

Designing a Multiplayer Game for Inflight Entertainment Systems

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MASTER THESIS

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Designing a Multiplayer Game for Inflight Entertainment Systems

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Abstract

The global airline industry is a significant market. Every year, millions of people travel by long-haul flights for different purposes. Inflight entertainment (IFE) systems are offered as a service in the aircraft cabin to keep these passengers entertained during the flight. Since IFE can significantly impact the passenger's journey, aviation companies need to be at the forefront of providing and developing well-developed systems. Furthermore, a feature that can enhance the flight experience is a multiplayer game. Thus, this thesis aims to investigate how to design the user interface (UI) and the user experience (UX) of a multiplayer game suitable for a wide variety of users.

A user-centered design process with a focus on universal design has been followed throughout the project. Additionally, the four main activities of interaction design have been carried out to reach the final result, which is a high fidelity prototype developed in Figma. The result has the potential to be a commercial product if being further developed. Thereby it could both enhance passenger satisfaction and give added business value to the airlines.

Keywords: Inflight Entertainment Systems (IFE), Interaction Design, Multiplayer Game, Prototyping, Universal Design, User-Centered Design, User Experience (UX), User Interface (UI)

Sammanfattning

Den globala flygindustrin är en betydande marknad. Varje år reser miljontals människor med långdistansflyg för olika ändamål. Inflight entertainment (IFE) system erbjuds ofta som en tjänst på långflyg för att underhålla dessa resenärer under deras resor. Eftersom IFE avsevärt kan förbättra resenärens resa bör flygbolagen ligga i framkant när det gäller att tillhandahålla och utveckla välutvecklade IFE system. En tjänst som kan förbättra flygupplevelsen är ett multiplayer-spel. Därför syftar detta examensarbetet till att undersöka hur man designar användargränssnittet (UI) och användarupplevelsen (UX) för ett multiplayer-spel som är lämpligt för en mängd olika typer av användare.

En användarcentrerad designprocess med fokus på universell utformning har följts under hela projektet. Dessutom har de fyra huvudaktiviteterna inom interaktionsdesign genomförts för att nå det slutliga resultatet, som är en high fidelity prototyp utvecklad i Figma. Slutresultatet har potential till att bli en kommersiell produkt om den skulle vidareutvecklas. Därigenom skulle den både kunna öka användarnöjdheten hos resenärerna och resultera i mer affärsnytta till flygbolagen.

Nyckelord: Användarcentrerad design, Användargränssnitt (UI), Användarupplevelse (UX), Inflight Entertainment System (IFE), Interaktionsdesign, Multiplayer spel, Prototyp, Universell Utformning

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Lund, June 2022

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List of Acronyms and Abbreviations

FP - Final prototype

Hi-fi - High fidelity

IFE - Inflight Entertainment

Lo-fi - Low fidelity

P1 - Prototype 1

P2 - Prototype 2

PBS - Project Breakdown Structure

REQ - Requirement

RQ - Research question

SME - Subject Matter Expert

SUS - System Usability Scale

TL - Test leader

TP - Test participant

UCD - User-centered design

UD - Universal Design

UI - User interface

UX - User experience

WCAG - Web Content Accessibility Guidelines

Contents

1	Introduction	6
1.1	Background	6
1.1.1	Tactel	6
1.2	Purpose and Goal	7
1.3	Related Work	8
1.4	Delimitations	9
1.5	Distribution of Work	9
2	Theory	10
2.1	Activities of Interaction Design	10
2.1.1	Establish Requirements	10
2.1.2	Designing Alternatives	11
2.1.3	Prototyping	11
2.1.4	Evaluating	11
2.2	User-Centered Design	12
2.3	Usability and User Experience	12
2.4	Universal Design	13
2.5	Design Guidelines	13
2.5.1	Norman's Principles of Interaction Design	13
2.5.2	Shneiderman's Eight Golden Rules	14
2.6	User Study	14
2.6.1	Identify the Users	15
2.6.2	Data Gathering	15
2.7	Analyze Data	16
2.7.1	Affinity Diagram	16
2.7.2	Card Sorting	17
2.7.3	Dot Voting	17
2.7.4	Personas	17
2.8	Ideation Methods	17
2.8.1	Brainstorming	17

2.8.2	Braindrawing	18
2.9	Conceptual Design	18
2.9.1	Storyboard	19
2.9.2	Project Breakdown Structure	19
2.9.3	User Flow	19
2.10	Prototyping	19
2.10.1	Low Fidelity Prototyping	20
2.10.2	High Fidelity Prototyping	20
2.11	Evaluating	20
2.11.1	Usability Testing	20
2.11.2	Usability and User Experience Questionnaires	21
3	Design Process	23
3.1	Establish Requirements	23
3.1.1	Literature Study	23
3.1.2	User Study	25
3.1.3	Results From User Study	27
3.1.4	Personas	31
3.1.5	Requirements	33
3.2	Designing Alternatives	34
3.2.1	Conceptual Design	34
3.2.2	Physical Design	42
3.2.3	Meeting with Stakeholders	43
3.3	Prototyping	44
3.3.1	Low Fidelity Prototyping	44
3.3.2	High Fidelity Prototyping	53
3.4	Evaluating	62
3.4.1	Usability Testing	62
3.4.2	Results From Usability Testing	65
4	Final Result	70
4.1	Takeaways from the Usability Testing	70
4.2	Final Prototype	71
4.3	Feedback Session with Designer	81
4.4	Further Improvements	82
5	Discussion	84
5.1	Overall Reflection	84
5.1.1	Goals	84
5.1.2	Requirements	85
5.2	Design Process	86
5.2.1	Establish Requirements	87
5.2.2	Designing Alternatives	87
5.2.3	Prototyping	87
5.2.4	Evaluating	88
5.3	Universal Design	89
5.4	Research Questions	91

5.5	Future Work	92
6	Conclusion	93
	References	94
	Appendix A User Study	98
A.1	Questionnaire	98
A.1.1	Questionnaire Script	98
A.1.2	Questionnaire Questions	98
A.2	Interviews	102
A.2.1	User Interview Questions	102
A.2.2	Subject Matter Expert Interview Questions	104
A.3	Figures	105
A.3.1	Affinity Diagram	105
A.3.2	Diagrams	107
	Appendix B Designing Alternatives	115
B.1	Affinity Diagram	115
	Appendix C Prototyping	117
C.1	Low Fidelity Prototyping	117
C.2	High Fidelity Prototyping	124
	Appendix D Usability Testing	140
D.1	Scenarios	140
D.2	Questionnaire	141
D.2.1	SUS	141
D.2.2	AttrakDiff	142

Chapter 1

Introduction

This chapter gives a brief overview of this thesis. Background to the subject is presented, and an introduction to Tactel. Additionally, the purpose and goal, related work, delimitations, and distribution of work will be presented.

1.1 Background

The global airline industry is a major market, and in 2019 the number of flights was 38.9 million [36]. The number was forecasted to increase if it was not for the pandemic. It is almost inevitable not to encounter inflight entertainment (IFE) systems when traveling by long-haul flights. Many of the big companies in the aviation industry offer some kind of IFE. The IFE system is provided to the passengers on airplanes by a seat-back screen or a display where they can watch movies, play games, listen to music, read the news, and follow the journey by air maps, among other things. By providing a well-developed and usable IFE system, aviation companies can contribute to the passengers having a pleasant experience during the flight. Since IFE can significantly impact the passenger's journey, aviation companies need to be at the forefront of providing a well-developed system. Due to this, it is a research subject of interest. A company that has extensive experience in developing IFE systems is Tactel. The development possibilities for the IFE systems are huge due to digitization. Therefore, an area of interest suggested by Tactel is to develop and investigate the possibility of offering multiplayer games in their IFE system. Hence, this master thesis will look deeper into this research field with a primary focus on the user interface (UI) and the user experience (UX) with the seven Universal Design (UD) principles considered [31].

1.1.1 Tactel

This thesis was done in cooperation with Tactel. The company is a digital interaction agency that became a part of Panasonic Avionics Corporation in 2015 [38]. They have around 100

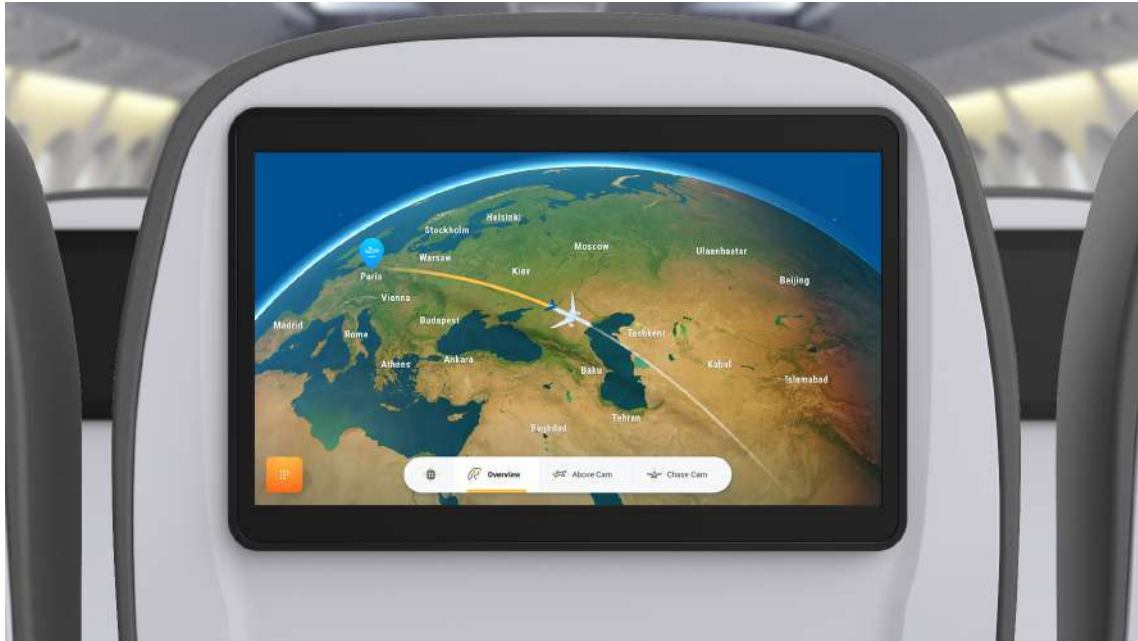


Figure 1.1: Arc presented on an IFE system on a seat-back screen.¹

employees with offices in Malmö, Stockholm, and Umeå. Tactel delivers digital and business solutions across the world in various industries and has some of its largest customers within the aviation industry. Hence, they are designing, developing, and building the next generation IFE system for Panasonic Avionics Corporations and their customers, where the majority are some of the world's leading airlines.

One of Tactel's main projects within the development of the IFE system is called Arc. Arc is a unique solution that is a moving, high-resolution map function [37]. An example of Arc presented on a seat-back screen can be seen in Figure 1.1. The map is based on satellite images and a 3D engine. Arc is flexible and built to be integrated and uniquely adapted to the airlines' different IFE systems. Due to the huge processing power of the 3D engine used, the potential and possibilities for Arc are enormous. This is why Tactel is one of the leading actors on the market.

1.2 Purpose and Goal

This thesis aims to investigate how a multiplayer game on the IFE system should be designed to meet a wide variety of users. The unique environment in the aircraft cabin and the passenger's individual needs have to be taken into consideration when designing the game. Additionally, the purpose is to enhance customer satisfaction and provide the passengers with a new, innovative flight experience. Doing this can give an increased business value for the airlines.

Based on the purpose, four overall goals and four research questions for the thesis were established. These are presented below and will lay the foundation for the project.

¹<https://www.tactel.se/en/cases/exploring-the-world-below-from-the-sky-above/>

Overall Goals:

- To develop a high fidelity (hi-fi) prototype showing a UI of the multiplayer game on the IFE system.
- To involve Arc in the game to exploit its potential.
- To fulfill the relevant principles of UD for the large target group.
- To have a user-centered design (UCD) process.

Research Questions:

- *RQ1:* Who are the users and how can their requirements be satisfied?
- *RQ2:* How should the solution be designed to ensure that the UD principles are covered?
- *RQ3:* How can the design of the interface ensure that the users can play together regardless of age, culture, and background?
- *RQ4:* How should the interaction between potential players be designed?

1.3 Related Work

Two previous master theses were done in collaboration with Tactel, which is related to this thesis' subject of interest. The first thesis was done by Eriksson and Svensson in 2017 and is named *Accessibility within Inflight Entertainment* [12]. Even though their thesis focuses more on the evaluated accessibility support in IFE systems, they have a similar design process and subject as this thesis. The second thesis was done by Balek in 2019 and is named *User Interaction in Inflight Entertainment Map Application* [5]. The thesis focuses on how to improve the user experience when interacting with the map application, using mobile augmented reality.

This year, three master theses, including this master thesis, related to developing multiplayer games on airplanes are carried out in parallel at Tactel. This thesis is partially done in collaboration with Bastmark and Domell. Their thesis, named *Developing a Multi-Passenger Game for Inflight Entertainment Systems* also focuses on a multiplayer game on long-haul flights [6]. However, they have a different purpose and goal of the project and instead focus on investigating the technical possibilities in the aircraft cabin. Moreover, the third thesis is done by Berntsson and Sidemo, named *Multiplayer Entertainment on Short-Haul Flights* [7]. As the name implies, it focuses on multiplayer entertainment in various ways on short-haul flights. The significant difference compared to this thesis is that they cannot use Arc and the IFE system on the seat-back screens; instead, they have the overhead monitors and the passenger's personal devices at disposal.

1.4 Delimitations

Due to the project's time frame and to fulfill the goals, scope delimitations were necessary. The focus has been on the design aspects of the multiplayer game. The more technical aspects of creating a multiplayer game for long-haul flights have been in focus in Bastmark and Domell's thesis. Consequently, no software or hardware development has been done in this thesis. The final result is a hi-fi prototype developed in Figma². Due to these delimitations, Arc has only been included in the concepts and not for real in the prototype. Instead, screenshots are used to visualize how the map application could be used.

Additionally, the main focus of the final prototype has been on making the UI, the UX and to fulfill the principles of UD. Hence, the game concept has not been in focus, and therefore the game is not complete. Therefore, only some examples of what the game could look like are presented.

1.5 Distribution of Work

We have contributed equivalently to the project. Most of the work has been carried out together as a team. However, to streamline the prototyping phase, the work was distributed equally between us, and we were in charge of designing and developing one prototype each. Additionally, we had different consistent roles during the feedback session and usability testing. Amanda was the test leader, whilst Linnéa took notes and was the observer.

²<https://www.figma.com>

Chapter 2

Theory

This chapter presents the essential theories used in the thesis. It contains theories about interaction design, universal design, and different design guidelines. Additionally, the methods used in the thesis are presented.

2.1 Activities of Interaction Design

Interaction design is about how people interact with technology, and the main goal is to ensure that the user understands how, why, and when to interact with a certain product [28]. The design process of interaction design consists of four main activities: *establish requirements*, *designing alternatives*, *prototyping* and *evaluating* [30]. These activities all relate to each other and should be performed iterative and with a user-centered design approach. A visual overview of the activities can be seen in Figure 2.1, and are presented more in detail below.

2.1.1 Establish Requirements

Establish requirements is the first activity in the design process and is a fundamental part of interaction design according to Preece, Rogers, and Sharp [30]. This is since the requirements will specify what purpose and functionality the product must have to fulfill the users' needs. In order to establish requirements, the user needs to be identified and analyzed, which can be done by gathering data using several methods such as interviews and questionnaires. Cooper, Reimann, Cronin, and Noessel [9] presents a design principle linked to this phase; "Define what the product will do before you design how the product will do it". This indicates that it is essential as a first step in the design process to decide *what* the product should do.

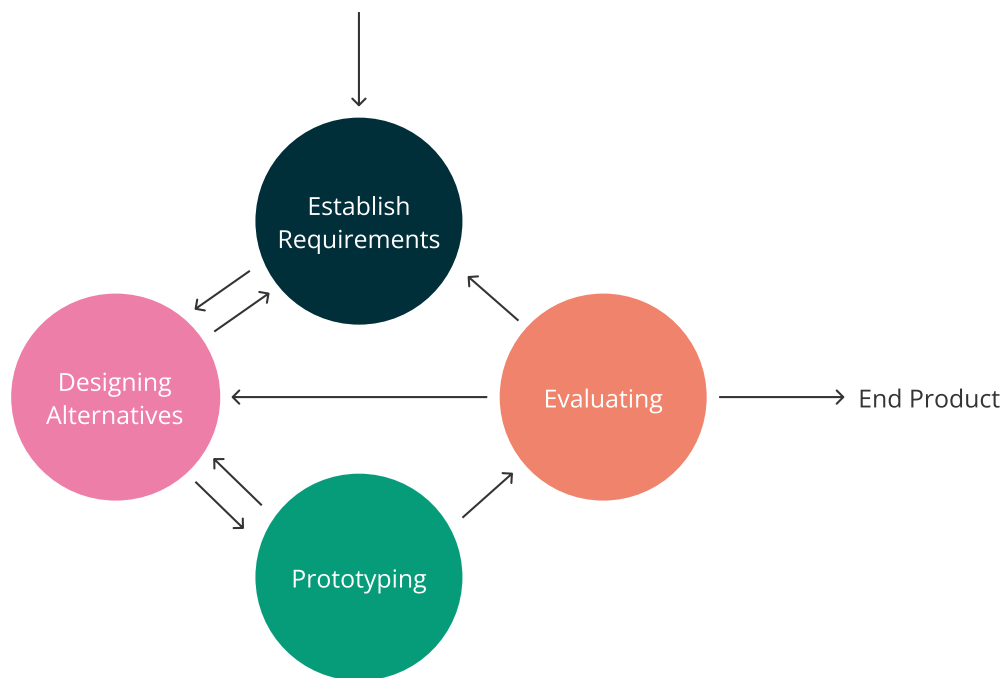


Figure 2.1: The four main activities of interaction design.

2.1.2 Designing Alternatives

Designing alternatives is the second activity in the design process and can be done when the requirements are set. In this phase, the question of *how* the product should look, behave and operate is going to be decided [9]. The different alternatives should meet the requirements in the best possible and most suitable way. This phase can be divided into two phases, the conceptual design and the physical design [30]. The conceptual design describes what the user can do with a product abstractly, including concepts and metaphors needed to understand how to interact with it. The physical design includes the details of the product, such as what colors should be used, deciding on fonts, and what kind of icons are suitable for the product.

2.1.3 Prototyping

Prototyping is the activity where the designed alternatives become interactive and, therefore, also possible to test. There are different levels of prototypes, low fidelity (lo-fi) and high fidelity (hi-fi) prototypes [30]. Producing prototypes makes it possible to get feedback on the interaction and the design early on in the design process, which means that it helps ensure that the established requirements are being met.

2.1.4 Evaluating

Evaluating is the last activity in interaction design. However, it is one of the most important ones. It is when evaluation of the design is done that it can be determined if the established requirements, and the user needs, are being fulfilled [30]. This activity should be performed

repeatedly throughout the whole design process. The evaluation of the design can be done by doing user testing and usability testing.

2.2 User-Centered Design

A user-centered design (UCD) process is ubiquitous in interaction design. It means that the users' needs and goals should be the driving force behind developing a product. Thus, the goal of the UCD process is to design a product in line with the users' needs. The users have to be involved in the entire design process to achieve this. There are three main principles connected to UCD that were introduced and recommended by Gould and Lewis in 1985 [16]. These principles will help produce valuable systems that are easy to use and are presented below.

- *Early focus on users and tasks:* Important to focus on the users early in the process to understand who will use the designed product. Here the cognitive, behavioral, anthropometric, and attitudinal characteristics of the users are being studied by observing them doing their regular tasks.
- *Empirical measurement:* The users help with testing simulations and prototypes during the entire process. By analyzing, recording, and observing the performance and reactions of the users, as well as asking them questions, the developers and designers can improve the product to better meet the needs of the users.
- *Iterative design:* The design is updated based on feedback from user testing. There are different cycles where the design is updated, tested, and redesigned based on user input. The process is repetitive and repeated as often as needed.

2.3 Usability and User Experience

Usability and user experience (UX) are two fundamental and commonly used attributes related to interaction design, and both of them have their ISO definition.

ISO 9241-11 defines the term usability as "the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [19].

ISO 9241-210 instead defines the term UX as "a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service" [20]. The term UX can, in other words, be described as how well a product is being perceived by users when taking the emotional effects into account. UX is all about the feeling or satisfaction that a user gets when interacting with a product [30].

There is a crucial difference between usability and UX. While usability focuses on meeting requirements when designing the product, UX instead focuses on the emotional and social values of the product and may, in turn, depend on previous experiences, attitudes, personality, and knowledge [3].

2.4 Universal Design

Universal design (UD) means "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [39]. UD focuses on designing a future that includes all people, regardless of age and ability. The ambition is that everything new created in society should be used by all citizens without needing a specialized design. New designs should consider that people are different, with different needs, and that diversity is natural.

There are seven principles related to UD to have in mind when designing new things. These are presented by Preiser and Smith [31] and are:

- *Equitable use*: People with diverse abilities will find the design useful and marketable.
- *Flexibility in use*: Various preferences and abilities can be accommodated by the design.
- *Simple and intuitive use*: Regardless of the level of experience, knowledge, language skills, or concentration, users can easily understand how to use the design.
- *Perceptible information*: Despite ambient conditions or user abilities, the design effectively communicates needed information to the user.
- *Tolerance for error*: Hazards and adverse effects caused by accidental or unintended actions are minimized in the design.
- *Low physical effort*: Using the design is efficient and comfortable with minimal fatigue.
- *Size and space for approach and use*: No matter what size, posture, or mobility the user has, the system is sized and placed appropriately to allow them to access, reach, manipulate, and use it.

