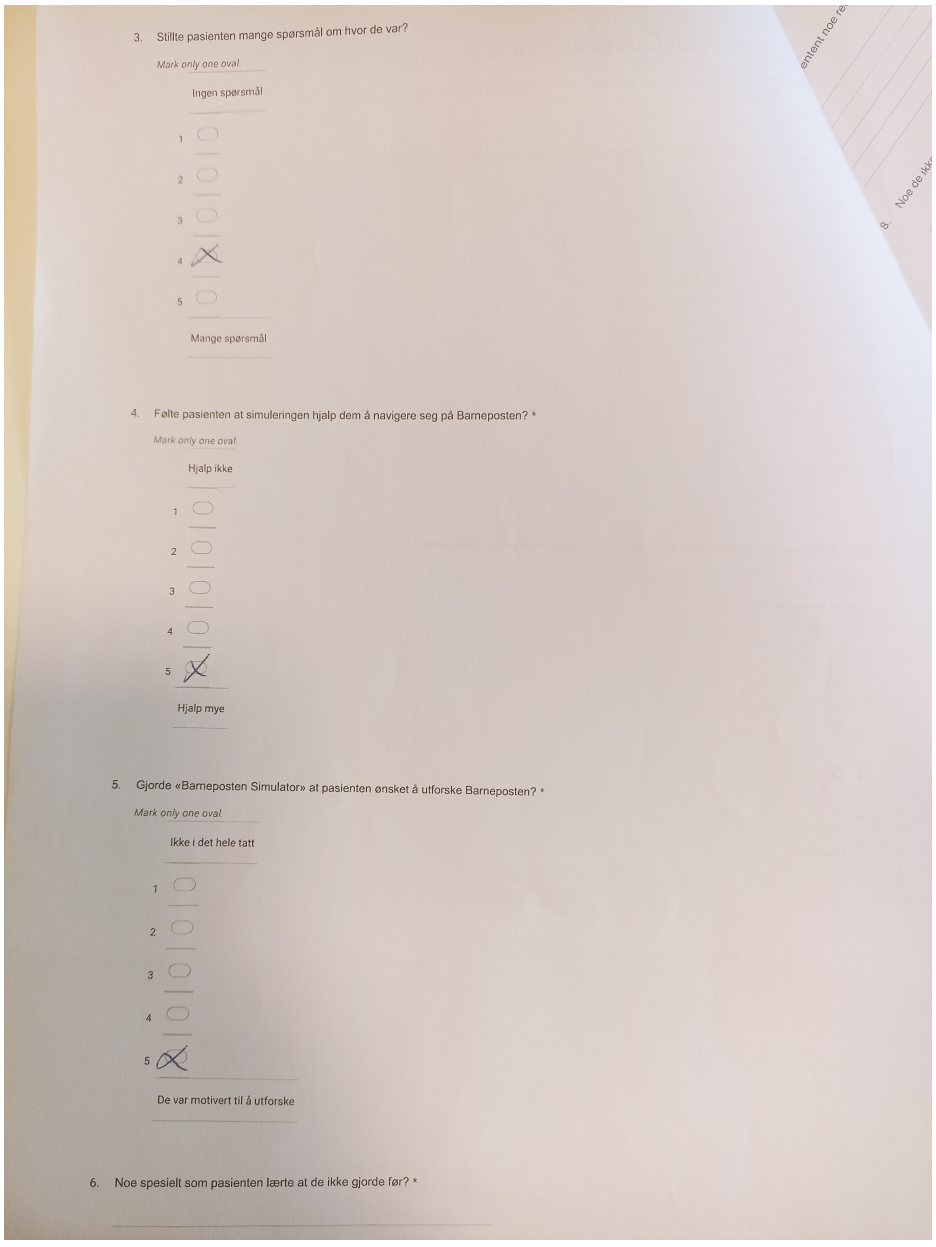
Null og niks
1
2
3
4
5
Veldig mye

2. Har spille «Barneposten Simulator» gjort pasienten mindre nervøs for å være i Barneposten? *

Mark only one oval.

Ingen forandring
1
2
3
4
5
Mye mindre

Figure C.35: Participant 3: Page 1



3. Stillte pasienten mange spørsmål om hvor de var?

Mark only one oval.

Ingen spørsmål

1 ○
2 ○
3 ○
4 ✕
5 ○

Mange spørsmål

4. Følte pasienten at simuleringen hjalp dem å navigere seg på Barneposten? *

Mark only one oval.

Hjalp ikke

1 ○
2 ○
3 ○
4 ○
5 ✕

Hjalp mye

5. Gjorde «Barneposten Simulator» at pasienten ønsket å utforske Barneposten? *

Mark only one oval.

Ikke i det hele tatt

1 ○
2 ○
3 ○
4 ○
5 ✕

De var motivert til å utforske

6. Noe spesielt som pasienten lærte at de ikke gjorde før? *

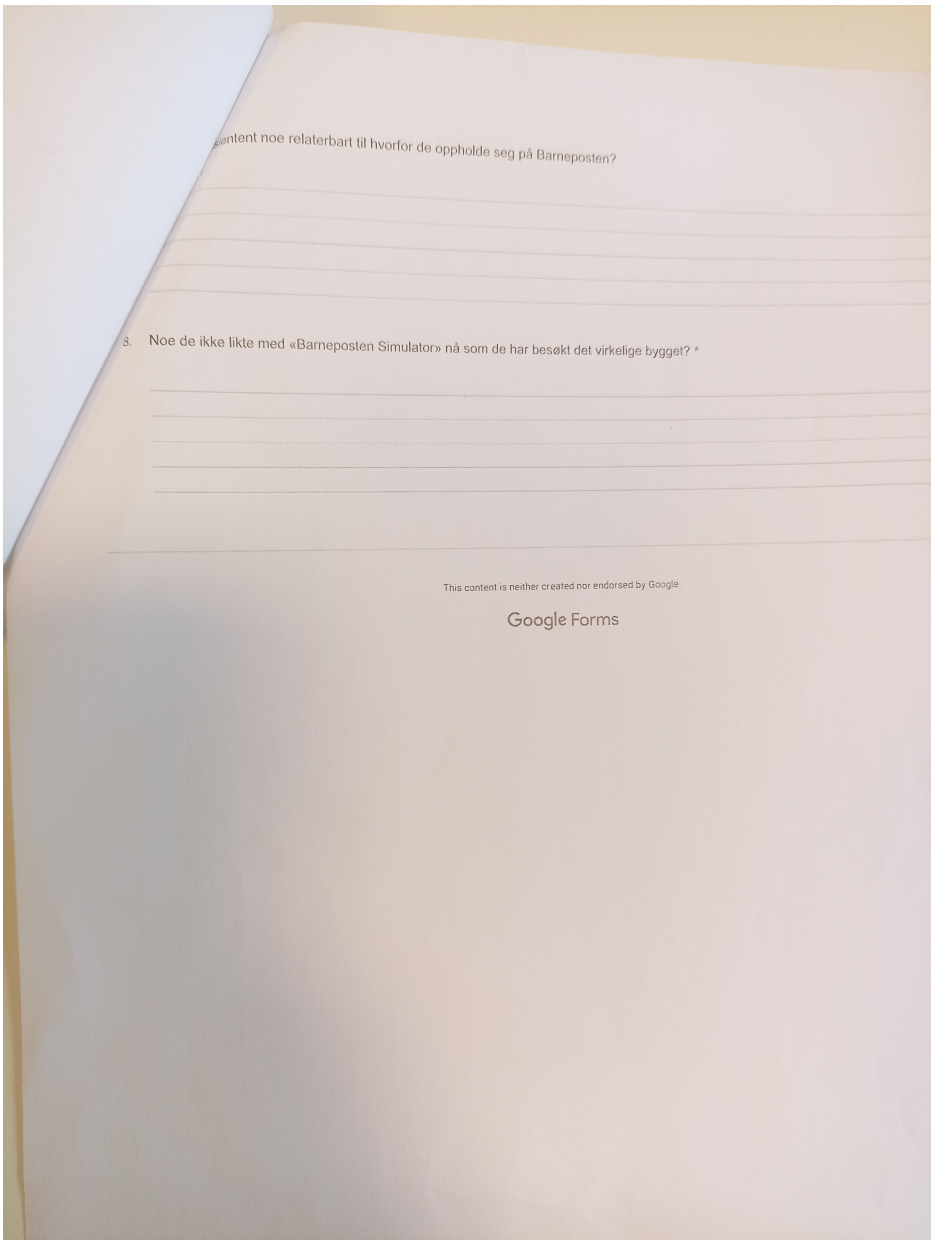


Figure C.37: Participant 3: Page 3

Appendix D

Demo and Code

This the link to the playthrough of the application:

https://www.youtube.com/watch?v=_avTFl9TKBU

Link to the three version of the application:

https://1drv.ms/f/s!AgRuCPrJOXqAie8YnrMJw1HrZ1PAGQ?e=PNddQQ

The code to Barneposten Tour game is in this link:

https://1drv.ms/f/s!AgRuCPrJOXqAie8YnrMJw1HrZ1PAGQ?e=PNddQQ