2.5 Design Guidelines

There are several design guidelines that should be considered when designing alternatives. The guidelines can be graphical regarding the UI as well as guidelines regarding interaction design and UX [30]. In this section, Norman's principles of interaction design will be presented, as well as some of Shneiderman's eight golden rules of interface design.

2.5.1 Norman's Principles of Interaction Design

Norman has created five fundamental principles of interaction design that are derived from the *discoverability* of a product [28]. These principles are presented below.

- *Affordances*: Is the relationship between how the object looks and what the object can do. If the affordance of an object is good, the user should instantly know what interactions are possible to do with the object.
- *Signifiers*: Is a way of communicating to the user what actions are possible to do with an object. This can be done through signs, labels, or words, to name a few examples.

- *Constraints*: By limiting the possible interactions, the user gets clues about how the interaction with the object should be done. These can be physical, logical, and semantic constraints.
- *Mapping*: Describes the relationship between an object's interaction and the effect. A classic example is a vertical scroll bar. When moved down, the page is also moved down, which means that the interaction the user does correlate with the effect appropriately shown.
- *Feedback*: Is when an object hints to the user that it works as intended by communicating that an action has been made. The feedback must be immediate, informative, and appropriate. Examples of feedback can be sounds, lights, vibrations, or graphics.

2.5.2 Shneiderman's Eight Golden Rules

Shneiderman has defined eight golden rules for designing user interfaces to provide the best possible UX. The rules are heuristically developed, and it is possible to adapt them depending on the environment in which the system should be used [35]. The relevant rules related to the thesis are presented below.

- *Strive for consistency*: Consistency and the same design patterns, and sequence of actions should be used in similar situations. Consistency may refer to using the same colors, icons, typography, menu hierarchy, and terminology throughout the project.
- *Offer informative feedback*: It is essential to constantly give feedback to the users on where they are in the system and what is going on. There should be some form of feedback for every operation the system performs. More uncommon operations should have more extensive feedback.
- *Minimize short-term memory load*: It is about minimizing the user's cognitive load by creating a consistent interface. For example, it should not be necessary for the user to remember information from one dialogue to another.

2.6 User Study

A user study is a part of the first activity of interaction design, *establish requirements*. It is essential to get information about the users and their needs to develop the right product. In the user study, the users' needs are identified and analyzed by gathering data in different ways. The user data gathered will lay the foundation for the requirements.

Different principles can be followed to plan the user study, and these are: *set an objective, decide on the methods, design the tasks, determine the setting, decide what to record, determine the roles, determine which users to involve and to prepare* [25]. In addition, various activities can be used in the user study to obtain information about the user of a product [25]. The activities used to identify and analyze the users in this thesis are presented below.

2.6.1 Identify the Users

To set the objective and determine which users to involve in the user study, the users have to be identified. Additionally, when having a UCD process, it is vital to involve the correct users to develop a successful product. According to Eason [11], there are three categories of users, which are:

- *Primary*: Users who are using the system frequently.
- *Secondary*: Users who use the system occasionally or are indirectly using the system.
- *Tertiary*: Users who are affected by the system in some way, like when it is introduced, used, or affects its purchases.

2.6.2 Data Gathering

There are different methods for gathering data to obtain information about the users, their goals, and their needs. The theories about quantitative and qualitative data are presented below, and the methods of interviews and questionnaires.

Quantitative Data

Quantitative data refers to answers from the users that can be presented numerically [30]. The quantitative data gathered from user research sets a good foundation that provides credibility and authority to make decisions in the design process. It is also a way to find common denominators from the user research that can have an impact on the design process [9].

Qualitative Data

Qualitative data can give rich details about real situations. It can give complex answers to questions like *what*, *why* and *how*, in a way that the quantitative data cannot [9]. According to Cooper et al. [9], qualitative data can help the designer to understand the context and constraints of a product, identify behaviors and patterns of potential users, and to understand the technical and environmental contexts of the product. Additionally, when defining and designing a product, qualitative data is often the most valuable since it can present the behavioral knowledge of the users.

Questionnaire

Questionnaires are a research method that primarily collects quantitative data. According to Magnusson, Rasmus-Gröhn, Tollmar, and Deaner [25], it is a relatively inexpensive method to gather a large amount of data, especially if using an online questionnaire. When developing a questionnaire, it is essential to get the choice of questions, the order of the questions, and their format correct [25]. This is because there is no way back when the questionnaire is published. Therefore, it is reasonable to do a pilot test to ensure every question in the questionnaire is precise and clear before publishing. In addition, the questions should be based on the objectives and hypotheses found in the previous research made in the design process.

It is common to encounter the concept of a Likert scale when creating a questionnaire. A Likert scale is a common way of measuring opinions, attitudes, and perceptions that often give a better nuance than just having "yes/no"-questions [33]. It is usually graded with five or seven response options, ranging from one extreme attitude to an opposite extreme attitude. The goal of using the scale is to obtain subjective and quantitative data for the user study.

Interviews

Interviews are a research method that collects qualitative data. Cooper et al. [9] present four different kinds of interviews which have different purposes. Two of them are *user interviews* and *subject matter experts (SME) interviews*. The user interviews focus on the actual or potential users in the target group of a product. The goal could be to understand the users' motivations and goals of using the product, get an understanding of the users' mental model, get to understand current problems or frustrations in the context of the product, and understand *why*, *when*, and *how* the product could be used from the users perspective.

The SME interviews have another focus. These interviewees could be persons within the domain where the product will operate. The SME interviews can give invaluable information and new perspectives, especially if the context where the product will be used is complex or very technical.

According to Magnusson et al. [25], there are different ways to conduct an interview depending on how much the interviewer interacts with the interviewee. For example, in a *semi-directive interview*, a pre-established interview guide is followed, but the interviewer can ask more questions to the interviewee when needed. It is recommended to use questions that ask a combination of *why* and *how* since the interviewee needs to explain their underlying thoughts to the question asked. Before carrying out an interview, it is crucial to think through how to collect and analyze the outcome since interviews often generate vast amounts of data [25].

Interviews can be used in many phases of the design process. However, it is an effective method to use in the activity *establish requirements*, where the data typically is gathered from a less controlled group of participants to get an overview of the problem [25].

2.7 Analyze Data

The gathered data needs to be compiled and analyzed to move forward in the design process and to establish the requirements. Various methods can be used for this purpose. The methods used to compile and analyze data in this thesis are affinity diagram, card sorting, dot voting, and personas. These will be presented below.

2.7.1 Affinity Diagram

Affinity diagram is a method that can analyze and visualize qualitative research data or data from ideation sessions. The goal is to identify and organize the unstructured data into categories in a hierarchy to show different themes and structures that can be distinguished from the data [30]. The themes appear from the data. Additionally, the themes can be related to different aspects of the product and can be used in different parts of the design process.

2.7.2 Card Sorting

A method related to affinity diagrams is card sorting, which is a method that can be used when team members need to categorize and group items and/or relate various concepts to each other [26]. It is a way to structure information and for the members to identify the items and write them down on index cards or sticky notes. After that, the cards are sorted and arranged in different categories, or natural groups, based on their relationship.

2.7.3 Dot Voting

Dot voting is another method commonly used with affinity diagrams. Nielsen Norman Group [14] describes dot voting as "a simple tool used to democratically prioritize items or make decisions in a group setting". The technique is straightforward and makes it easier to narrow down different alternatives into a set of concepts. Each team member obtains a certain number of dots for individual voting when using the method. With the help of voting, the team can select which option(s) is considered the best.

2.7.4 Personas

A persona is a detailed description of the typical users of a product under development [30]. It represents a summary of numerous real users who have been involved in data collection over time. A persona has different characteristics and properties that are precisely defined. These include skills, attitudes, tasks, environment, and a goal. Since the persona is created based on user research, these characteristics and descriptions must be realistic. When developing, it is much easier for the designers to focus on the specific personas instead of the entire user group, to design the product accordingly. Therefore, it is common to produce several personas for the project based on the user study.

Cooper et al. [9] present various advantages of using personas, meaning that "the best way to successfully accommodate a variety of users is to design for specific types of individuals with specific needs". Additionally, the personas help the designers determine what the product should do and how to behave, communicate with people involved in the process, build consensus and commitment to the design, measure the design's effectiveness, and support the marketing and sales plans. Moreover, personas also help designers avoid common design issues during development.

2.8 Ideation Methods

When the requirements have been established, the second activity in interaction design, *designing alternatives*, can be initiated. To be able to design alternatives, several ideation methods can be used. The ones used in this thesis are presented below.

2.8.1 Brainstorming

Magnusson et al. [25] describe brainstorming as a method used to generate many ideas and solutions to a specific design problem. The method is often carried out in groups where the

ideas are written down on sticky notes. The idea of the method is that it should be focused on the quantity of new ideas and not on the quality. Additionally, it is important to postpone criticism of the ideas generated and that everyone during the session has to be judgemental-free. To help the participants think in new and innovative ways, it is encouraging to let the participants build on each other's ideas. Before the brainstorming session, the context has to be set. Then, the purpose has to be clarified and explained to the participants. The next step is to generate as many ideas as possible during a specific time frame. After the session, it is a good idea to discuss the most valuable ideas within the group. Another method is to use voting after the sessions, where the participants can vote for their favorite idea with the most potential.

Method 6-3-5

A common technique to use when doing brainstorming is *method 6-3-5* (also called Brain-writing) [3]. The method is a systematic way to generate ideas. What 6-3-5 stands for is that there are six participants in the session, writing down three ideas each, and then there are five rounds of iteration. When the first round starts, everyone writes down three ideas on paper. After the first round, everyone passes their paper with ideas to their neighbor, who continues to develop ideas based on the previous round. The participant's neighbor can either add three additional ideas or modify existing ones. This process is then repeated five times which means that all the basic ideas are built on and developed gradually. Usually, after five rounds, the team analyzes and evaluates the result and then chooses the top three ideas that they want to continue with in the ideation process.

2.8.2 Braindrawing

Braindrawing is a method similar to brainstorming. It can most easily be explained as a type of visual brainstorming. Instead of writing down the ideas, the participants draw sketches based on the ideation subject [27]. Braindrawing is advantageous when exploring visual alternatives for icons and screen layouts, among others. The same principles for brainstorming apply to braindrawing, as previously mentioned.

2.9 Conceptual Design

The first phase in the activity *designing alternatives* is called conceptual design. It describes how a product can be used by a user abstractly, along with the conceptual framework needed to understand how it works, including images and metaphors [30]. The developed conceptual design must be anchored in the user study and previous ideation activities in the design process. Therefore, it is essential to consider the specific personas created and the objectives determined to be desirable when doing the conceptual design.

Since the design is on an abstract level, only the main lines of the design are visualized without going into details. Therefore, the conceptual design should be as simple as possible but still provide the desired functionality. When doing conceptual design, one can use different methods such as storyboards, project breakdown structure and user flows [30]. These methods will be presented below.

2.9.1 Storyboard

A storyboard is a method used to visualize and identify key activities that are performed when the user interacts with a product by performing a task [30]. The interaction is presented in different steps through sketched images, typically put into a series of sketches. The storyboard shows the product's context, and the environment in which the user is located is also presented and taken into account. A storyboard can be used to give the designers a better and mutual understanding of the interaction and aspects that can be affected by the environment.

2.9.2 Project Breakdown Structure

A Project Breakdown Structure (PBS) can be seen as a mind map and hierarchical structure over what ideas to implement in a project [10]. It typically covers a wide range of ideas generated in the brainstorming process. It is used to visualize the work and makes it easier to get an overview of the system being designed and developed from the user's perspective and point of view.

2.9.3 User Flow

A user flow is a high-level diagram that displays the complete path that a user takes when using a product [17]. With the help of a user flow, it is easier for the design team to map out each step the user takes in the process and focus on the user's needs when designing. As a result, using user flows makes it more likely for the team to develop a product with good UX. Additionally, user flows help to sort out which components should be present on which screens and in which order they should appear.

2.10 Prototyping

The third activity in interaction design is *prototyping*. Prototypes can have different levels of detail and are usually used to demonstrate a proposed solution [30]. It can be seen as a simple and scaled-down version of the designed main product. Depending on the level of details, the prototype can be anything from a simple layout done on paper to a very realistic digital prototype.

The prototypes are often used for user testing and usability testing. By having something concrete to show the users, it is easier for the designers to ask more questions, redefine problems, make choices that improve the product and, as a result, improve the UX. In other words, the feedback from the users helps the designers when making design decisions and improvements to the design. By making multiple prototypes, the designers have a chance to examine different alternatives and compare different solutions to move forward in the process. Moreover, prototypes are a relatively cheap method to use in the design process. Making changes to a prototype is much cheaper than when the product is being developed [30].

Prototypes are often divided into different categories depending on their level of detail. Presented below are two different types of prototypes, low fidelity prototypes, and high fidelity prototypes.

2.10.1 Low Fidelity Prototyping

A low fidelity (lo-fi) prototype is a simple prototype often used early in the design phase. It is typically made of paper or cardboard and is a way for the designers to concretize the ideas from, among other things, the conceptual design [3]. Lo-fi prototypes are cheap to manufacture and can be tested early. The design is done quickly, and the idea is that the prototype will test the main flow, comprehensibility, and overall concept. Additionally, it is easier for users to give critical comments and suggestions for improvements, as they see that not too much time has been spent on the design. In addition, it is easy for the designers to modify and rebuild after each evaluation of the prototype. This type of prototype is excellent to use when exploring different design alternatives.

2.10.2 High Fidelity Prototyping

In contrast to lo-fi prototypes, high fidelity (hi-fi) prototypes are more complex and show an overview of the potential end product [30]. These prototypes are created later in the design phase and take longer to make. They are usually made in some digital tool and make it possible for the users to interact with the screen. The prototype is similar to the final product in appearance and contains more details and functionality than a lo-fi prototype. It aims to be very similar to the end product and gives a feeling of how the finished product will work. Testing this type of prototype makes it possible to get valuable feedback from users regarding the usability and the UX, and errors can be found before the final product is created.

2.11 Evaluating

The fourth activity of interaction design is *evaluating*. How to evaluate a product or a prototype can vary massively depending on the project. However, it is usually done by conducting user tests and usability tests. By doing that, the designers can get user input and determine if the established requirements and user needs are being fulfilled.

2.11.1 Usability Testing

Usability testing is usually carried out when a prototype or design has been developed. By doing this type of testing, the designers can investigate whether the design works as intended. In other terms, usability testing is all about understanding if the design works in practice or not. By doing this type of testing, the designers can discover issues with the prototype, improve functionalities and validate if the users succeed in using the prototype as intended [33].

There are different techniques and ways to conduct usability testing. The relevant theories and methods used for this master thesis are presented below.

Comparison Testing

Comparison testing is a method that can be used to get feedback about various designs. By comparing design alternatives, the designers can get an insight into which solutions the users prefer. It also helps the designers decide which solutions work for the users and which do not. Doing comparison testing means that the test participants look at two or more prototypes side-by-side and ask themselves which one they like the most in terms of the design and UI [33].

Think Aloud

Think Aloud is a method often used when doing usability testing. It means that the test participants are encouraged to continuously comment and explain their actions and intentions during the test [33]. Letting the test participants express their delight, confusion, or frustration aloud makes it easier for the test leader to read the test participant's thoughts and understand what happens during the test.

There are many benefits of using the method, and it can often be beneficial. The method can provide much information that can be difficult to ask for in debriefing sessions. Additionally, the method can help the test participant stay focused and concentrate on the task [33].

Observation

Doing observations of the test participants is common when doing usability testing. The observations help the team understand how the test participant performs and results in quantitative and qualitative data. In addition, by doing observations, it is possible to analyze how the test participant interacts with the product, and the environment [33].

Debriefing

Debriefing is often conducted after a test is performed and is a very important moment. A debriefing session gives a chance for the test leader to question and discuss different things that happened during the test with the test participant [33]. It is a chance to get clarity on things, and it is an excellent opportunity for the test leader to collect subjective data. By having a debriefing session, the test leader can understand why the test participant acted as he or she did during the test. It is essential to perform since it is possible to get information about what the test participant experienced during the test session [33]. In addition, there is room to ask the test participant more specific questions and can thus supplement the information that might have been missed during the test.

2.11.2 Usability and User Experience Questionnaires

To get subjective and quantitative data about the product, it is common to have a questionnaire or a rating scale with answer options that can be easily quantified after the test session. Different types of questionnaires can be used for this. However, the two used in this project are System Usability Scale and AttrakDiff, and both of them will be presented below.

System Usability Scale

System Usability Scale (SUS) is a questionnaire that asks general questions about the product and how useful it feels. It aims to measure the users' satisfaction and focuses on their previous experiences and feelings [33].

SUS consists of ten statements that examine the usability of the product. Each statement has five answer options and a neutral midpoint according to a Likert scale [33]. The questions alternate between being a positive statement and a negative statement. Compiling the results from each question makes it possible to calculate a SUS score. How to calculate the score can be seen in the mathematical expression below, see equation 2.1. The score ranges from 0 to 100, and a higher score indicates better usability. Usually, a result of 71-80 or above indicates a good product, while a result of 51-60 and below indicates shortcomings in the design.

$$i = 1 - 10$$

Completely disagree: $x(i) = 1$

Completely agree: $x(i) = 5$

$$SumPos = \sum ((x(i) - 1))$$

for $i = 1, 3, 5, 7, 9$

$$SumNeg = \sum ((5 - x(i)))$$

for $i = 2, 4, 6, 8, 10$

$$Score = (SumPos + SumNeg) \cdot 2,5 \quad (2.1)$$

AttrakDiff

AttrakDiff is another rating scale that can measure the user perception of a product. The goal is to examine both the pragmatic quality in the form of functionality and efficiency, as well as the hedonic quality in the form of enjoyment and attraction value [4]. The method is based on a semantic differential and explores the attitude towards the product. Each attitude is represented by two adjectives that oppose each other. There are 28 different word pairs, and the test participant has to decide which adjective best describes the product being tested on a seventh-graded scale. A score is then calculated for each pair of adjectives to understand the product's attractiveness.

Chapter 3

Design Process

In this chapter, the design process used for the thesis will be presented in detail. The process consists of the four activities of interaction design; establish requirements, designing alternatives, prototyping, and evaluating. Moreover, all the design decisions are presented and motivated.

3.1 Establish Requirements

The design process started with the activity *establish requirements*. A literature study was first done to do research and to investigate the field connected to flight habits and the aviation industry. This is to get an overview of the complexity of the particular circumstances on airplanes and understand the context. Secondly, a major user study was conducted to identify the users and their needs. Based on the literature study and the user study, the requirements could be established.

3.1.1 Literature Study

A literature study was carried out in the initial stage of the thesis work. The study was comprehensive and focused on finding relevant information about flight habits and passengers' flight behaviors. Additionally, methods and theories related to interaction design and UX were studied. The relevant literature was mainly retrieved from Lund University's library resources. One access point used a lot was *LUBsearch*¹, which gave access to numerous databases. One database used was *Scopus*², which has a vast range of peer-reviewed articles. When searching for information of interest, different keywords related to the master thesis were used, for example; *IFE, flight, passengers, game habits* and *universal design*. In addition to *LUBsearch*, *Google Scholar*³ were also used to find relevant information, as well as theoretical

¹<https://www.lub.lu.se/en/find/lubsearch>

²<https://www.scopus.com>

³<https://www.scholar.google.com>

books with information about design. In addition, Tactel also provided relevant articles and summaries about flight statistics.

The unique environment on airplanes can cause negative stress, and physiological and psychological discomfort [23]. Thus, inflight entertainment (IFE) systems are often installed on long-haul flights to entertain passengers and increase their comfort level. Despite this, Yao and Vink [41] have done a survey about passengers' experiences on long-haul flights and say that people get bored fast on flights if the entertainment alternatives offered are limited and non-interesting. The authors also say that "feeling bored also makes people more sensitive to their levels of physical comfort..." which means that there is a risk that the passengers are experiencing a feeling of discomfort when being bored [41]. Alamdari is on the same track and states that passengers traveling in economy class often have problems staying entertained because the seat configuration makes it problematic to relax or sleep [2]. Patel and D'Cruz [29] also touch on this topic and conclude that it is a unique challenge to try to enhance passenger comfort within the environment of the air cabin.

Due to the circumstances, Alamdari further states that it is essential that the airlines find ways to entertain and satisfy the passengers in economy class [2]. Liu and Rauterberg [24] agree with this but point out that it is challenging to develop an IFE system that suits all the passengers since the target group for people flying is so broad. The passengers vary in, for example, gender, age, and ethnicity and have different entertainment preferences that might be individual. Moreover, Cole, Robinson, Brown, and O'Shea [8] mean that cultural and demographic background also has an impact on what passengers accept when it comes to their expectations of comfort. However, La, Bil, and Heiets [22] mean that offering an IFE system in multiple languages is one way to enhance passenger satisfaction.

Additionally, Richards, Jacobson, and Kuhlthau [32] mean that engaging passengers with activities can help them from noticing discomfort. Liu [23] gives an example that music and games can help reduce the stress that passengers experience during a flight. However, developing aircraft games has its challenges that need to be considered. Most importantly, the game being played should not affect the behavior of the users in a way that bothers the neighboring passengers or jeopardizes the plane's safety. Patel and D'Cruz [29] also mention this in their paper, stating that noise and undesired interaction from neighboring passengers can be annoying and prevent a passenger from performing preferred activities. Another challenge to take into consideration when developing games for airlines is stated by Akl, Gayraud, and Berthou [1], who means that there are considerable engineering challenges concerning providing a gaming experience with high quality in the aircraft cabin. Nowadays, many passengers are used to sophisticated computer games with excellent game performance and video rendering. A risk with this is that the passengers might have high expectations of the provided games in the IFE and that the games, in turn, cannot meet the users' expectations.

La et al. [22] have written a paper on how digital technologies can impact airline operations. In their study, it can be seen that digitization is a strategy that can be used to enhance customer loyalty. Offering the passengers an up-to-date IFE system is a way for the airlines to differentiate from other competitors. This is also well in line with what Alamdari [2] states, which means that product differentiation is a way for companies to surpass their competitors. Thus, all authors mean that providing an IFE system with a good selection of entertainment services can contribute to a passenger choosing a particular airline when booking a flight. Consequently, this can attract more customers and, in that way, positively affect the annual revenue of the airlines. Important to remember, however, is that different passengers have

different expectations of the IFE. A study made by Gilbert and Wong [15] show that West European and North American passengers have lower expectations of the IFE than passengers from Japan or China, which have higher demands.

3.1.2 User Study

The literature study provided a better understanding of the purpose of the thesis. Delimitations about the target group could be made based on this, for example, only focusing on passengers traveling in economy class since they have problems staying entertained on long-haul flights [2]. Another delimitation was to only focus on adults since they stand for over 96% of the travelers worldwide [18]. Based on this information and the literature study, the primary, secondary, and tertiary users could be identified.

The primary users are passengers from all over the world flying long-haul flights in economy class. These passengers get easily bored and have problems resting. Additionally, the primary users like to explore what the IFE offers and are not afraid to try new technology. The secondary users are the indirect users who, in some way or another, will be involved in the primary users' interaction with the IFE. These can, for example, be the neighbors, the travel company, or the flight attendants. Finally, the tertiary users are stakeholders, like Panasonic Avionics Corporation, the cabin crew, and the airlines, who all have a profit interest in the development of the IFE.

The objective of the user study was to understand potential users and their needs within the subject of games and flight habits. The methods used in the study were both an online questionnaire and semi-directive interviews to gather quantitative data and qualitative data. By doing this, the principle of triangulation can be accomplished. The principle intends to combine data gathering methods to get both variants of data [30].

Questionnaire

The online questionnaire was made with Google Forms⁴ and consisted of three sections; background information, previous flight experience on long-haul flights, and game interest. In the background information, questions about demographics were asked to see if the respondent fitted into the target group. The questions related to previous flight experience focused on flight habits, such as how they stay entertained on long-haul flights and if there are things that annoy them during flight. The most important question in this section was to find out what travel class the respondents mostly fly in, since the previously mentioned delimitation about focusing on passengers traveling in economy class. The last section focused on finding out previous experience in playing games on the IFE system and what game preferences each respondent has. Additionally, questions about multiplayer games were also asked to map out possible categories for the multiplayer game being developed in the thesis. All the questions in the questionnaire can be found in Appendix A.1.2.

The questionnaire aimed to have questions with predefined answers as alternatives to make it as easy as possible for the respondents to answer quickly, as well as make the output easy to analyze. Therefore, some questions had multiple choice answers, while others had a Likert scale grading between 1-5 [33]. To also collect some qualitative data from the questionnaire, some optional questions were asked as free-text answers. Two pilot tests were made

⁴<https://www.google.se/intl/sv/forms/about/>

before the questionnaire was sent out on different forums. Valuable feedback was given, and some questions were rephrased before publishing the final questionnaire.

The questionnaire was first published on various forums and personal pages on Facebook⁵. It was also sent out to people working at the Department of Design Sciences at the Faculty of Engineering at Lund University. Additionally, it was published on one of the largest flight forums in Scandinavia for frequent travelers. In total, the questionnaire was published in 14 different places for five days.

The questionnaire got 425 responses, which means that the data can be used as a solid ground when establishing requirements. 56.2% of the respondents were women, 43.5% were men, and 0.3% of the respondents preferred not to answer. After filtering out the relevant respondents, 326 answers could be used. The ones that could not be used were the respondents who had not been on a long-haul flight once within the last ten years and the respondents who mostly fly in another travel class than economy class. The age interval of the respondents was between 16 to 79 years, with an average age of 37.3 years of age, and the median age was 33 years. The gender distribution of the respondents was now 65.3% females, 34.4% males, and 0.3% who preferred not to answer. Of the collected answers, it can be seen that 63.2% of the respondents fly long-haul flights 2-10 times in ten years. Additionally, 54.8% fly for holiday.

Interviews

In addition to the questionnaire, six semi-directive interviews were conducted to collect qualitative data. It was five user interviews and, in addition, one subject matter expert (SME) interview.

The questions for the five user interviews were divided into the same sections as the questionnaire. In addition to these sections, questions related to the project idea were asked to get valuable feedback and involve potential users. The asked questions can be found in Appendix A.2.1. Since the interviews had a semi-directive structure, the interviewer could ask more questions than the pre-established interview guide and change the order of the questions when needed. Additionally, the interviewees were able to give more detailed and comprehensive answers in comparison to the questionnaire. The interviews took 30 minutes and were all recorded. Two of the interviews were face-to-face, while the remaining were carried out remotely with video cameras. Both in the team attended the interviews and switched roles between holding the interview and taking notes.

The interviewees that participated were all a part of the target group, and the goal was to have a good distribution between both age and gender. Therefore, the interviewed persons were two females, aged 26 and 31, and three males, aged 23, 35, and 55. All interviewees were Swedish. In addition, these people were interviewed because of their differentiating behavioral and demographic variables. Things considered were their frequency of flying, the purpose of flying, flight habits, and interest in games.

The SME interview was held with a flight attendant at one of the world's largest airlines. She is 51 years old, has 23 years of flight experience, and has done over 500 long-haul flights in her position. With her expertise, valuable insights and perspectives within the flight domain could be presented. The questions asked to her were regarding the duties of the flight attendants during a flight, passengers' flight habits, how the passengers utilize the IFE from

⁵<https://www.facebook.com>

her perspective, and an open discussion about the project's idea. The questions can be found in Appendix A.2.2. The interview took 50 minutes and was remote, with both team members attending. Also, this interview was recorded.

3.1.3 Results From User Study

Presented below are the results from the user study, including the questionnaire and the six interviews.

Questionnaire

The results are based on the 326 valid answers from the questionnaire, and all calculations and percentages presented are based on this number. Since 65.3% of the filtered responses came from women, some of the analyzed data are divided into gender categories to avoid bias. The results are divided into the same sections as the form, and the main takeaways are presented below. The takeaways are based on the diagrams from the user study, which can be found in Appendix A.3.2.

Flight habits:

- There are 35.0% of the passengers in economy class that struggle both with sleeping and staying entertained. Of these 35.0% are two-thirds women.
- 54.8% of the passengers travel for the purpose of holiday and 63.2% travels between 2-10 times per ten years. This indicates that long-haul flights are something most passengers rarely do.
- The three most popular activities to stay entertained during a long-haul flight are watching movies/series, listening to music/podcasts, and reading. The fourth most preferred activity to stay entertained is to play games on devices.
- Top three things that disturb the passengers are neighbors taking too much space, neighbors talking too much, and the ones leaving their seats too often.

Game preferences:

- The general game interest that the respondents have is similar to a normal distribution curve, as can be seen in Figure 3.1. A Likert scale is seen, where the number 1 corresponds to *not so interested*, while the number 5 corresponds to *very interested*. Most of the respondents have estimated their game interest to average.
- 43.3% of the respondents play some kind of multiplayer game today.
- The women prefer to play quiz games, board games, word games, and cards. On the other hand, the men preferably play strategy games, action/adventure games, quiz games, board games, and word games. Consequently, the three mutual game preferences are quiz-, board-, and word games. An overview of the game preferences can be

seen in Figure 3.2. Some favorite games were expressed in the optional field. The most commonly mentioned games were *quiz*, *Wordfeud*⁶, and *Candy Crush*⁷.

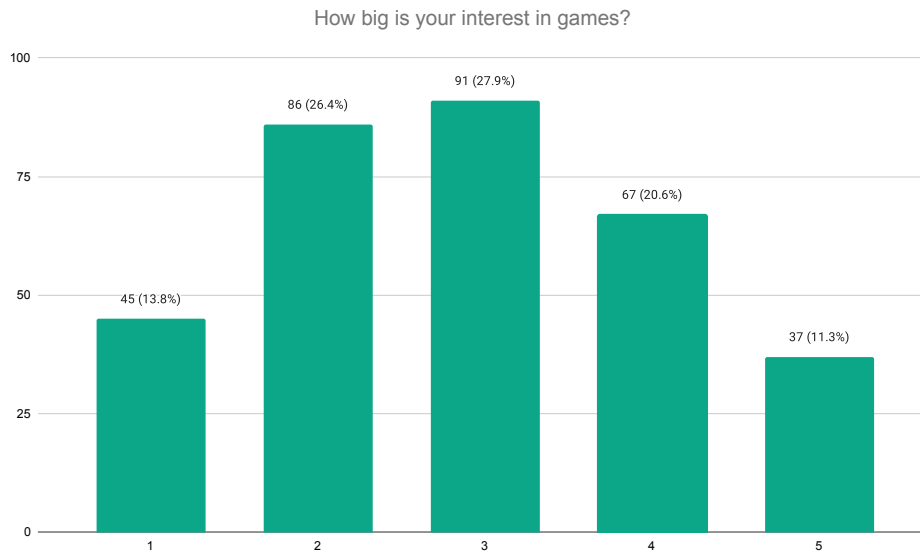


Figure 3.1: Diagram of game interest from user study. 1 corresponds to *not so interested*, and 5 to *very interested*.

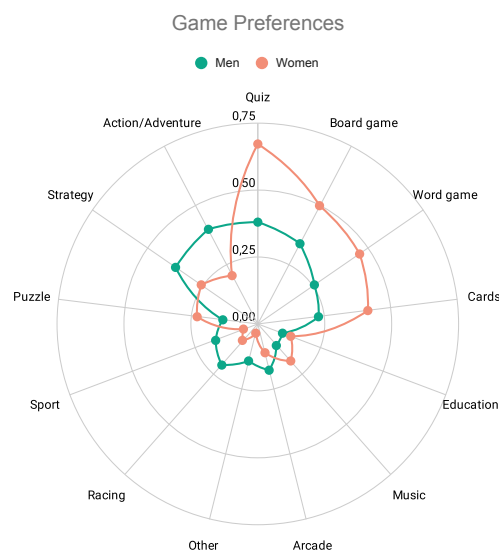


Figure 3.2: Diagram of game preferences from user study. The numbers shown are percentage statistics.

⁶<https://www.wordfeud.com>

⁷<https://www.king.com/game/candycrush>

IFE and technology:

- 51.8% are willing to interact with the IFE from their own device. However, 27.6% answered that they did not know. In the optional question, four respondents expressed concern about connecting their device to the IFE due to security risks.
- 43.9% of the respondents have tried to play games on the IFE before. The games tried are mainly cards, puzzles, and arcades.
- The majority of the respondents are willing to try new technologies and feel quite confident in doing so.

User Interviews

All the interviewees had one flight activity in common: they enjoyed looking at and interacting with the flight map on the IFE, including all types of information displayed. Besides this, the interviewees had some requirements and suggestions regarding the game and gave many examples of things to consider. Moreover, they had some ideas related to the multiplayer aspect and the actual game. All suggestions and ideas are presented in the lists below.

Requirements:

- A game that is stylish.
- A game that is innovative.
- A game that looks good graphically.
- A game with high responsiveness.
- A game that is challenging.
- Have a stable connection.
- Have rules that are easy to learn.
- No delay on the IFE.

Suggestions:

- Display information about how many passengers are playing at the moment.
- Have a scoreboard.
- Have the ability to pause the game.
- Have a game with a learning aspect.
- Important with the social aspect, some kind of interaction among the players would be appreciated. Suggested ideas were a chat or sending emojis.
- The ability to win rewards.
- The importance of having different levels.
- The idea of interacting with the IFE with personal devices was appreciated.

Multiplayer aspect:

- Having the opportunity to play with anyone on the flight.
- Play together as a row or with travel companions.
- The importance of having the opportunity to stay anonymous, especially if playing with strangers.
- Would be fun to pick whom to play with.

Game ideas:

- Card games, strategy games, classic board games, quizzes, and geography games.
- Games like *Mario Kart*⁸, *GeoGuessr*⁹ and the format of the Swedish TV game show *På Spåret*¹⁰.
- Specific quiz ideas mentioned: having questions about the destination, the flight route, and questions about the place being flown over at the moment.

Subject Matter Expert Interview

The subject matter expert (SME) interview gave another perspective on passengers' flight habits compared to the user interviews. Additionally, an overview of the entire flight experience for the passengers from a different perspective was also described.

The flight attendant explained in detail what duties they have during a long-haul flight. There are several moments where the flight attendants interact with the passengers. Except for serving food and drinks, they also interact when handing out forms or customs documents and every time a passenger needs help or wondering about something. Additionally, they have complete responsibility for ensuring everyone is well during the flight.

Due to the interviewee's long experience in the industry, she has a different perspective on the passengers' flight habits. She explains that there is a big difference in how well the passengers can rest in business class versus economy class due to the ergonomics of the seats and better facilities offered. Furthermore, she perceives that most passengers in economy class can keep themselves entertained by watching movies, eating, drinking, or sleeping. In recent years, one significant change that she has noticed is that passengers are increasingly bringing their own devices to stay entertained and watch their own choice of movies or play games. Additionally, the interviewee confirms that most passengers become most impatient when there are about two hours left on the flight. It is the same thing regardless of flight time.

The interviewee explains that she can see distinct cultural clashes depending on which destination she is flying to or flying from. For example, she claims that Scandinavians tend to have a great need for a large personal space, while passengers of Asian origin generally are quite the opposite. Depending on the origin, there is a difference in how disciplined or how loud and chaotic the atmosphere in the aircraft cabin is. However, these cultural clashes

⁸<https://www.mariokart8.nintendo.com>

⁹<https://www.geoguessr.com>

¹⁰<https://www.svtplay.se/pa-sparet>

mainly occur when boarding or when the plane gets emptied. Her feeling is that more and more passengers want to be at peace when flying; they do not want to be disturbed. It is more common nowadays that they put on their headphones directly, sometimes even before boarding.

Moreover, she explains that most of the passengers interact with the IFE in some way. The primary activities for the passengers are watching movies/series or listening to music. Additionally, many passengers are interested in watching the flight map to see how their journey progresses. She has also seen that some passengers like to play digital games when flying, either on their own device or on the IFE. Among the games they offer on their IFE, *Sudoku* and *Mahjong* are the ones preferred. Furthermore, she explains that you can see each other's screens in some way, but depending on the angle, you can see more or less.

Lastly, she gave her perspective on the idea of offering a multiplayer game on the IFE. Her initial reaction was: *"It sounds very fun! It is something completely new, and it has been a long time since something new came into the aviation industry. I think it would be highly appreciated."* However, she stated some things that need to be considered in her opinion. Firstly, the difficulties with the language. Many travelers do not know any English. On some flights, they offer English, Japanese, and Chinese on their IFE, but that is often not enough. Secondly, she is wondering how much desire there is for a multiplayer game since, in her opinion, many passengers do not want to be disturbed or want to interact more than necessary socially. Nevertheless, despite that, she was very positive about the idea.

Summary

An affinity diagram was first made to get an overview of the results from the questionnaire and the six interviews. In the diagram, the different outcomes from the user study were organized into categories. After that, the card sorting method was used to categorize the ideas further. Two main themes could be identified based on the affinity diagram and the card sorting method; these were *game ideas* and *concepts*, which include interaction possibilities and overall ideas. An overview of the process and the themes can be seen in Appendix A.1.

3.1.4 Personas

Three personas could be created based on the literature study, user study and the gathered data. The characteristics, goals, and personalities are invented yet realistic because the information is based on data from the user study. When creating the personas, attempts have been made to cover all possible factors of interest and aim for a great variety of users. The personas create sympathy and empathy for us and make it easier to discuss design alternatives and design a product accordingly.

The personas Steven, Isabella, and James are presented in Figure 3.3, 3.4 and 3.5. The three personas have different travel habits, game preferences, and backgrounds. Under each persona, their motivations, frustrations, interests, and goals are described. Moreover, their characteristics are also presented. The different citations for the three personas are taken directly from the free-text answers from the questionnaire and the interviews. The personas will be used as references for the typical users during the development.



Figure 3.3: The persona Steven.



Figure 3.4: The persona Isabella.



Figure 3.5: The persona James.

3.1.5 Requirements

Based on the identified users' needs from the user study, a list of requirements could be established. The requirements specify what functionalities the prototype should have and for what purpose it is developed. The list of requirements is presented below.

- *REQ.1:* Aim for a challenging, entertaining, and motivating game.
- *REQ.2:* Aim to be personal, but still preserve a traveler's integrity.
- *REQ.3:* Present different levels.
- *REQ.4:* Interaction between players should be possible.
- *REQ.5:* Offer different language possibilities.
- *REQ.6:* Aim for an ergonomic seating position.
- *REQ.7:* Aim to not disturb neighbors.
- *REQ.8:* Involve Arc.
- *REQ.9:* Should be suitable for a wide variety of users.

3.2 Designing Alternatives

The second activity in this thesis was *designing alternatives* for the multiplayer game. This could be done when the requirements were established. The phase is divided into conceptual and physical designs, described further in this section.

3.2.1 Conceptual Design

A conceptual design could be created based on the personas and the requirements. Various methods were used to establish concepts and metaphors that should be used in the prototype.

The conceptual design phase has involved setting goals for the project, one brainstorming workshop with designers at Tactel, brainstorming regarding concepts, and creating a storyboard. Details of each step are presented below.

Goals

When designing and developing a product, it is essential to set different goals for what to achieve when the project is completed. Doing this makes it easier for the people in the team to have a common picture of what to strive for. Additionally, it is easier for the team to discuss various factors when needed. For this project, three different types of goals have been established, these are: *user experience goals*, *usability goals* and *efficiency goals*.

User experience goals: The user experience (UX) goals show the product's subjective qualities. It is about how the product feels to the user and how it behaves when used by people in real life [30]. When working out these goals, both the desired and unwanted aspects of the product is taken into account. The UX goals for this project are:

- *UX goals to achieve:* Fun, enjoyable, motivating, engaging, challenging, surprising, pleasurable, enhancing sociability, rewarding, exciting, entertaining, and aesthetically pleasing.
- *UX goals to avoid:* Frustrating, annoying, unpleasant, and making one feel stupid.

Usability goals: The usability goals are the objective goals for the product being developed. The purpose of the goals is to provide the team with a concrete method to evaluate different aspects of the development [30]. By having these goals in mind, the designers can be aware of potential design problems and design conflicts at an early stage in the process and prevent them from occurring. The usability goals are:

- *Effectiveness:* How good the system is at doing what it is supposed to do.
- *Efficiency:* The way a system supports users in carrying out their tasks.
- *Safety:* Protecting the users from dangerous conditions and/or undesirable situations.
- *Utility:* Extent to which the system provides the right kind of functionality so that users can do what they need or want to do.
- *Learnability:* How easy a system is to learn to use.

- *Memorability*: How easy a system is to remember how to use once learned.

Efficiency goals: The efficiency goals give an answer to why a project should be developed and implemented [30]. The goals are based on the quantitative and qualitative data from the user study. The efficiency goals are:

- For the passengers to get a good flight experience where they feel entertained and make the time pass quickly.
- For the airlines to make better use of the capacity of the IFE and the 3D engine that Arc utilizes.
- For the airlines to market their destinations.

Brainstorming I - Workshop

A workshop with a brainstorming session was held at Tactel to generate ideas for the project. The session was held by us but done in collaboration with the other thesis students at Tactel, the authors of *Developing a Multi-Passenger Game for Inflight Entertainment Systems* [6] and *Multiplayer Entertainment on Short-Haul Flights* [7]. 13 persons participated in the workshop, ten of these working with design at Tactel, and the rest were the other thesis students. Seven participants did the brainstorming at Tactel's office, while the other six participants did it remotely. The participants were divided into two groups; thus, six participants generated ideas for our thesis. A picture from the workshop can be seen in Figure 3.6.

The brainstorming session was 30 minutes and started with a short presentation of the project to set the context for the participants. Then, the user study's three main categories for game preferences were presented, and the workshop's purpose was further clarified and explained. The main goal for the session was to generate as many innovative ideas and design solutions as possible for a multiplayer game and different interaction methods.

The method used during the brainstorming was similar to Method 6-3-5. However, the difference was that the participants were encouraged to generate as many ideas as possible instead of only three each and that only three rounds of iteration were made instead of five. The digital tool Miro¹¹ was used for the brainstorming session. Each participant got one digital board where they put their ideas on sticky notes. A new color was chosen for each new round for the sticky notes. In addition, a couple of keywords connected to the project were seen up to the left on each board. These helped the participants to get inspired and reminded of the purpose. An visualization of the boards in Miro can be seen in Figure 3.7.

Analyze of Material

To analyze the workshop's outcome, an affinity diagram was firstly created in Miro to identify and organize the data into categories. Then, by using the card sorting method, the affinity diagram could be further categorized by putting labels on the different identified themes. A visualization of the affinity diagram can be seen in Figure 3.8.

After doing the affinity diagram and the card sorting, the result was further sorted into hierarchical order. Based on this, two main themes were identified, the same ones as in the

¹¹<https://www.miro.com>



Figure 3.6: Brainstorming session with employees at Tactel.

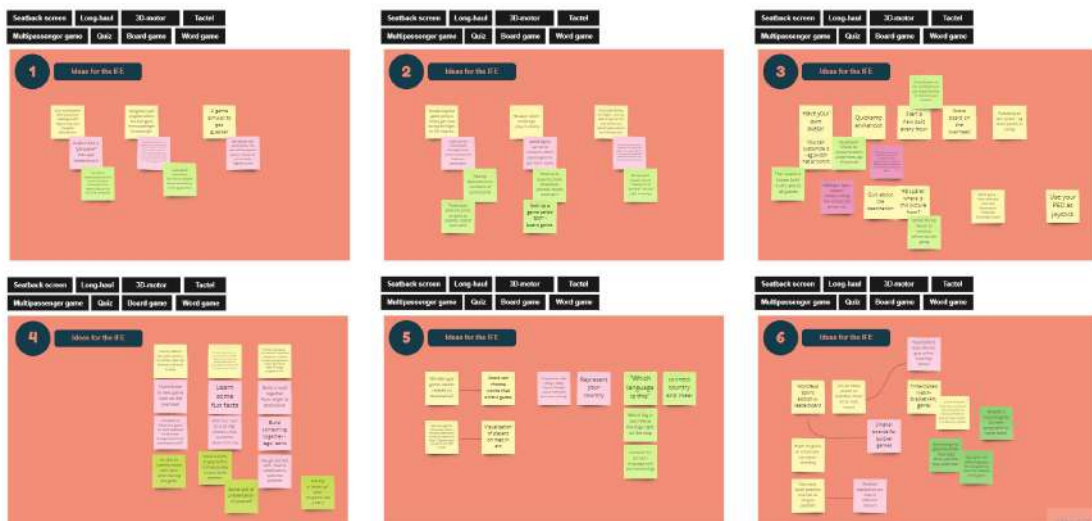


Figure 3.7: A visualization of the boards in the digital tool Miro.



Figure 3.8: A visualization of the affinity diagram after card sorting.

affinity diagram from the user study (see Figure A.1), *game ideas* and *concepts*. The diagram from the brainstorming can be seen in Figure B.1. The resulting hierarchical order gave an overview of all the ideas from the workshop.

Since both the affinity diagram from the user study and the affinity diagram from the workshop had the same main categories, they were merged to get a better overview of all the ideas. Then, dot voting was carried out to sort out the interesting ideas. We had unlimited votes and voted for all ideas that were relevant and of interest. The ideas without votes were then discarded. The dot voting made it possible for us to narrow down the game ideas to only three comprehensive concepts related to the three game preferences from the user study; *quiz*, *board game* and *word game*. Presented below are the ideas related to the three main concepts for the multiplayer game.

Board game:

- A game inspired by *Cluedo*¹² where crimes are solved together as a team.
- A game inspired by *Escape Room*¹³ where the team needs to find clues to win the game.
- Having a main task related to a destination where the player can get hints about the continent and country et cetera along the way.
- A game related to the flight map. It could be inspired by *GeoGuessr* where the player

¹²<https://www.en.wikipedia.org/wiki/Cluedo>

¹³https://www.en.wikipedia.org/wiki/Escape_room

should find a specific place on the map with as few steps as possible. Along the way, clues could be given to find the specific place.

Quiz:

- A game inspired by the Swedish concept *På Spåret* and *GeoGuessr*. The player should follow a route on the game plan or the route of the journey, and questions about the route should be answered to get closer to the destination.
- A game that utilizes Arc's database for the questions and where the passengers can find answers to the questions based on the information provided in the map on the IFE.
- A game where one player pins a place on the globe, and the other players try to get as closest to the pin as possible with help from a picture.
- A game with questions about tourism-related topics about the destination that the flight is going to.

Word game:

- A game inspired by *Wordfeud* and *Wordle*¹⁴ where questions and words are related to the destination.
- A game where the player should guess the language of the word presented.

The advantages and disadvantages of the three main concepts were discussed further to decide the final concept for the multiplayer game. From the questionnaire in the user study, it could be seen that word games were the least preferred game preference of the three concepts presented. Consequently, the ideas connected to the concept of a word game were sorted out. The final concepts landed in combining the ideas from the above-mentioned quiz- and board game ideas. The relevant ideas from these two concepts are presented below in combination with additional ideas for the game that came up during a discussion.

Final ideas:

- A game related to the flight map. It could be inspired by *GeoGuessr* where the player should find a specific place on the map with as few steps as possible. Along the way, clues could be given to find the specific place.
- Have a game plan that is inspired by a physical board game such as *Ticket to Ride*¹⁵.
- A game that utilizes Arc's database for the questions and where the passengers can find answers to the questions based on the information provided in the map on the IFE.
- A game with questions about tourism-related topics about the destination that the flight is going to.
- Having a quiz with questions related to the specific flight route and the places that the player is flying over at the moment.

¹⁴<https://www.nytimes.com/games/wordle/index.html>

¹⁵[https://www.en.wikipedia.org/wiki/Ticket_to_Ride_\(board_game\)](https://www.en.wikipedia.org/wiki/Ticket_to_Ride_(board_game))

- A game inspired by the Swedish concept *På Spåret* and *GeoGuessr*. The player should follow a route on the game plan or the route of the journey, and questions about the route should be answered to get closer to the destination.

The ideas presented above are well in line with the result of the user study. This is since the game can have a learning aspect and can be challenging. Additionally, the game gives a possibility to have a social aspect and to provide a game with different levels. Moreover, this idea of a game could be highly appreciated since it is a combination of the suggested game ideas from the interviews.

Brainstorming II - Concepts

An additional brainstorming session with the two authors was held to specify and visualize game ideas and interaction concepts for the actual game. Firstly, a ten-minute session was held where the focus was on generating game ideas. Each team member wrote the ideas down on physical sticky notes and then sorted them into different categories using the methods affinity diagram and card sorting. The identified categories were *rating and clues*, *game plan*, *the use of Arc/the live map*, *language*, *ideas for questions*, *thoughts*, and *other*. Presented below are the chosen ideas, thoughts, and concepts generated from the brainstorming for each category.

- *Rating and clues*: Treasures hidden on the map and collected clues can become bonus points, the rating system should be connected to correct answers and clues.
- *Game plan*: Can be a globe, can be a net where different dots are the destinations, answer questions to move forward in the route, a route connected to the airline's destination, a game similar to *Diamant*¹⁶.
- *The use of Arc/the live map*: Find the answers to the questions based on the information provided from Arc.
- *Language*: As little text as possible, think about language preferences.
- *Ideas for questions*: Having a wide range of questions/missions, having questions based on different themes, present the questions in each destination.
- *Thoughts*: Think about political aspects regarding national borders and countries, having the game plan on the IFE and answer the questions on your own personal device, think about the multiplayer aspect, should the players solve the assignment by themselves or in a team?
- *Other*: The players should be able to choose their avatar and see where the other players are on the globe. Moreover, an idea is to have different levels and high scores.

Secondly, an identical session was held. However, the theme now instead was to focus on interaction concepts. The identified categories in this case were *teamwork*, *communication*, *personalization*, and *social*.

¹⁶[https://www.en.wikipedia.org/wiki/Diamant_\(board_game\)](https://www.en.wikipedia.org/wiki/Diamant_(board_game))

- *Teamwork*: Work in a team where team members can send requests about clues to each other and where the team can help find information about the destination with the information provided from Arc. A game where the team should help each other to answer questions over the entire globe. Think about how to build a team and how many members that are in a team. The team should be able to win rewards.
- *Communication*: Having a pop-up that shows if a game is in progress. Be able to actively choose if they want to play or not. Think about difficulties with the language. It would be fun to be able to chat with each other but think about what happens if someone sends inappropriate messages.
- *Personalization*: Having an avatar with a chosen name but at the same time be able to stay anonymous.
- *Social*: Important with the social aspect. Being able to see each other on the map. Have real-time ranking, interact with emojis, or by chatting.

Based on the above-presented ideas, a final concept for the multiplayer game was established. It was decided that the game should be a quiz-based trivia where the questions have a connection to the flight routes and destinations provided by the airline. The questions will be presented on a game plan, visualized on a 3D map with inspiration from a physical board game and Arc. The questions for the quiz will be shown on the IFE, and the players can decide if they want to play the game on their own devices or on the screen of the IFE. The players should be able to play in teams, either with their fellow travel company or with random passengers. Moreover, different levels should be available, and some sort of clues can be collected and used when having trouble answering a question. A leaderboard is also something that should be included in the game. If ranked on the leaderboard, the player will win some sort of reward. Furthermore, the players could choose their personalized avatar but at the same time be able to stay anonymous. Additionally, the players should be able to interact with each other somehow, for example, by using emojis or by having a chat.

Storyboard

Based on the final concept for the multiplayer game, a storyboard could be created as a last part of the conceptual design. Two individual storyboards were first created. Doing this made it possible for us to discuss and compare each other's conceptual models and thereby select the best concepts in each one. The chosen concepts were then merged into a mutual storyboard.

The final storyboard can be seen in Figure 3.9. It shows what a flight experience can look like for a traveler when interacting with the IFE and discovering the multiplayer game. Many of the fellow travelers get involved, and they enjoy their time on the airplane. This is the context that we have to keep in mind when designing the prototype.

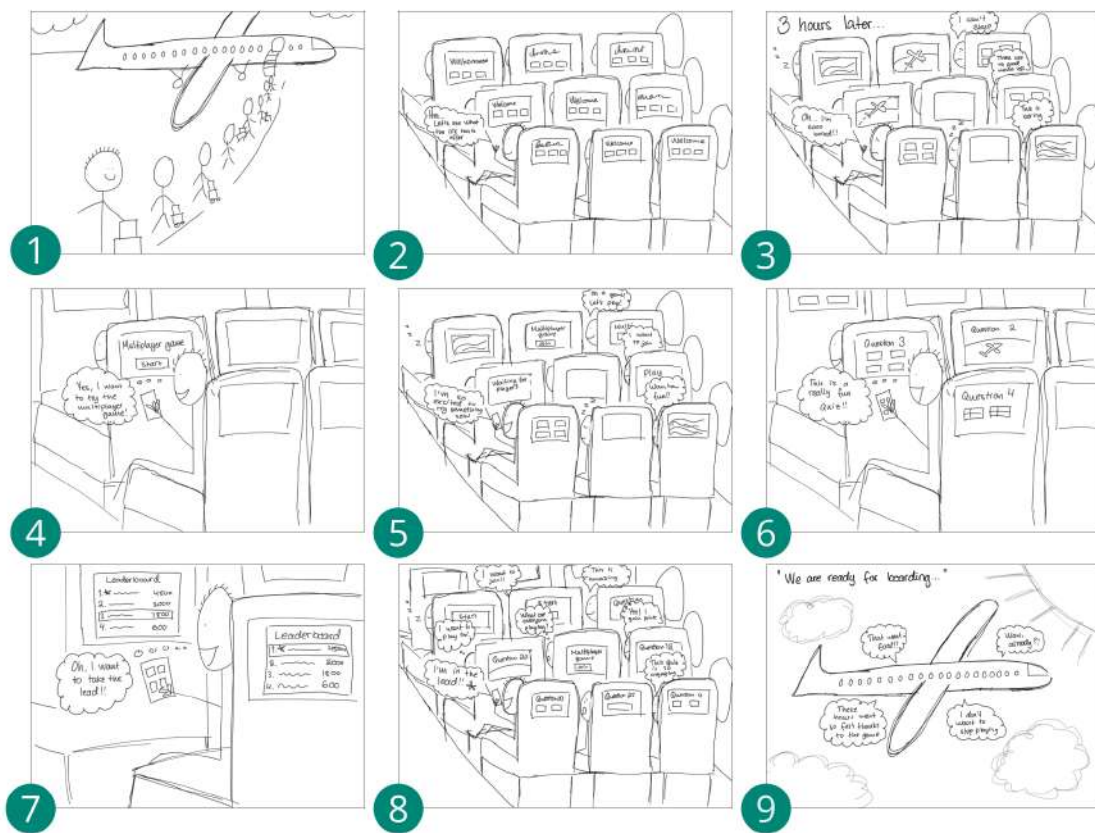


Figure 3.9: The mutual storyboard.

3.2.2 Physical Design

As a second part of the activity *designing alternatives*, the physical design could be created. To visualize the structure of the game, a project breakdown structure and a user flow were made. These are presented more in detail below.

Project Breakdown Structure

To get a hierarchical overview of the system being developed, a project breakdown structure (PBS) was created. The different eligible functions were established as well as the structure of the prototype. We got a mutual, visualized overview of what to accomplish by doing this. It was easier to decompose each functionality into sub-functionalities by having the user's needs, goals, and requirements in mind.

As seen in the PBS in Figure 3.10, the user first starts on the welcome page on the IFE, followed by instructions on how to connect the phone to start playing. When the connection is established, the user is forwarded to the game's home page, where six options are displayed. The four options to the left lead the user to different pages displaying different information and options. The option called *start game* leads the user to the actual game plan. Here the user answers the questions that have a connection to Arc's database. The user here uses the phone to answer the questions. If help is needed, an option showing instructions is also presented.

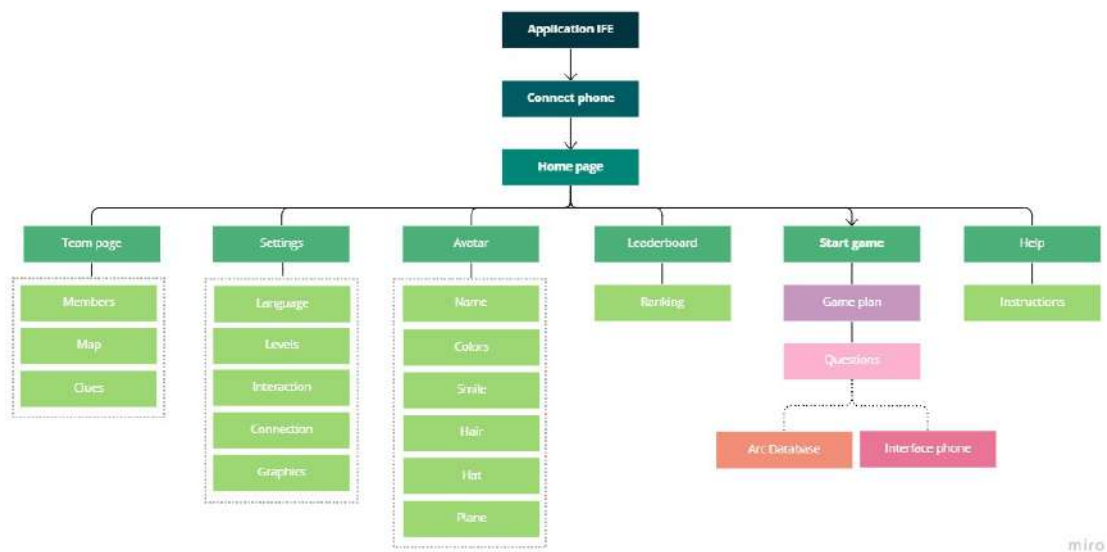


Figure 3.10: The project breakdown structure (PBS).

Selection of Prototype Functions

The prototype being developed will be a T-prototype. This means that the prototype will have both horizontal and vertical depth. The functions implemented horizontally are not implemented in-depth. However, it looks like they are finished and appear to work. The functions implemented vertically are instead fully functional with more details and work as intended [13].

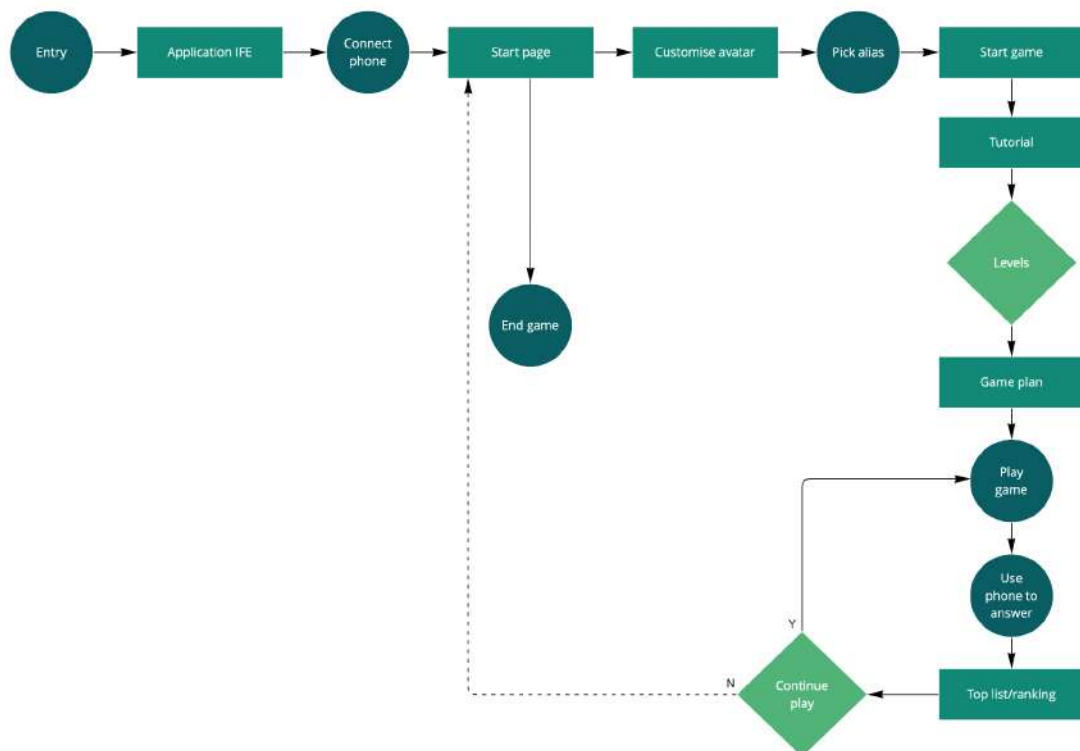


Figure 3.11: The user flow for the *start game*-option.

Based on the PBS and the principle of a T-prototype, the two main functions that should be implemented vertically were decided. These functions are the actual game, that is the option called *start game* and *settings* in PBS. The reason why settings are one of the two main functions is because it makes it possible for the users to customize the game experience according to their preferences. Hence, many of the UD principles can be met.

User Flow

Based on one of the selected main functions, start game, a user flow was created. The user flow visualizes the users' complete path from entering the application on the IFE to ending a game. The flow is presented in Figure 3.11. The circles represent an action for the user. Furthermore, the rectangle represents a page or a screen that the user can interact with. However, no action is needed to be taken here. The diamond-shaped figure represents a decision that the user needs to take to progress in the interaction.

3.2.3 Meeting with Stakeholders

Since this master thesis is done in collaboration with Tactel, the opportunity to meet two representatives from Panasonic Avionics Corporation appeared. One of the representatives was the Digital Product Line Manager at the company, and the other was a Senior Director for Digital Product Management. It was an excellent opportunity to meet the thesis's actual stakeholders and pitch the idea of a multiplayer game in the IFE. The overall feedback was very positive, and the stakeholders were interested in seeing how the project progresses. In

addition, they presented that 80% of the passengers like to interact with the map when flying, which confirms that the concept of involving Arc in the game is a good idea.

The stakeholders presented some crucial challenges to have in mind when designing and developing the multiplayer game. First, they have seen a problem engaging passengers with the activities offered on the IFE today. This is because some passengers bring their own devices and interact with them instead of using the IFE. It is a challenge to compete with today's highly developed personal devices. Another aspect to consider is how to make the system personalized without being intrusive since it is a fine line. Furthermore, the passenger data can create added value for the airline and can therefore be an interesting factor for developing this kind of application. Moreover, another interesting value for the airline is the idea of involving their routes and destinations engagingly. An idea from the stakeholders was to involve the loyalty programs in some way since they are vital for the airlines and a way to differentiate from the competitors. Lastly, they expressed the importance of remembering that the IFE has the purpose of being entertaining and fun.

It was an insightful meeting with a lot of valuable thoughts and perspectives. The stakeholders confirmed that the idea for the multiplayer game was comprehensible and innovative. Their valuable feedback will be taken into consideration when designing and developing further.

3.3 Prototyping

The third activity in this thesis was the *prototyping* phase. The conceptual design and the physical design laid the foundation for the prototyping of the multiplayer game. This phase is divided into two phases, a low fidelity (lo-fi) prototyping phase, and a high fidelity (hi-fi) prototyping phase.

3.3.1 Low Fidelity Prototyping

This section will describe and present the process related to the lo-fi prototyping. During the design process, multiple lo-fi prototypes were made; however, the end result where two comprehensive prototypes. The process consisted of a research phase, multiple braindrawing sessions, drawing sketches, feedback sessions, and an evaluation phase.

Research

As a first step in the prototyping phase, research about different popular games was made to get inspiration. Proven concepts and features in the games were analyzed and discussed. According to Sherin [34], research is an important step to do to get information about competitors in the area, what actually works, and to get an overview of what has already been designed, to avoid copying any existing work. The games analyzed were successful, classical mobile games that have existed for a long time and are thus built on concepts and metaphors that seem to work and are appreciated by the users. The apps analyzed were: *Quizkampen*¹⁷,

¹⁷<https://www.sv.wikipedia.org/wiki/Quizkampen>

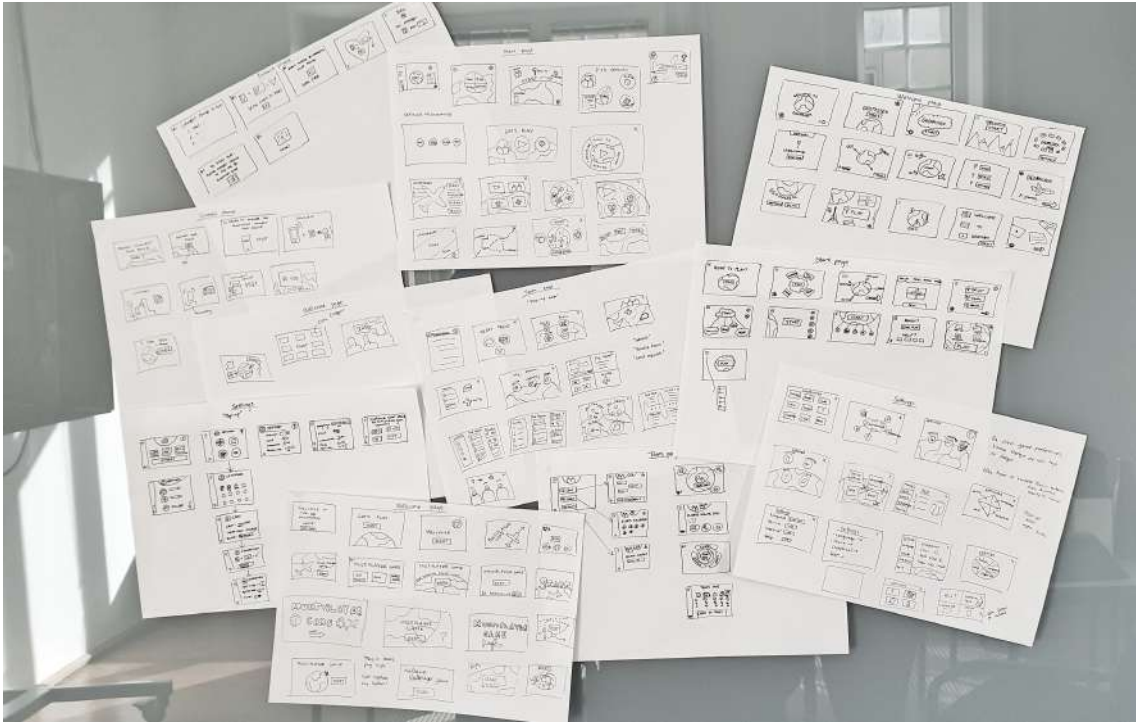


Figure 3.12: A visualization of the result from the first braindrawing session.

*UNO!*¹⁸, *Kahoot!*¹⁹, *Among Us*²⁰, *Toon Blast*²¹, *Candy Crush*²², *Hay Day*²³, *Fruit Ninja*²⁴, *Angry Birds*²⁵, and *Geo Challenge*²⁶, to name a few. Features analyzed were the construction of different views, interaction possibilities, structures of the quiz games, point systems, motivational aspects, and how to make the game personalized by using avatars. The result of the research was then used as inspiration when developing the lo-fi prototypes.

Braindrawing

To start developing the lo-fi prototypes, a variant of a braindrawing session was carried out by us. Five views were in focus for the session. These were the *welcome page*, *connect phone page*, *home page*, *settings page* and the *team page*. For each view, a session of 5-15 minutes was held. All possible ideas for each view were sketched out during this time, and different alternatives were presented. The goal was to produce as many ideas as possible in a short amount of time. An overview of the result from the first braindrawing session can be seen in Figure 3.12.

When the braindrawing session for the different views was completed, dot voting was used to sort out the favorite ideas for each view. The voting was made individually and was

¹⁸<https://www.letsplayuno.com/>

¹⁹<https://www.kahoot.com>

²⁰https://www.en.wikipedia.org/wiki/Among_Us

²¹<https://www.peak.com/products>

²²<https://www.king.com/game/candycrush>

²³<https://www.hayday.com/en>

²⁴<https://www.halfbrick.com/games/fruit-ninja>

²⁵<https://www.angrybirds.com>

²⁶<https://www.holonautic.com/geo-challenge-classic>



Figure 3.13: A visualization of a theme from the braindrawing session after the dot voting.

then merged. The sketches could get zero, one, or two votes each. The sketches with two votes were given the highest priority since we both voted for that sketch. The sketches with zero votes were sifted out.

The prioritized sketches of each view were then sorted into different themes based on the similarities of the graphical elements and concepts. The result was six different themes, each containing the five views that were in focus for the braindrawing session; *the welcome page*, *the connect phone page*, *the home page*, *the settings page* and *the team page*. Moreover, one additional view for *the connect phone page*, *the home page* and *the settings page* was also selected. The purpose of the themes was to present different suggestions on how the layout and design for the game could be developed. There are many different ways to present the same information, and the six different themes show examples of this. An example of one of the themes can be seen in Figure 3.13.

After the braindrawing session related to the views was completed, the same procedure was then carried out for the *game view* and the interface of the *phone view*. The result from the braindrawing session with the focus on the game view can be seen in Figure 3.14. In addition, a short braindrawing session focused on the design of the avatar and different ways to personalize the game was carried out.

Sketches

Based on the result from the braindrawing sessions, the sketches for the five views and the game view were redrawn more thoroughly. Presented in Figure 3.15 a poster of the views for the IFE is shown. The different alternatives for the five views; *welcome page*, *connect phone*, *home page*, *settings* and *team page* are presented and numbered in different rows. The themes are grouped together in each column and thus have the same number. *Geopasser* is used as a placeholder for the title of the multiplayer game in these sketches.

In Figure 3.16, four alternatives for the *game view* are shown on a poster. Common to all alternatives, a game plan, a home page button, a settings button, and a help button are presented. Additionally, all alternatives show the players ranking, points, numbers of clues,

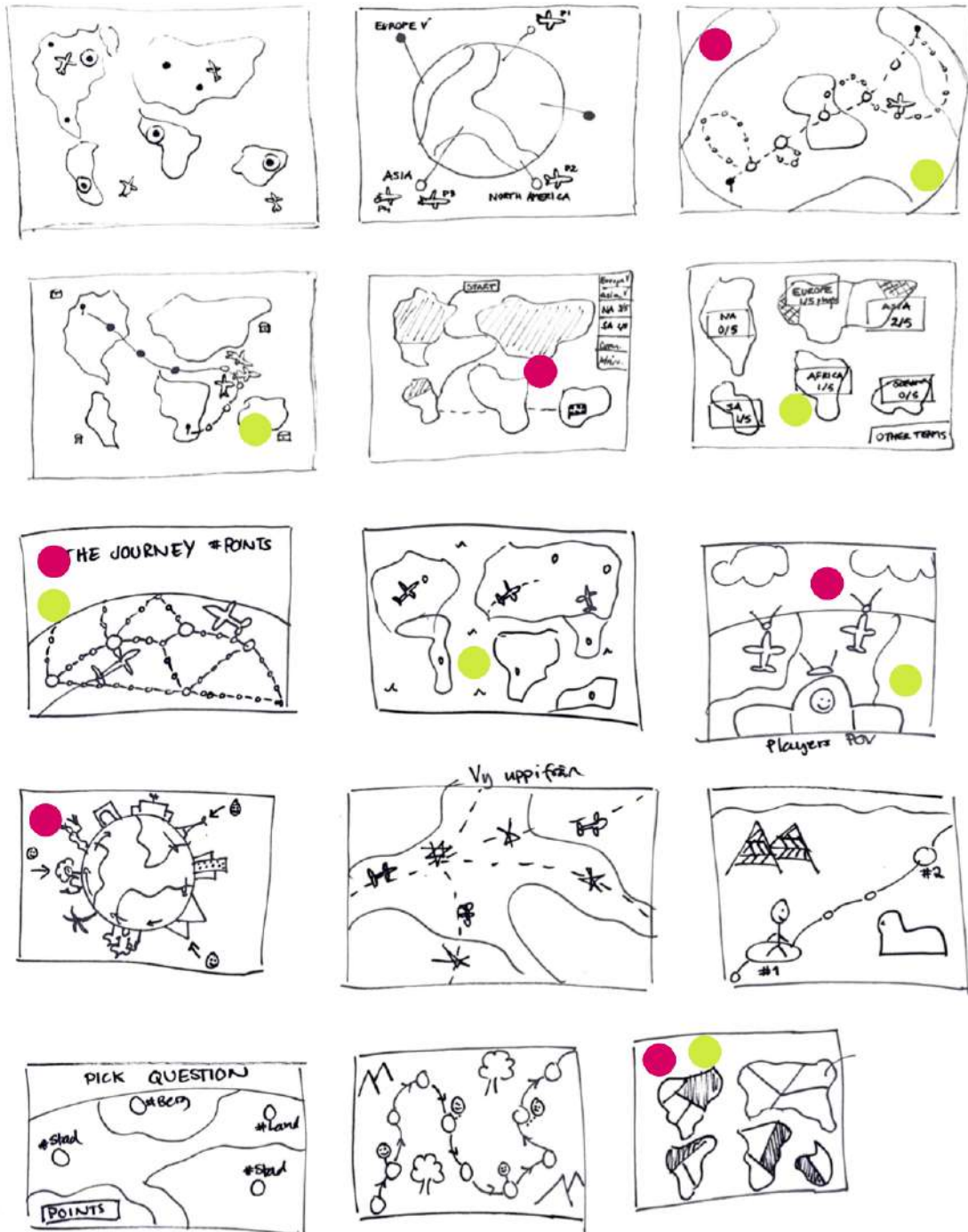


Figure 3.14: A visualization of the result from the braindrawing session with focus on the game view after dot voting.

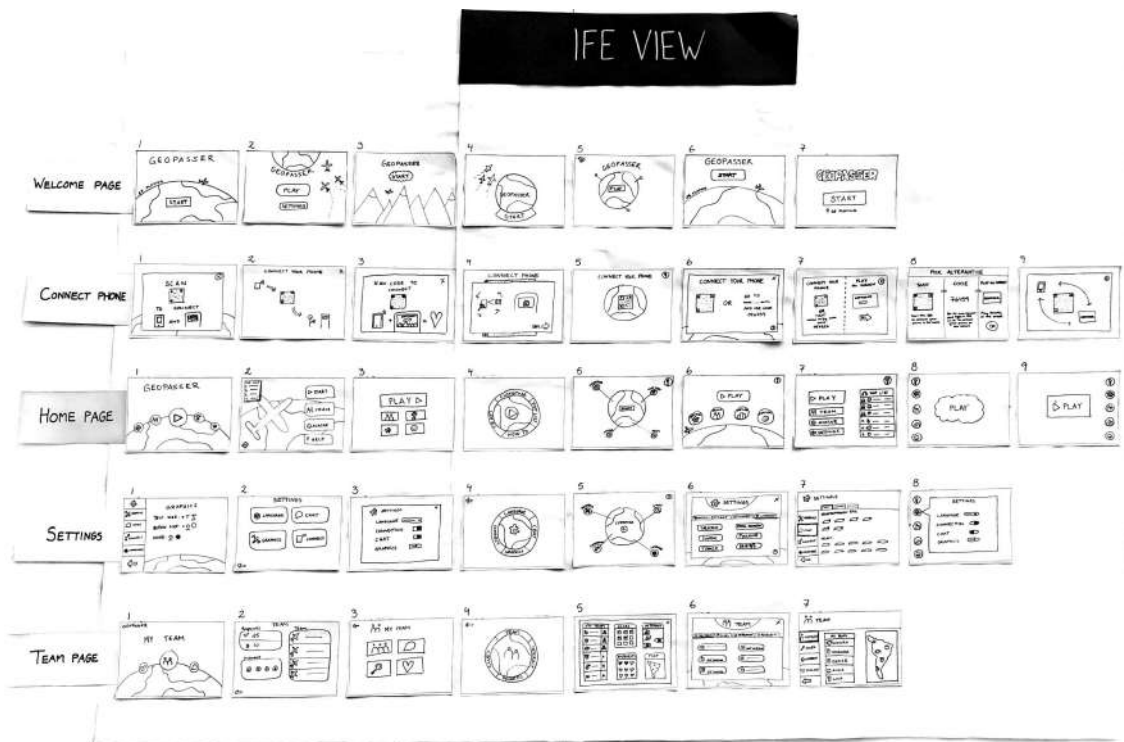


Figure 3.15: A visualization of the poster with the views for the IFE.

and numbers of questions answered. A leaderboard is also visualized on all the alternatives, yet presented in different forms. Moreover, all four alternatives show some type of globe that visualizes Arc. However, the alternatives show different possible layouts for the game view and game plan. The alternatives have slightly different ideas for the rules and concepts of the game. The unique elements for each alternative are presented below.

- *Alternative 1 (in Figure 3.16):* The game plan is a globe where the player navigates between possible destinations visualized as dots. At each destination, several questions are asked. When one destination is finished, the dot changes color, and the player can move to another destination connected to the route and get new questions. There are several alternatives of paths to choose from between different destinations. The planes show where the other players are at the moment. This specific view has a minimalistic design. The leaderboard is well in line with this design approach and shows only the avatar, alias, and points.
- *Alternative 2 (in Figure 3.16):* The game plan has many similarities with alternative 1. The difference is that the tiny dots between the destinations also have questions. Another difference is that the game plan is seen from the avatar's point of view. An overview of the entire map can be seen in the down-left corner of the game view. This makes it possible for the player to see which routes have been covered. The leaderboard also has some differentiating elements compared with the first alternative. For example, it is possible to interact with the players presented on the board in this leaderboard. Moreover, this leaderboard does not have any avatars and highlights your ranking.
- *Alternative 3 (in Figure 3.16):* The third game plan visualized the entire globe and show the flight route in a more linear order. Here the player answers questions along the

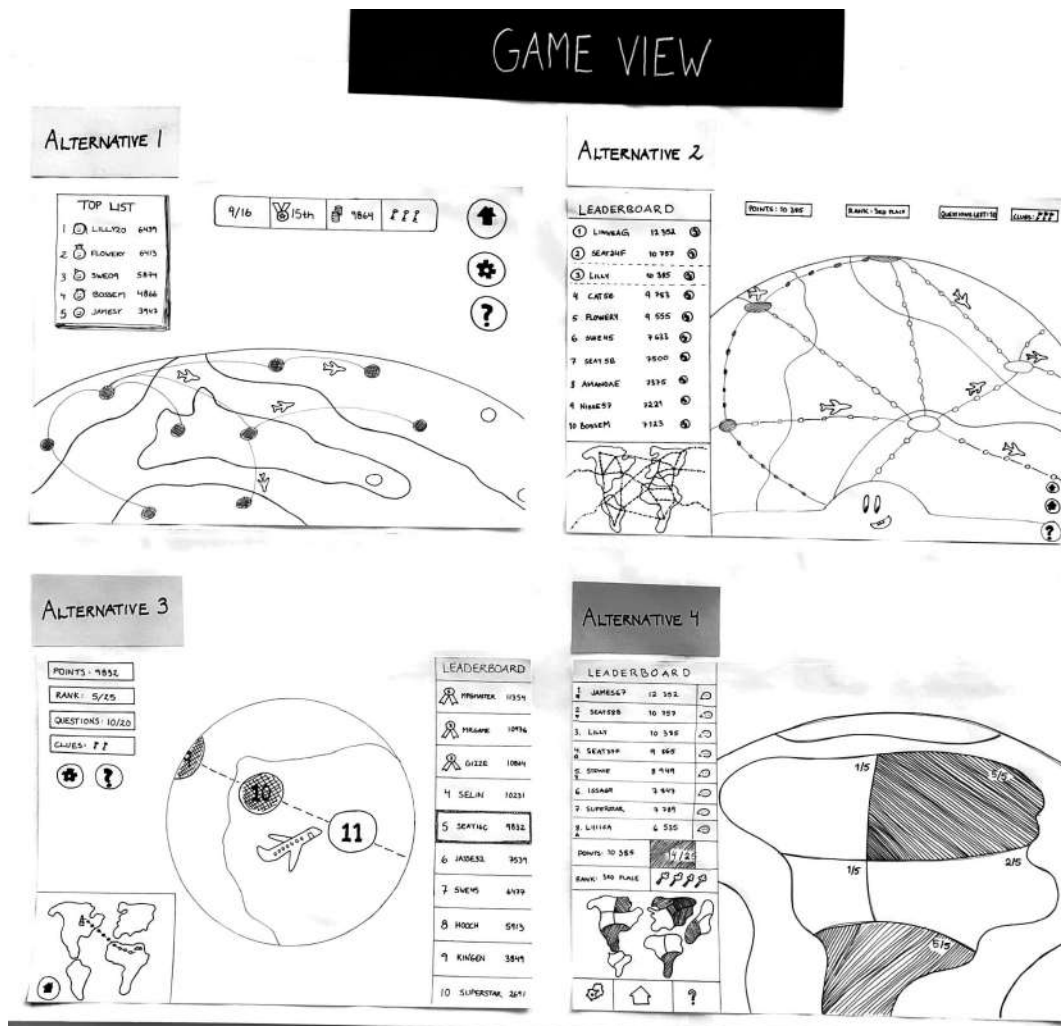


Figure 3.16: A visualization of the poster with the four alternatives for the game view.

route and not on specific destinations as in the first two presented alternatives. This game view also shows an overview map and the route at the down-left bottom. The goal is for the player to go from A to B. This leaderboard also highlights your ranking, and the top three players have a rosette ribbon.

- *Alternative 4 (in Figure 3.16)*: The last alternative has another approach compared with the first three alternatives. Here the player gets more continent-based questions, and the idea is to answer questions from all the continents. The continent will change color when all the questions are answered, and the goal is for the player to fill the entire world globe with color. As seen in alternatives 2 and 3, this alternative also has an overview map in the down-left corner, where the player sees the colored continents. The leaderboard is similar to alternative 2 with interaction possibilities. In addition, this leaderboard also has arrows showing how the player's ranking changes over time. In this alternative, all elements are visualized coherently to the left of the screen.

Feedback Session

To get feedback on the sketches, several so-called *feedback sessions* were conducted. The purpose of the sessions was to get different perspectives on the developed concepts and sketches. In addition, another intention was to get insights into what could work for the final prototype from people with much knowledge within the technical field. The goal was to end up with three sketches of each view singled out as the best by the participants.

The participants were all employees at Tactel, all with great technical knowledge and expertise in different subjects. In total, ten persons participated, and the advantage was that all had different competencies and could bring different points of view to the project. Additionally, all participants fit into the target group and could be seen as potential users of the multiplayer game. The participants were two designers, one project manager, one tester, four software engineers, one coordinator, and one employee working in the human resources department. The average age was 30.4 years, and the gender distribution was four males and six females. Each session was held individually and took approximately 20 minutes.

The session started with a short introduction to the project, followed by explaining the purpose of their participation and the feedback session. Then, one of us guided the participant through the session while the other one took notes. The two posters of the sketches, the *IFE view* and the *game view*, seen in Figure 3.15 and 3.16 respectively, were set up on a board. As previously mentioned, each row of the *IFE view* presented the different alternatives for the views. The participants were told to look at one row at a time. To avoid cognitive strain for the participants, the rows below the one in focus were covered. The participants were asked to think aloud and say everything they could come up with.

On each row of the *IFE view*, the participants were informed to rank their top three favorite alternatives. This was done by putting sticky notes in different colors on the alternatives, where the different colors represented different rankings. This can be seen in Figure 3.17. At the same time, the participants were asked to motivate their choices. By doing this, the result over which were the favorites of each view could easily be seen in the end. On the poster for the *game view*, the participants instead were encouraged to give more overall feedback and to express their first impression of each game view. The goal was to point out one favorite of the four alternatives and get feedback on the layout of the different elements.



Figure 3.17: A picture from the feedback session.

Evaluation

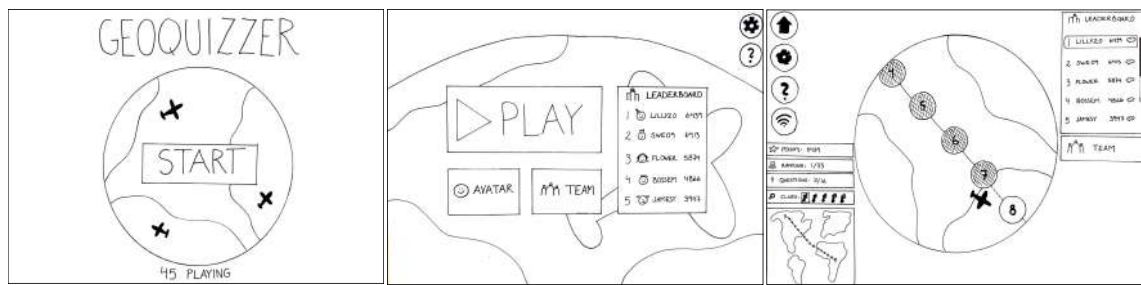
The result from the feedback session was evaluated by analyzing the participants' votes and feedback in Miro. To analyze the votes, the sticky notes were converted into a number. The first prioritized vote got three points, the second prioritized two points and the third prioritized got one point. However, the sticky notes from the two designers were rated higher and got double points. This is since their knowledge within the area weighs heavier than the other participants' opinions. The points were added together to see which sketches got the best feedback and could thus be appointed as the favorites among the participants from the feedback session. Three alternatives from each view could be sorted out based on the points, as can be seen in 3.18. The sketches were analyzed based on the participants' motivations, and the best components and ideas from each sketch were highlighted and sorted out. These ideas were then combined into two different comprehensive lo-fi prototypes that were redrawn more accurately.

Final Result

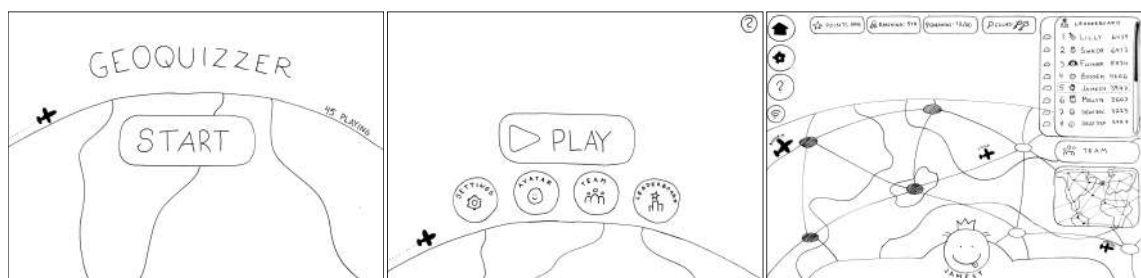
The two final lo-fi prototypes can be seen in Appendix C.1. Some examples of the same views from the two different prototypes can be seen in Figure 3.19(a) and 3.19(b), respectively. As seen in the figure, the multiplayer game is now called *Geoquizzer*. The two lo-fi prototypes are made by hand on paper. The result from the user study, the brainstorming sessions, the feedback sessions, and various design guidelines were considered when drawing these. The reason for developing two lo-fi prototypes is to be able to create two different hi-fi prototypes that differ aesthetically and in layout to be able to, later on, do comparison testing.



Figure 3.18: A visualization of the analyzed result from the feedback session in Miro. The sketches that received the highest scores are shown.



(a) Sketches for the first lo-fi prototype.



(b) Sketches for the second lo-fi prototype.

Figure 3.19: Sketches for the lo-fi prototypes showing welcome page, home page and the game view.

3.3.2 High Fidelity Prototyping

In the following section, the process related to the high fidelity (hi-fi) prototyping will be further explained. The hi-fi prototypes are based on the lo-fi prototypes. The process started with a preparation phase, then a first iteration where two prototypes were implemented, followed by usability testing and evaluation phases.

Preparation

The hi-fi prototyping phase began with several preparations. The first step included doing a mood board and graphics research. This helped us get a common idea of what the prototypes should look like and what style to strive for. It was also an excellent opportunity to ensure that we had the same idea of what to achieve with each prototype. For the two prototypes, two different styles and approaches were decided. The differences between the prototypes can be seen in Table 3.1. Henceforth, the prototypes will be referred to as P1 and P2, respectively. P1 is based on the lo-fi prototype that can be seen in Figures C.1-C.3 in Appendix C.1, and P2 is based on the lo-fi prototype seen in Figures C.4-C.6 in Appendix C.1.

Table 3.1: Differences between the concepts in the hi-fi prototypes.

<i>Prototype 1 (P1)</i>	<i>Prototype 2 (P2)</i>
Present much information	Present little information
Straight corners	Rounded corners
Serious	Playful
Colorless	Colorful

A design system for each prototype was set up in Figma. The design system helped to fulfill Shneiderman's rule of *Strive for consistency* by ensuring that the style in each of the prototypes was consistent and coherent. Each design system consisted of chosen colors, fonts, icons, and components. Except for some of the icons, every component was made from scratch. The compound components were fully interactive, and these were used to create the two final hi-fi prototypes. The requirement for the fonts was that they should be easy to read and thereby as accessible as possible.

When making the design system, the *Web Content Accessibility Guidelines* (WCAG) was taken into consideration. WCAG are international established recommendations for accessible content on the web [40]. Even though the multiplayer game being developed is not a webpage, the recommendations from WCAG could still be helpful in this project. Considering the guidelines ensured that all the colors used in the prototypes had good contrast to each other and thus approved according to WCAG.

Interactive Prototypes

After the preparations, developing the two highly interactive hi-fi prototypes, P1 and P2, in Figma began. The goal of this iteration was to make two different hi-fi prototypes based on the design of the two lo-fi prototypes, as previously mentioned. By designing P1 and P2 based on the concepts presented in Table 3.1, the aim was to examine which UI the users preferred. Due to the comprehensive lo-fi prototypes, these could be used as wireframes in this phase.

The ideas, central concepts, design motivations, and related theories for each view in the prototypes will be presented below.

Welcome page:

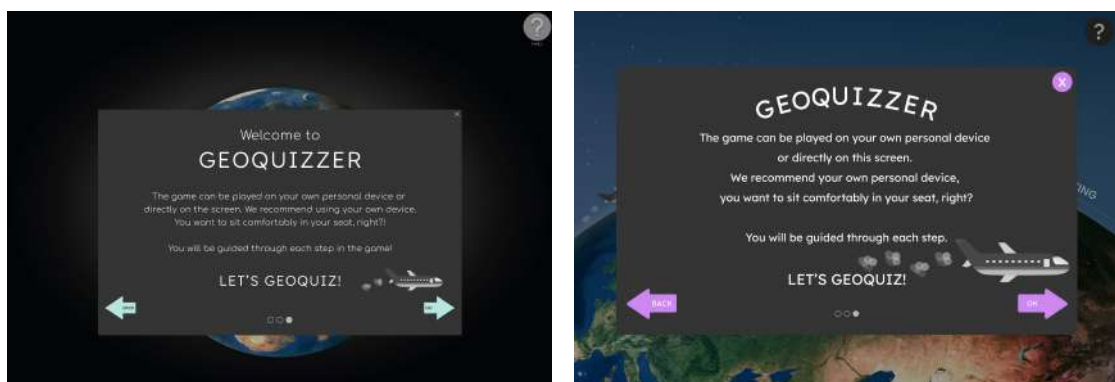
The *welcome page* is the default view that the user sees when the game is launched on the seat-back screen. The view for each prototype is shown in Figure 3.20. The *welcome page* shows how many passengers on the flight that are currently playing *Geoquizzer*, and additionally, two interactable buttons are visible, marked with "?" and *Start*. The "?"-button is presented up in the top right corner in both of the prototypes. If clicked, a pop-up with an introduction to the game and concept is presented on three slides, this can be seen in Figure 3.21. Moreover, in both prototypes, the *Start*-button is in focus and is centered on the screen. If clicked, another view is shown where the users should decide whether they want to answer the questions in the quiz with their personal device or not. This view will be further described in the paragraph *Connect phone* below.



(a) P1: Welcome page

(b) P2: Welcome page

Figure 3.20: The welcome page for each of the two prototypes.



(a) P1: Introduction, page 3

(b) P2: Introduction, page 3

Figure 3.21: The introduction for each of the two prototypes.

Connect phone:

On the *connect phone*-view, the user decides how to answer the questions in the quiz. As seen in Figures 3.22(a) and 3.22(b), the two alternatives are to use their phone or the seat-back screen. If the user decides on the latter alternative, the *home page* is directly shown. However, if the first alternative instead is decided, a new view on how to connect the phone is shown, as seen in Figures 3.22(c) and 3.22(d). The user can decide to connect the phone to the screen by using either the QR code to the left of the screen or visiting a webpage and entering a six-digit number to connect. These technical solutions for connecting the phone to the IFE have been investigated by Bastmark and Domell in their thesis *Developing a Multi-Passenger Game for Inflight Entertainment Systems* [6] and has been proved to be successful. In this step, the two prototypes differ a lot. In P1, the user gets information on how to connect the phone by descriptive text, which can be seen as a signifier. P2 has another approach. In this alternative, the design is stripped-down, only showing the most basic information. If the user gets stuck and does not know how to do it, the "?"-button up in the top right corner can be clicked to get more information. When the phone is connected to the IFE, an informative feedback page with the text "Connection successful!" is shown on both the IFE and the phone. Then the user gets directed to the *home page*. Giving the user this extensive feedback is an example of how Shneiderman's rule *Offer informative feedback* can be fulfilled.

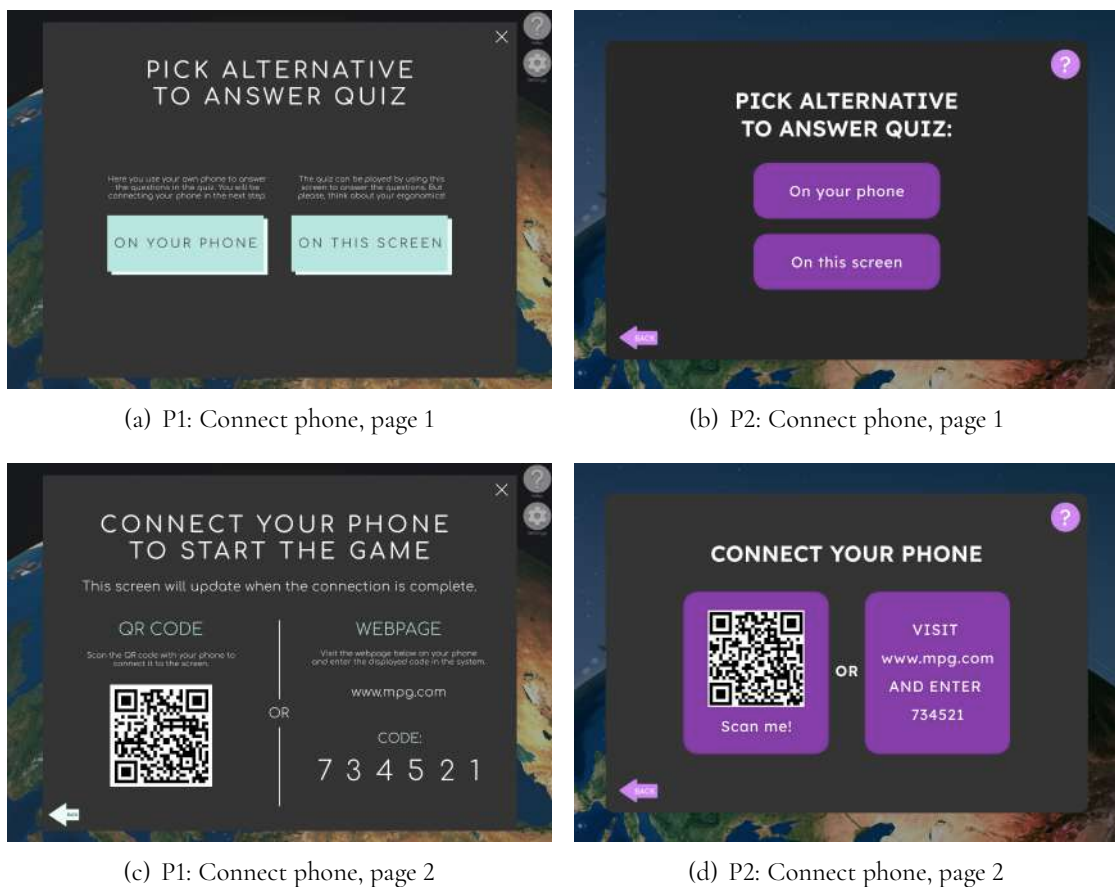
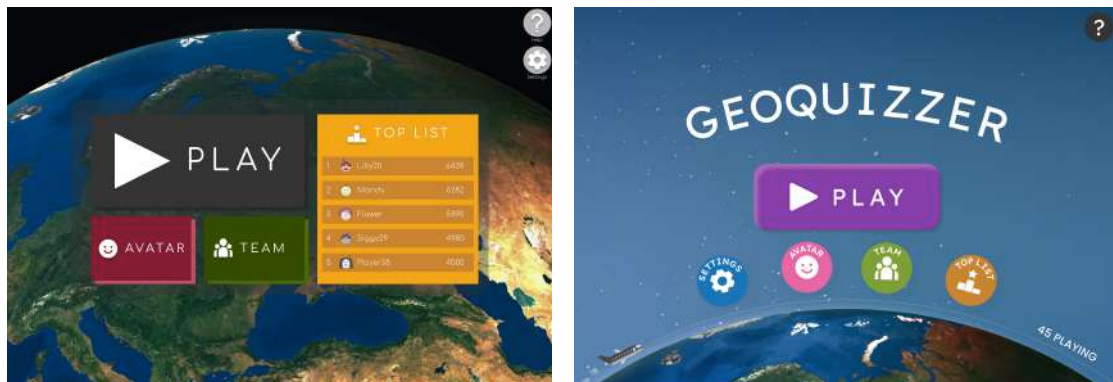


Figure 3.22: The connect phone page for each of the two prototypes.

Home page:

The *home page* view includes the same elements in both P1 and P2. However, the information is presented differently, as seen in Figure 3.23. The significant difference between the prototypes is whether the top list is seen directly on the *home page* or not. Additionally, the graphic design and layout differ a lot. Here is an excellent example of how the designs differentiate in accordance with Table 3.1. P1 conveys a more colorless and serious feeling with straight corners, whereas P2 is more colorful, playful, and has rounded corners. The *Play*-button is in focus in both prototypes; it leads the users to the *game view*. The additional features, such as *Settings*, *Avatar*, and *Team* can be reached from the other buttons presented. In P2, the *Top list* is reached from one of the buttons. The position of the *Settings*-button differs between the prototypes. It is located right under the "?"-button in the top-right corner in P1, and in P2, it is placed in line with the other buttons.

All the buttons, except the *Play*-button, lead to pop-up pages in both prototypes. Each prototype has its own layout and design of the pop-up pages. The design of the pages is coherent in each prototype; this fulfills Shneiderman's rule of *Strive for consistency*.



(a) P1: Home page

(b) P2: Home page

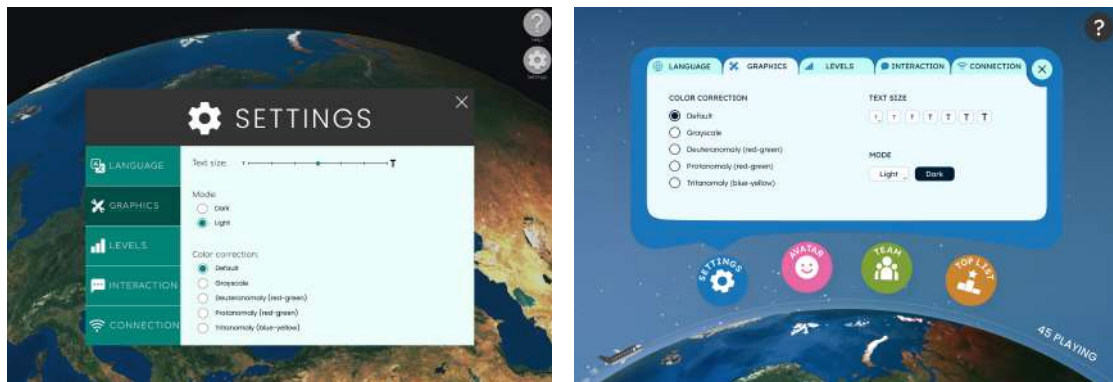
Figure 3.23: The home page for each of the two prototypes.

Settings:

The pop-up page for *settings* in each prototype is shown in Figure 3.24. The background becomes darker when the pop-up is shown in P1, and the other buttons can not be reached. If the user wants to interact with another feature, the "x"-button needs to be pressed. The "x"-button can be seen as a *constraint* for the user to only focus on the actions presented on the pop-up page. The *settings* page in P2 is a pop-up where the other functionalities are still presented underneath. This layout makes it easier for the user to navigate between the different pages and alludes to Shneiderman's rule named *Minimize short-term memory load*.

On the pop-up page, the user can navigate between different tabs. The tabs includes: *Language*, *Graphics*, *Levels*, *Interaction*, and *Connection*. In the *Language*-tab, the user can select a preferred language, this to meet the broad target group. The languages presented are the languages spoken by most people in the world [21]. In the *Graphics*-tab, the user can customize graphic elements in the game to make it more suitable. The presented graphical options are increasing or decreasing the text's size, selecting between dark mode and light mode, and

selecting between different color corrections such as grayscale, deuteranomaly, protanomaly, and tritanomaly. In the *Levels*-, and *Connection*-tabs, the user can choose what level for the game and see if the phone is connected to the IFE. In the *Interaction*-tab, the user can set several predefined phrases and emojis that can be used to interact with the other players. The phrases and emojis have a friendly yet fun tone. The initial thought was to have a chat with free-text messages but to avoid inappropriate messages and usage, the phrases and emojis are seen as a better solution.



(a) P1: Settings view, graphics

(b) P2: Settings view, graphics

Figure 3.24: The Settings view for each of the two prototypes.

Avatar:

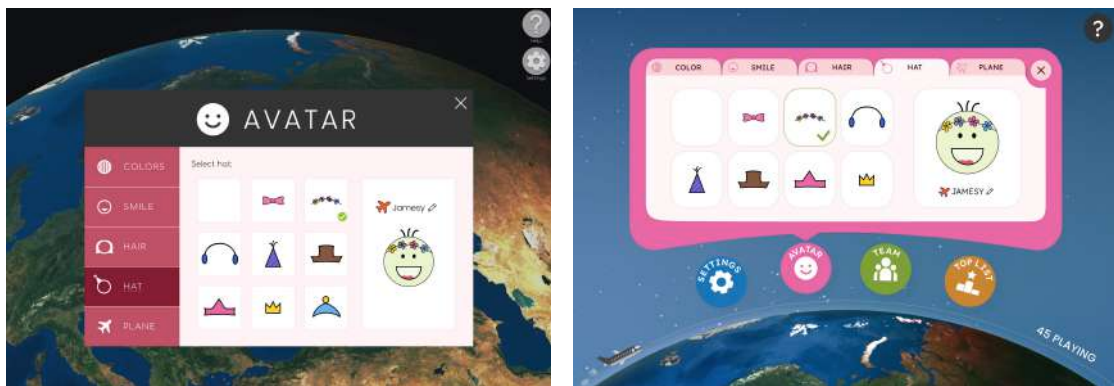
In the pop-up page named *Avatar*, the user can customize their avatar by picking a color, smile, hair, hat and a plane, as seen in Figure 3.25. The avatar is a cartoon character with a plane. When clicking one of the options, the user gets instant *feedback* since a green check mark is shown. Later on in the game, the avatar is shown in the *top list*, in the *team* view and on the *game plan*. The user can also set the name of the avatar, where they have the opportunity to stay completely anonymous if they want to.

Team:

In the pop-up page named *Team*, the user can get information about who is in their team and where the team players are on the map, as seen in Figure 3.26. Additionally, information about how many clues the users have are presented here. Thus, in this thesis, the focus has not been on how the team aspect should work. In the prototypes, it is only visualized how the information could be presented differently. In P1, Shneiderman's rule *Strive for consistency* has been followed since the information is presented as the other pop-up pages. In P2, all information is instead presented at once.

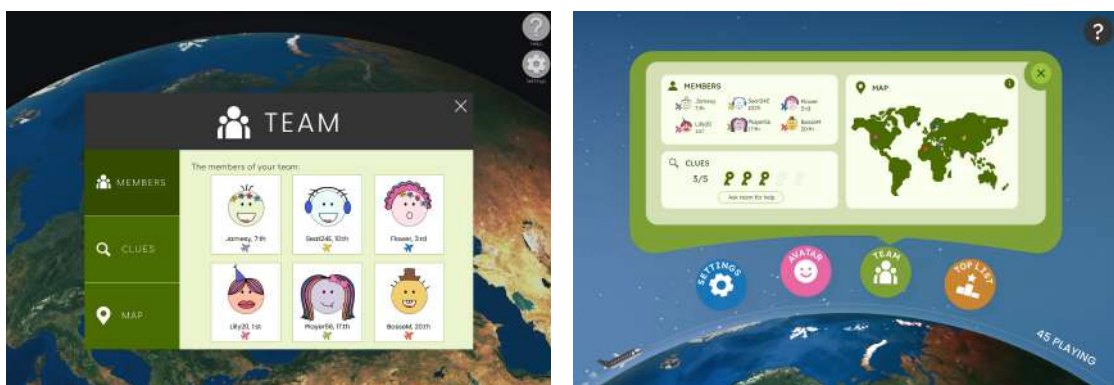
Game view:

The *game view* is the actual game in *Geoquizzer* and consist of a *game plan*, interactive components and informative elements. The game plans for the two prototypes differ in several ways, as seen in Figure 3.27. Additionally, the concepts of the game also differ significantly in P1 and P2. The reason for this is that we wanted to get as much feedback as possible on our various concepts and designs through usability testing.



(a) P1: Avatar view, hat

(b) P2: Avatar view, hat

Figure 3.25: The Avatar view for each of the two prototypes.

(a) P1: Team view

(b) P2: Team view

Figure 3.26: The Team view for each of the two prototypes.

The mutual game concept for both prototypes is that *Arc* is visualized through screenshots as the globe, and the same visual elements are presented, yet in different ways. In P1, the globe is zoomed out, and the visual elements are coherently placed to the left-hand side of the *game view*, as shown in Figure 3.27(a). The game concept for P1 is that the user follows their journey linearly. The user visits different destinations along the flight route that the airline company offers flights to. In this way, they can market their destinations and show the user what they can experience through the questions. The destinations are visualized through the dots marked with numbers. The purple dots are the destinations that the user has completed, the dark blue dot is the current destination, and the orange is the next destination. At each destination, the user gets a quiz with a number of questions related to the destination. The planes on the globe are the user's avatar and the other players.

In P2, as shown in Figure 3.27(b) the globe is zoomed in and presented from another perspective. To navigate on the globe, the user swipes in a chosen direction. The visual elements are placed more scattered throughout the *game view*, and the *top list* can be reduced. The destinations are visualized with the dots, and the user's avatar is the plane with the cartoon character. The completed destinations are marked in purple, and the lines between the des-

tinations are filled if completed. The uncompleted lines visualize different routes the user can navigate to. The different destinations are not attached to the user's flight journey. The user can go to destinations all over the globe. Like P1, the different destinations are places that the airline provides flights to. At each destination, the user gets a quiz with a number of questions related to the destination, as in P1.

The user can interact with the top list in both of the prototypes. In P1, the user can scroll through the top list. The player at the bottom of the top list is clipped in half; this works as an *affordance* to show that there is more below in the top list. In P2, a *signifier* is instead shown in the shape of an arrow. Both the *signifier* and the *affordance* also works as good *mapping* since it is two commonly used methods to show the possible interaction with the object. The same information is shown in the prototypes' top lists, except that the first, second, and third places are enhanced with medals in P2.

In both prototypes, the user can send interactions to the different players in the top list by clicking on the chat bubble placed next to their position. The user can pick the phrases and emojis that they have selected in the *Settings*-menu. When sending an interaction, the user gets instant feedback by presenting a check mark when the interaction has been sent, as seen in Figures 3.27(c) and 3.27(d). This fulfills Shneiderman's rule *Offer informative feedback*. When receiving an interaction from another player, the interaction pops up in the corner of the screen as a chat bubble. Regardless of what language the interaction is sent in, the receiver will always receive the interaction in their predefined language alternative.

On the game view in both prototypes, buttons for reaching the important features *Tutorial*, *Settings*, and *Home* are provided. Additionally, there is an indication of the connection status for the phone is shown. Another mutual component in the prototypes is the animated map. This component gives the user an overview of the game and their journey and can be enlarged. The different destinations are marked in the same way as on the globe on the animated map, for each prototype respectively.

Tutorial:

A tutorial in each prototype is presented in order to show the user concrete steps that can be done in the game. The tutorial goes through the main features of *Geoquizzer*, such as how the avatars and destinations are shown, as well as how the quiz works and the top list. The tutorials in the two prototypes differ in their presentation, as seen in Figure 3.28. In P1, the information is presented in a minimalistic way. In P2, on the other hand, the information is presented more playfully by using colorful elements. Additionally, the elements in the game view that are not in focus in the tutorial are darkened out to make the tutorial even clearer.

Quiz:

As previously mentioned, when the user reaches a destination, the user gets a quiz with a number of questions related to the destination. The design of the quiz follows the chosen design for each prototype.

After a destination is picked, a pop-up page with a quiz, consisting of a number of questions related to the destination, is presented on the seat-back screen. When the user is ready for the quiz, a countdown timer is shown before the first question is presented. Each question has four answer options presented, and below the options, a bar with the points is visualized. As time goes by, the time and the points tick down. The faster a question is correctly answered, the more points the player will receive. If the answer is wrong, no points are given.

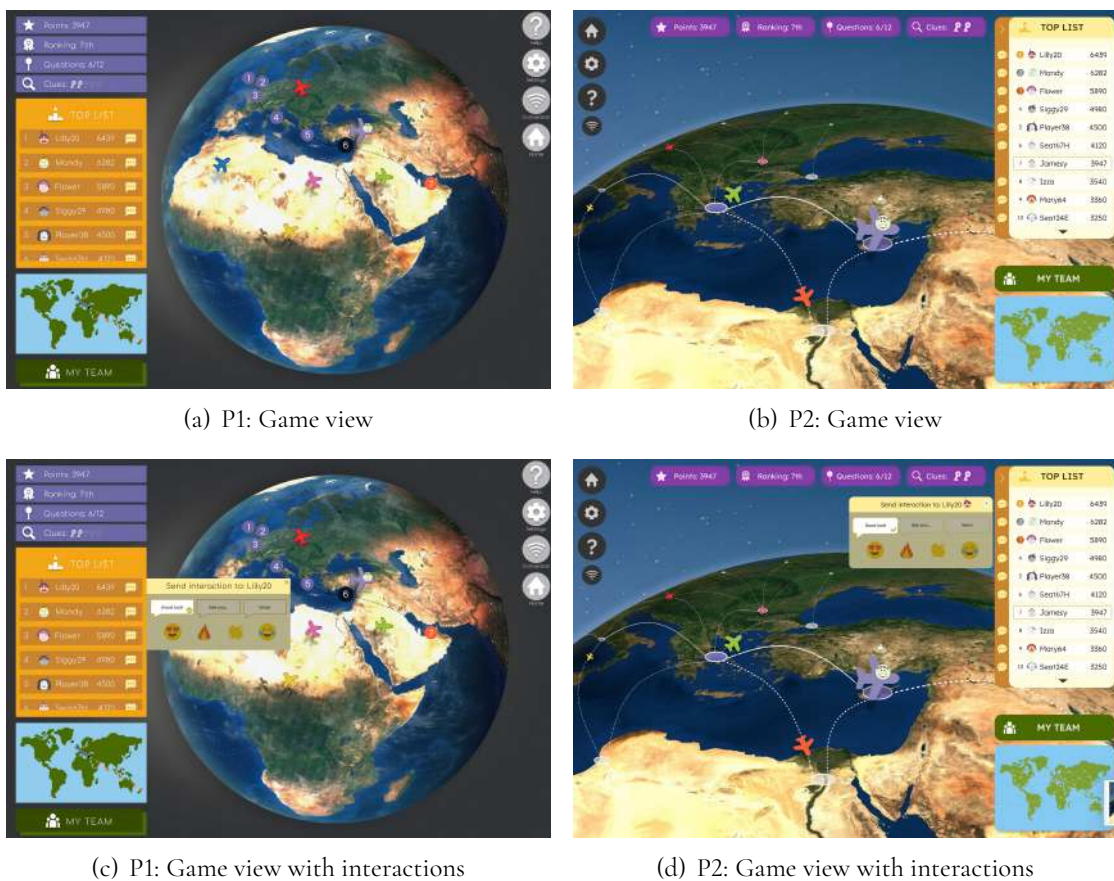


Figure 3.27: The Game view for each of the two prototypes.



Figure 3.28: The Tutorial for each of the two prototypes.

However, the players read at different speeds, and other circumstances in the aircraft cabin can affect the player's ability to answer a question. Due to this, the player will always receive some points if the answer is correct, regardless of how long time it took to answer the question. This solution is chosen instead of having the ability to pause the game. Finally, when a

question has been answered, feedback, if right or wrong, is visualized with a check or a cross on the different options, as well as the wrong alternatives are presented in grey.

The quiz is visualized in different ways in the two prototypes, as seen in Figure 3.29. In P1, the quiz is presented as a pop-up page covering parts of the globe, but with the visual elements still in focus. The four answering options are presented as white buttons with a symbol and text. Four different colors are used for the symbols and texts, one for each answering option.

The quiz is also presented as a pop-up page in P2. However, the pop-up page takes up almost the entire game view. Other visual elements are darkened to help the user focus on the quiz. Between every question, a countdown is shown. The four answering options are presented on big, colorful buttons with white text and symbols.

At the end of each quiz round, each prototype shows a summary. P1 shows both a summary of the rewarded points for the actual round and an updated top list, as can be seen in Figure 3.29(c). In P2, only the rewarded points for each question are presented, as can be seen in Figure 3.29(d).

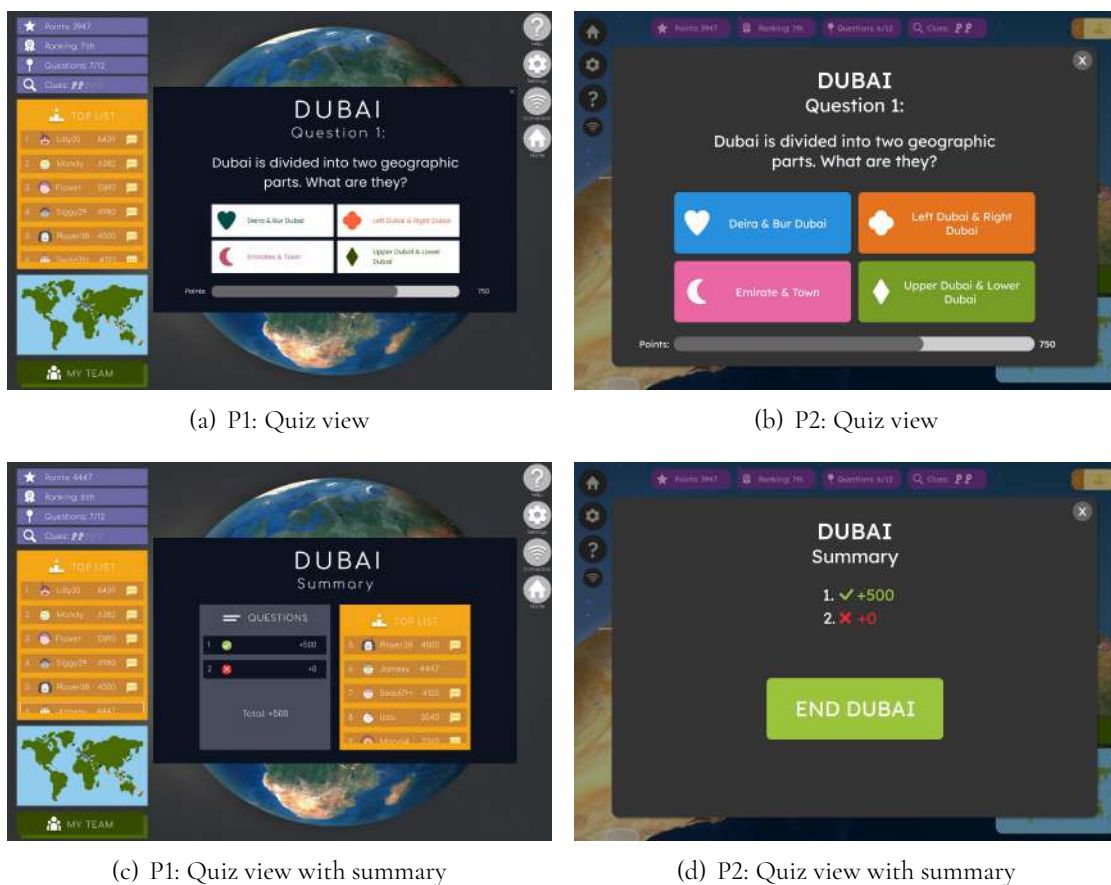


Figure 3.29: The Quiz view for each of the two prototypes.

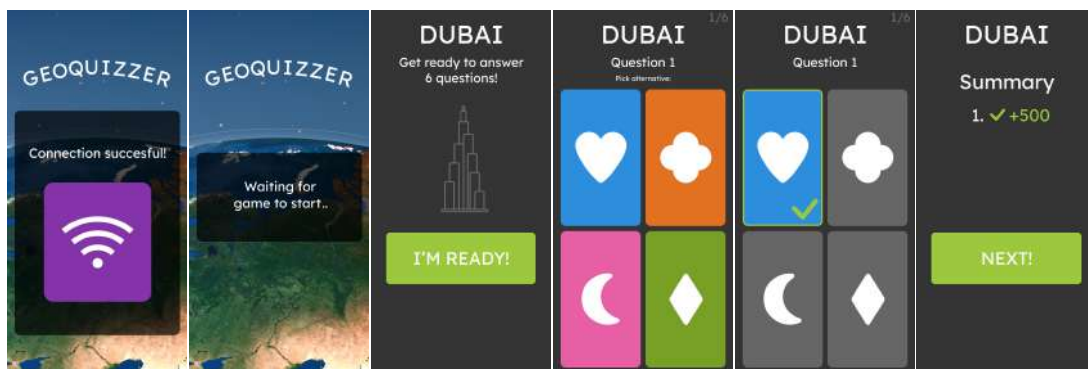
Mobile view:

The mobile views for the two prototypes follow the same design as the design for the seat-back screen, as shown in Figure 3.30. This is to provide the user with good *mapping* between the interfaces and to fulfill Shneiderman's rule *Strive for consistency*. The primary usage of the

phone is to answer the quiz. The UI is presented in the same way as the quiz on the seat-back screen. The user gets the different answer options but without the alternatives presented in text. Only the color and the symbol are shown on the mobile view. Hence, this provides good *mapping* by staying consistent. The same feedback is shown on the mobile view as on the seat-back screen.



(a) P1: Mobile views



(b) P2: Mobile views

Figure 3.30: The Mobile views for each of the two prototypes.

3.4 Evaluating

The fourth and last activity in interaction design and the project is *evaluating* the design of the prototypes. This is one of the most essential steps in interaction design since it is a way to ensure that established requirements and users' needs are fulfilled. In this thesis, the final evaluation was conducted by usability testing, described below.

3.4.1 Usability Testing

To evaluate the two developed prototypes' usability, design, and functionality, usability testing was an essential next step in the design process. The purpose of the usability testing was to compare the design alternatives for the two prototypes and, based on the feedback from the

test participants (TP), decide on the most appealing solution. A procedure compounded of various methods was used in order to reach the goal of presenting one final prototype showing the UI of a potential multiplayer game for inflight entertainment systems. The test procedure consisted of an introduction, a test with scenarios on one of the prototypes, a questionnaire based on SUS and AttrakDiff, comparison testing between the two prototypes, and lastly, a debriefing session. The following sections will describe the procedure and the usability testing results in more detail.

Test Plan

In order to ensure that all tests should be performed consistently and executed as equally as possible, a test plan was made. The test plan consisted of an orientation script describing the purpose and goal of the usability testing and should be used when introducing the TP to the session. Moreover, a manuscript was made to ensure that the test leader (TL) followed the same procedure for each test. In this phase, informed consent, scenarios for the test, and a questionnaire were made. The test scenarios are presented in detail in Appendix D.1, and summarized in Table 3.2 below. The scenarios let the TP test the main features for starting the game and the main features in the *game view*.

Table 3.2: A summary of the scenarios used in the usability testing.

<i>Scenario</i>	<i>Description</i>
Scenario 1	Find the introduction to <i>Geoquizzer</i> on the <i>welcome page</i>
Scenario 2	Connect the phone to the IFE by using the QR code
Scenario 3	Customize the <i>avatar</i> according to the instructions
Scenario 4	Try to change the color correction to grayscale in the <i>Settings</i> -menu
Scenario 5	Pick pre-defined phrases and emojis in <i>Interaction</i>
Scenario 6	Find the tutorial on the <i>game view</i>
Scenario 7	Send an interaction to a specific player via the <i>top list</i>
Scenario 8	Pick the destination Dubai and answer two questions
Scenario 9	Completed test

Also, the roles for the test sessions were established. For example, one of us should act TL and interact and guide the TP through the test, while the other should observe and take notes. Lastly, a user profile with requirements for the recruitment of TPs was set up.

Test Participants

To conduct the usability testing, the first necessary step was to recruit suitable TPs that fit into the target group for the multiplayer game. A small screening consisting of three questions, namely, age, gender, and technical interest, was made to select suitable participants. 18 persons with various technical interests and backgrounds were recruited as TPs based on these sample questions. Ten participants were women, and eight participants were men. Of these 18 persons, eight of them are employees at Tactel. The age span ranged between 20 to 61 years, with an average age of 35.4 years.

Pilot Test

A pilot test was first carried out to ensure that the test procedure worked as planned. The purpose of the pilot test was to validate that the test scenarios were easy to understand and validate that the test itself worked as planned. The pilot tester fulfilled the user profile and target group for the game and gave valuable feedback on things to improve in the test. The pilot test showed weaknesses in some scenarios, which were adjusted to the final usability testing.

Test Procedure

As previously mentioned, the same procedure was followed for each test according to the test plan. The setup for the test sessions was one computer with a touch screen (corresponding to the IFE), one phone to answer the quiz questions, one computer for the questionnaire and for showing one of the prototypes in the comparison test, an audio recorder, the test scenarios printed on cards and one computer that the observer utilized to take notes. Hence, the setup for all the test sessions was the same. However, different locations had to be used for the testing to facilitate the TPs. All the test sessions took approximately 45 minutes and were carried out individually by each TP. The test procedure is presented more in detail below.

- *Introduction:* In the introduction to the usability test, the orientation script was followed verbatim by the TL. This included an explanation of the purpose of the TP's participation, the test session's procedure, and the project's purpose. The TL clarified that it was the functionality of the prototypes that should be tested and not TP itself. Moreover, the TPs were informed to think aloud during the test session. The TPs were also informed that they could cancel the session at any time and asked to sign the informed consent. The consent gave us the right to use the results from the tests in an anonymous manner and the right to the sessions with audio. The TPs also could ask questions if needed.

At the end of the introduction, two background questions regarding technical experience and previous use of the seat-back screen were asked to the TPs. This was to get a deeper understanding of their background before starting the actual test.

- *Test with scenarios:* During this part of the test, the functionality and usability of one of the two prototypes were tested. Which prototype the TP interacted with varied between the tests. By alternating between the prototypes, it can be avoided that one of the prototypes is perceived as more complicated because it is constantly tested first. When starting the usability test, the TL set the context by saying "*You are on a long-haul flight and start to feel bored and restless. Your fellow traveler has told you about the new game Geoquizzer that you now want to try. You have already found the game on your seat-back screen in front of you, and now you want to start playing*". In front of the TP, nine cards with the test scenarios were placed upside down. The TP was informed about taking one scenario at a time, reading it out loud, and performing the task. This helped the TP not to be overwhelmed by too much information at the same time. Thus, the TP could focus on the right thing in the test. The TL did not confirm when the TP was doing right or wrong. Instead, the TP was encouraged to decide whether the scenario was completed.

- *Questionnaire:* After completing the test with scenarios on one of the prototypes, the TP was asked to answer a questionnaire based on SUS and AttrakDiff. The questionnaire allowed us to get quantitative data about TP's first impression of the tested prototype. To clarify, the TP only filled in the questionnaire for one of the prototypes. The questions asked in the questionnaire can be found in Appendix D.2. All ten questions related to SUS were asked, but only 13 of 28 word pairs from AttrakDiff were chosen for the questionnaire. Many of the chosen word pairs could be related to the UX goals in the project and thus were of interest. Letting the TPs take a stand on all 28 word pairs felt time-consuming and unnecessary for this purpose.
- *Comparison testing:* The next part of the test session was to compare the two hi-fi prototypes, P1 and P2. TL presented the unseen prototype side-by-side with the previously tested prototype. All the different views were presented and compared. The TP gave feedback and comments on the design and layout for each prototype. In this part of the test, the TL could interact with the TP and ask questions to get more extensive feedback. This resulted in qualitative data.
- *Debriefing:* After the comparison testing, a short debriefing session was held. This to get the subjective opinions and ideas from the TP, and in this way, more qualitative data could be collected. In addition, the purpose of the debriefing session was to discuss and follow up on comments that the TP had given during the test and to discuss positive and negative aspects of each design of the prototype, respectively.

3.4.2 Results From Usability Testing

The result from the test sessions consists of both quantitative and qualitative data. The quantitative data comes from the calculated task success rate for the various scenarios and the results from the questionnaire. On the other hand, the qualitative data comes from the observer's notes from the test sessions.

Quantitative data:

One metric calculated from the usability testing is the task success rate for the scenarios for each of the prototypes. For example, P1 had four persons out of nine that completed all the tests without needing help and scored a task success rate of 100%, which can be seen in Table 3.3. In contrast, as seen in Table 3.4, when testing P2, five TPs out of nine scored a task success rate of 100%. Moreover, it can be seen that the success rate for the different tasks differs between the two prototypes. In P1, three of the scenarios were completed without needing help from the TL. In P2, on the other hand, the number was instead five scenarios. The result indicates that P2 was a bit easier to understand.

From the questionnaire, both a SUS score and a graph representing the result from AttrakDiff could be extracted. As seen in Tables 3.5 and 3.6, P1 scored 83.0 in the SUS score, and P2 scored 83.6. This means that both prototypes got almost the same value and that the differences between the prototypes, on the whole, are not that big. The result from AttrakDiff, seen in Figure 3.31, shows some interesting metrics. In contrast to the task success rate and the SUS score, P1 scored a higher value in 16 out of the 13 word pairs. The AttrakDiff for P2 is more neutral and varies more in its result than P1.

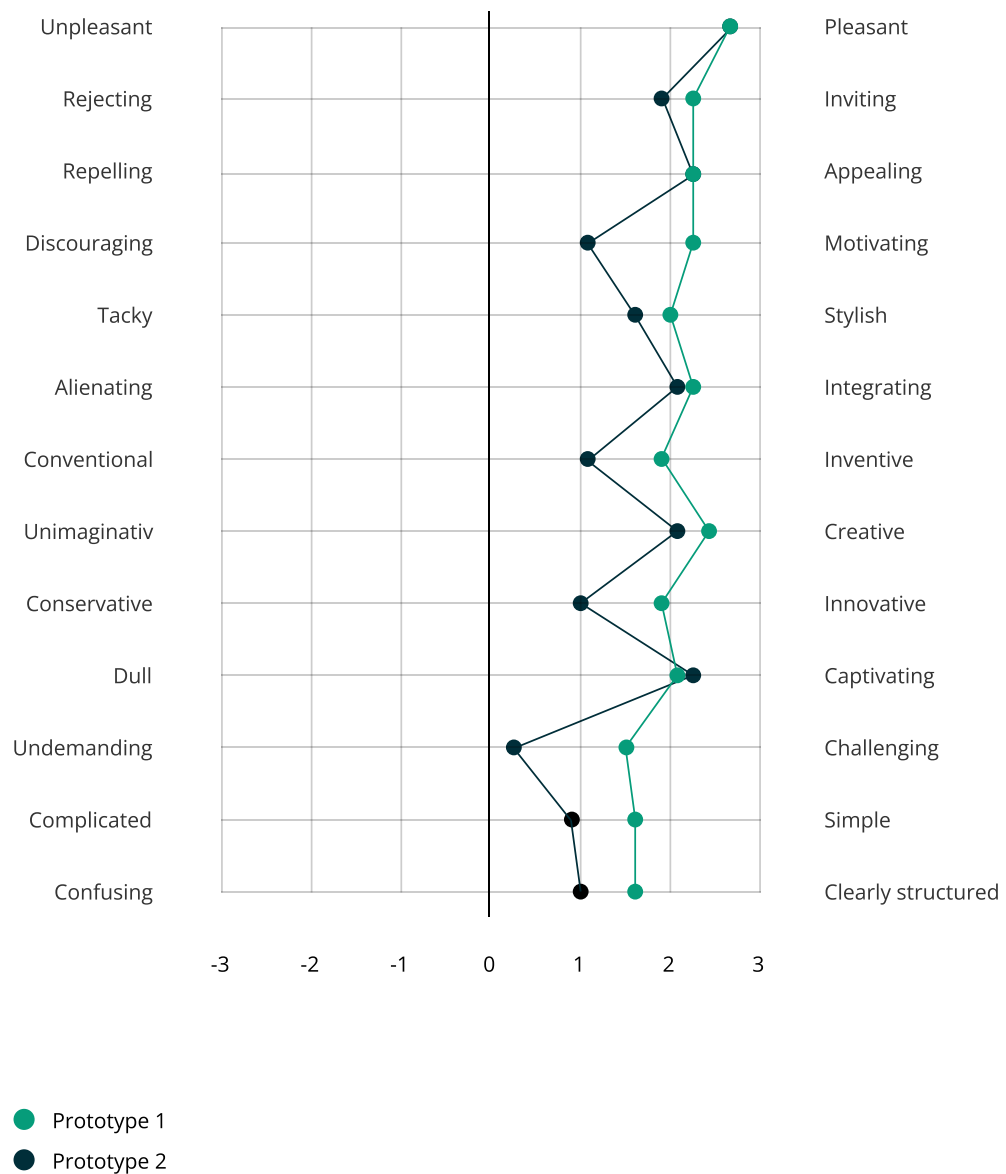


Figure 3.31: The result from AttrakDiff for both prototypes.

Table 3.3: The task success rate for P1.

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Success rate
Participant 1										67%
Participant 2										89%
Participant 3										89%
Participant 4										100%
Participant 5										100%
Participant 6										100%
Participant 7										78%
Participant 8										89%
Participant 9										100%
Success rate	100%	78%	89%	100%	89%	78%	89%	89%	100%	

Table 3.4: The task success rate for P2.

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Success rate
Participant 10										100%
Participant 11										100%
Participant 12										78%
Participant 13										100%
Participant 14										78%
Participant 15										100%
Participant 16										89%
Participant 17										100%
Participant 18										89%
Success rate	89%	89%	100%	100%	100%	89%	100%	67%	100%	

Table 3.5: The SUS score for P1. Q1-Q10 are the ten questions asked.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Sum
Participant 1	3	2	4	1	5	1	5	1	4	1	87.5
Participant 2	3	3	4	2	4	1	5	2	4	1	77.5
Participant 3	5	1	2	1	5	2	5	1	5	1	90
Participant 4	2	2	3	1	3	1	3	1	4	1	72.5
Participant 5	4	1	4	1	5	1	4	2	4	1	87.5
Participant 6	5	1	5	1	5	1	5	1	5	1	100
Participant 7	5	4	4	1	4	1	4	1	5	1	85
Participant 8	3	2	3	2	4	2	4	2	4	1	72.5
Participant 9	3	2	4	1	4	1	3	1	4	2	75
Sum											83.0

Table 3.6: The SUS score for P2. Q1-Q10 are the ten questions asked.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Sum
Participant 10	4	3	4	1	5	3	4	2	4	3	72.5
Participant 11	3	4	3	1	4	2	3	4	4	1	62.5
Participant 12	5	2	4	1	4	1	4	2	5	1	87.5
Participant 13	4	2	3	1	4	1	5	1	5	1	87.5
Participant 14	5	2	4	1	5	1	3	2	5	4	80
Participant 15	4	1	5	1	4	1	4	1	5	1	92.5
Participant 16	4	1	4	1	4	2	4	1	5	1	87.5
Participant 17	5	2	4	1	5	2	4	1	5	1	90
Participant 18	5	1	5	1	4	2	5	1	4	1	92.5
Sum											83.6

Qualitative data:

In order to compile and evaluate all the qualitative data from the tests, the tool Miro was once again used. In Miro, the views seen for each prototype in the comparison test were visualized in rows on a board. The board was also divided into two columns, one for each prototype. In addition, sticky notes with valuable comments from the testing were put up for each prototype view. The comments were grouped using the method of card sorting and placed in a group depending on whether it was something positive, negative, graphical, or overall ideas. When the comments were grouped, it was possible to count how many sticky notes said the same things and thereby quantify the qualitative data. In addition to the sticky notes, each TP's favorite design of each view was visualized by putting a green dot next to the view.

From the sticky notes and the votes, it was possible to conclude that P2 was the most appreciated design solution in the end. Most TPs found P2's design more playful, modern, and appealing. Interestingly, however, P1 was considered more stylish and appealing for one group of TPs, men over 40. The TPs who preferred P1 thought P2 looked too childish.

Chapter 4

Final Result

In this chapter, the result of the final prototype will be presented. The last iteration will be described, and takeaways and updates in the prototype based on the usability testing will be explained.

4.1 Takeaways from the Usability Testing

From the SUS score and the qualitative data, it could be concluded that P2 was the preferred prototype. The goal of the last iteration is to have one final prototype. Hence, P2 will lay the foundation for the development of the final prototype. The final prototype will, from now on, be called FP. However, the result from the usability testing also shows that P2 had its weaknesses and that there was room for improvements. P1 had some appreciated elements that also had to be considered in FP. Based on the compiled quantitative and qualitative data from the usability testing, a list of proposed improvements for FP could be made. The main takeaways from this and suggestions for improvements for FP are presented below.

- Check the contrasts to fulfill WCAG's requirements for accessibility.
- Present text in addition to all universal elements and icons.
- Buttons, tabs, texts, and icons should be bigger overall.
- Remove the welcome page.
- Change when the instructions for connecting the phone will be presented. Additionally, make the instructions clearer.
- Redesign the *game view* by combining the two prototypes from the latest iteration.

4.2 Final Prototype

Presented below are the changes and improvements made for FP. Each updated view will be described. As previously mentioned, FP is further developed based on P2 but with elements and concepts from P1.

Welcome page:

In FP, the *welcome page* is redesigned into a splash screen, which can be seen in Figure 4.1. In the previous design of the *welcome page*, the user needed to press on *Start* in order to come to the *home page*. This was a confusing and unnecessary step. When the game is launched, the *splash screen* loads for a couple of seconds. The text *Loading* is animated, as well as the moving plane and background. Consequently, it makes the first impression of the game look more visually pleasing. Additionally, the information about the number of active players is updated live, which motivates and engages new players in the game.

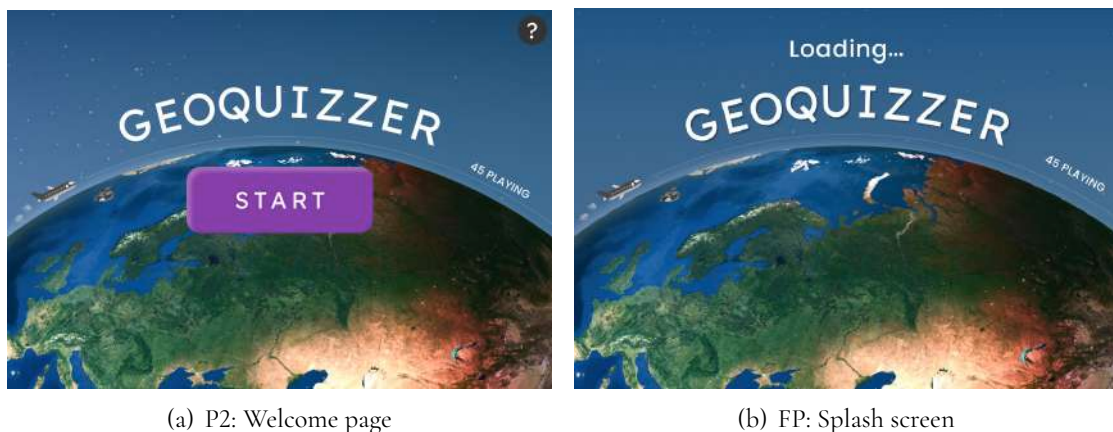


Figure 4.1: A comparison between P2's welcome page and the new, updated splash screen for FP.

Home page:

On the *home page*, which can be seen in Figure 4.2, a few changes have been made. The purple color on the *Play*-button is changed to make the game more uniform. In addition, the other buttons are enlarged. Even though many of the participants from the usability testing appreciated having the top list displayed on the *home page*, like it was in P1, it was decided not to have it in FP to avoid presenting too much information at once for the user.

In the previous design, the user could press the "?"-button to get help. This is replaced with an "i"-button with accompanying text underneath. When pressing the "i"-button, the user comes to the *introduction* of the game.

Introduction:

In FP's introduction to the game, which can be seen in Figure 4.3, the information is presented with less text. The text is presented in the form of a list and is left-aligned to enhance its readability. The color on the *Exit*-button is changed and accompanied by text underneath as

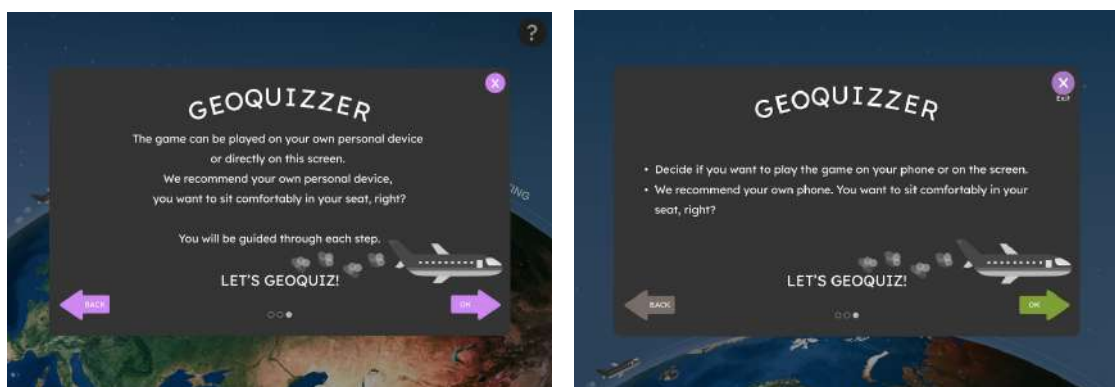


(a) P2: Home page

(b) FP: Home page

Figure 4.2: A comparison between P2's home page and the new, updated home page for FP.

well. The arrows where the user can navigate between the different pages have also changed color to grey, and on the last view of the introduction, the arrow is now green instead.



(a) P2: Introduction, page 3

(b) FP: Introduction, page 3

Figure 4.3: A comparison between P2's third introduction page and the new, updated page for FP.

Settings and Avatar:

The following changes have been made to all of the pop-up pages in FP. The views for the *Settings*-view and the *Avatar*-view are shown in Figures 4.4 and 4.5. The changes that have been made are that the pop-up pages have been enlarged to make the hit area bigger for the different buttons. The text presented on each tab has changed from uppercase to lowercase and is also enlarged to enhance readability. The icons presented on the tabs have also been enlarged and have changed color to enhance the contrast. The name of the previous tab *Levels* has been changed to *Difficulty*, and *Interaction* to *Social*. The icons for the tabs *Difficulty* and *Connection* has additionally been changed.

The check mark that is shown as *feedback* when the user has made a choice is enlarged, and additionally, a frame around the chosen element is shown in green to make the *feedback*

even more apparent. Furthermore, on the *Graphics*-tab, the buttons for choosing text size are enlarged, as well as the buttons for picking mode.

Except for the changes presented above, the additional changes made on the *Avatar*-view is that the user gets *feedback* in terms of a check mark and an informative text that informs the user that their changes have been saved. This was something many of the participants in the usability testing requested.

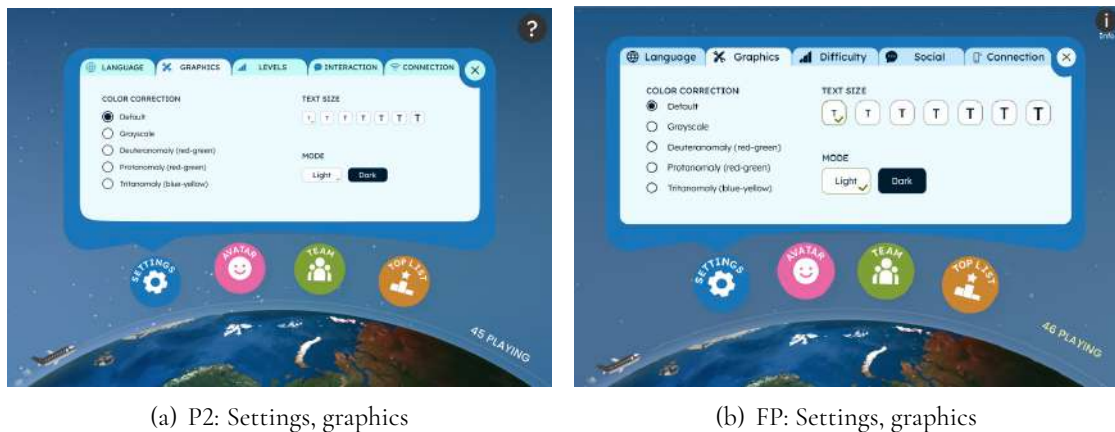


Figure 4.4: A comparison between P2's Settings page and the new, updated page for FP.



Figure 4.5: A comparison between P2's Avatar page and the new, updated page for FP.

Connect phone:

The pages for *connect phone* are in FP presented after the user has pressed the *Play*-button on the *home page*. These can be seen in Figure 4.6, 4.7, and 4.8. The reason for rearranging the order of when to present this screen was that it was shown in the usability testing that the user forgot their phone if connecting it too early. By presenting it directly before they

are going to use their phone, the risk of having drop-outs and the cognitive load for the user reduces. If the users clicks the button *On this screen*, as seen in Figure 4.6, they are navigated to the *game view* directly.

From the usability testing, different parts from P1 and P2 were preferred for these views. The initial screen from P2 has been saved, yet the purple colors and the color of the arrows have been changed. Additionally, icons for a phone and a screen have been added to the buttons. The help-button has been clarified with text, and if pressed, instead of turning into a cross like in the previous iteration, the purple color gets a bit darker. The informative text has been left-aligned and shortened to enhance readability. The alternative *On your phone* has been highlighted as recommended for the user. Another feature implemented is that if the user stays on the first screen for too long, the information and guidance are being displayed even though they have not pressed the *help*-button.

The second screen for *Connect phone*, seen in Figure 4.7, has inspiration from P1 since this received great feedback from the usability testing. The screen from P2 received feedback that the information looked like buttons. The difference from P1 is that the information is not shown from the beginning in FP. Instead, it will be presented if the user presses the *help*-button or if staying on the page for too long.

When the user has connected their phone by scanning the QR code or connecting through the webpage, the last screen is shown, seen in Figure 4.8. The symbol for *Connection successful* has been replaced, as well as an animated check mark has been added. Additionally, informative text is presented to the user to clarify when to use their connected phone. The last view disappears after a couple of seconds, and then the user gets to the *game view*.

Game view:

The updated game view for FP is a combination of P1 and P2. The result can be seen in Figure 4.9. In FP, the user starts in a zoomed-out position similar to P1, which can be seen in Figure 4.9(c). The entire globe is visible, and the different routes that the user can take across the game are marked with lines between the turquoise dots. The user can go to a specific destination by pinching and zooming on the globe. When doing so, a similar view to that of P2 shows up, which can be seen in Figure 4.9(d). The user can then switch between the views.

An added feature in FP is an alternative solution to navigate on the globe can be seen in the lower left corner in Figures 4.9(c) and 4.9(d). A control with "+"-sign and "-"-sign, as well as a zoom-element, are added. Also seen in the lower left corner is a small focus button. This can be used if the user has got lost on the globe and needs to easily and quickly find the way back to the personal avatar.

In FP, many features are updated. For example, all the completed destinations are now marked with green dots, and as previously mentioned, the uncompleted destinations are instead marked with a turquoise color. Using different colors for completed and uncompleted destinations gives the user visual feedback of the game's current status. In addition, the lines between the dots have also been updated to give the user even better feedback. The lines are now thicker, and there is a solid line between completed destinations. Uncompleted destinations are, in turn, marked with a dashed line instead. Moreover, all destinations now have a pin showing the city's name in the zoomed-in view. This makes it easier for the users to see the destinations of the current route. Furthermore, in FP, the colored planes showing the different players in the game are updated to be more consistent with the other graphics in

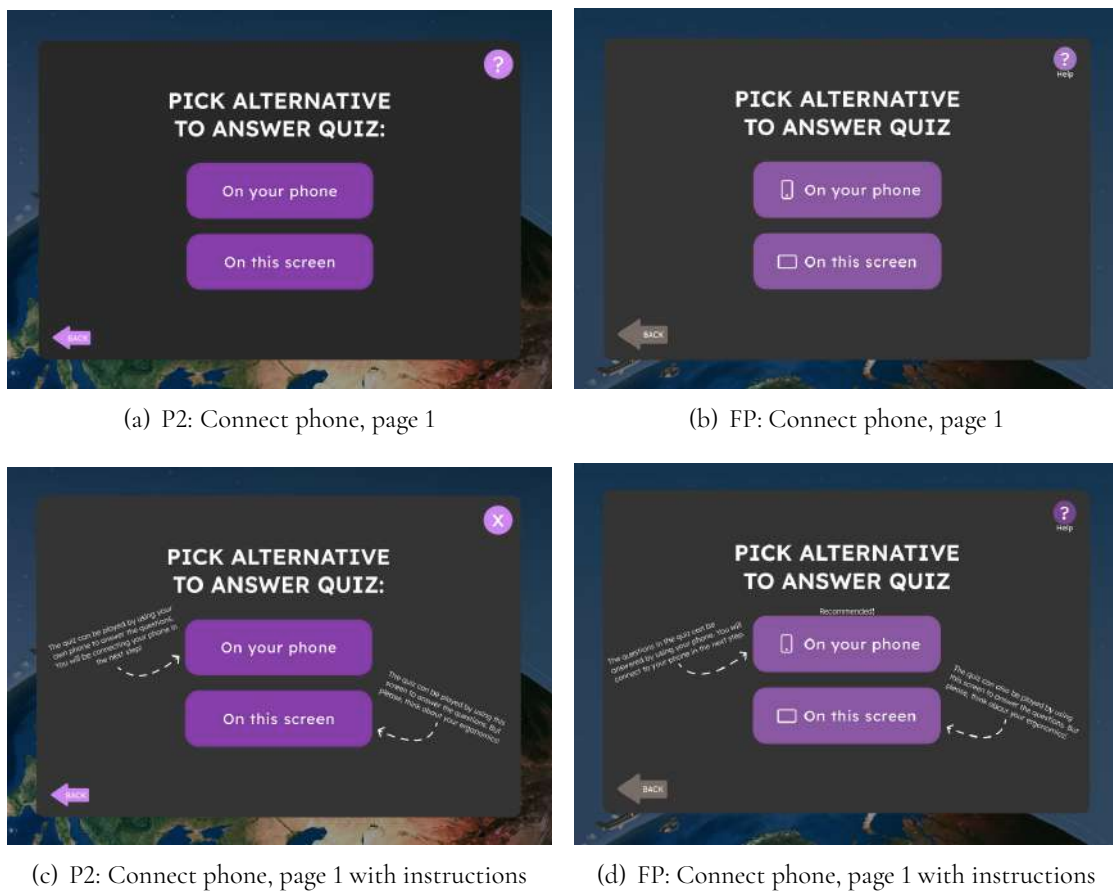


Figure 4.6: A comparison between P2's connect phone (page 1) and the new, updated page for FP.

the game. In addition, the user's own plane now also shows the user's chosen name.

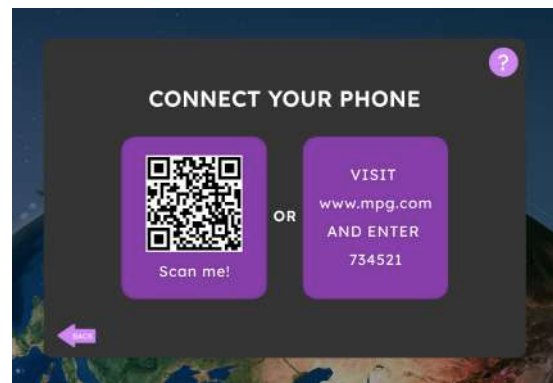
Even more updates have been made to the interface for FP. One example is that a blue circle with an icon now can be seen in the upper left corner; see Figures 4.9(c) and 4.9(d). This indicates whether the user's phone is connected to the IFE or not. Another update from the previous game view in P2 is that the buttons for *settings* and *team* now are moved to the upper right corner, along with the button for *avatar*. In addition, the buttons are now mapped in color with the buttons on the *welcome page*, and putting them directly on the game plan makes it possible for the user to open the tabs directly on the game plan instead of having to go to the home page of the game. An example of this can be seen in Figure 4.10(b). Furthermore, text is also added underneath each button on the screen. This is to clarify the icons if the user is uncertain about their meaning.

The purple elements at the top of the game view have also been updated. The purple color is changed in order to fulfill WCAG's requirements better. Moreover, the third information element has changed name from *questions* to *destination* to better describe what the information presents. This is since the usability testing showed that some test persons did not understand the meaning of that information.

Also, the *top list* has been updated in the design. The colors are changed to better blend in with the rest of the theme in the game. In addition, only half of the information is shown for



(a) P1: Connect phone, page 2



(b) P2: Connect phone, page 2

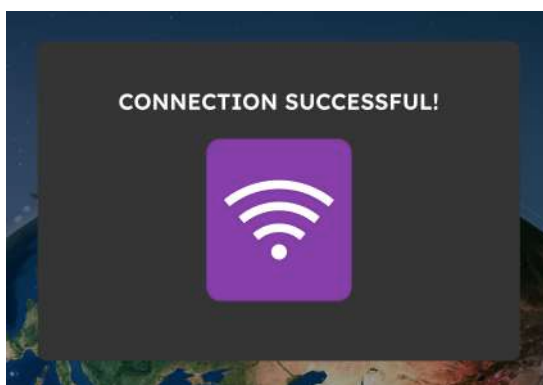


(c) FP: Connect phone, page 2

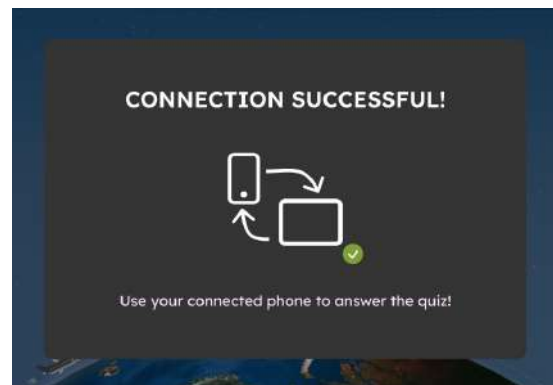


(d) FP: Connect phone, page 2 with instructions

Figure 4.7: A comparison between P1's and P2's connect phone (page 2) and the new, updated page for FP.



(a) P2: Connect phone, page 3 connection successful



(b) FP: Connect phone, page 3 connection successful

Figure 4.8: A comparison between P2's connect phone (page 3) and the new, updated page for FP.

the tenth person on the top list. Doing this gives a clearer *affordance* to the user that the *top list* is scrollable. Just as in P2, is it possible to minimize the top list by clicking on the small

arrow to the lower left of the element. In FP, minimizing the small 2D map in the lower right corner is also possible. A small globe is shown if swiping the map down to the corner. Making it possible to minimize both the top list and the map makes the game plan cleaner, as can be seen in Figure 4.10(a). This can be helpful in case the user feels that there is too much information presented at the same time.

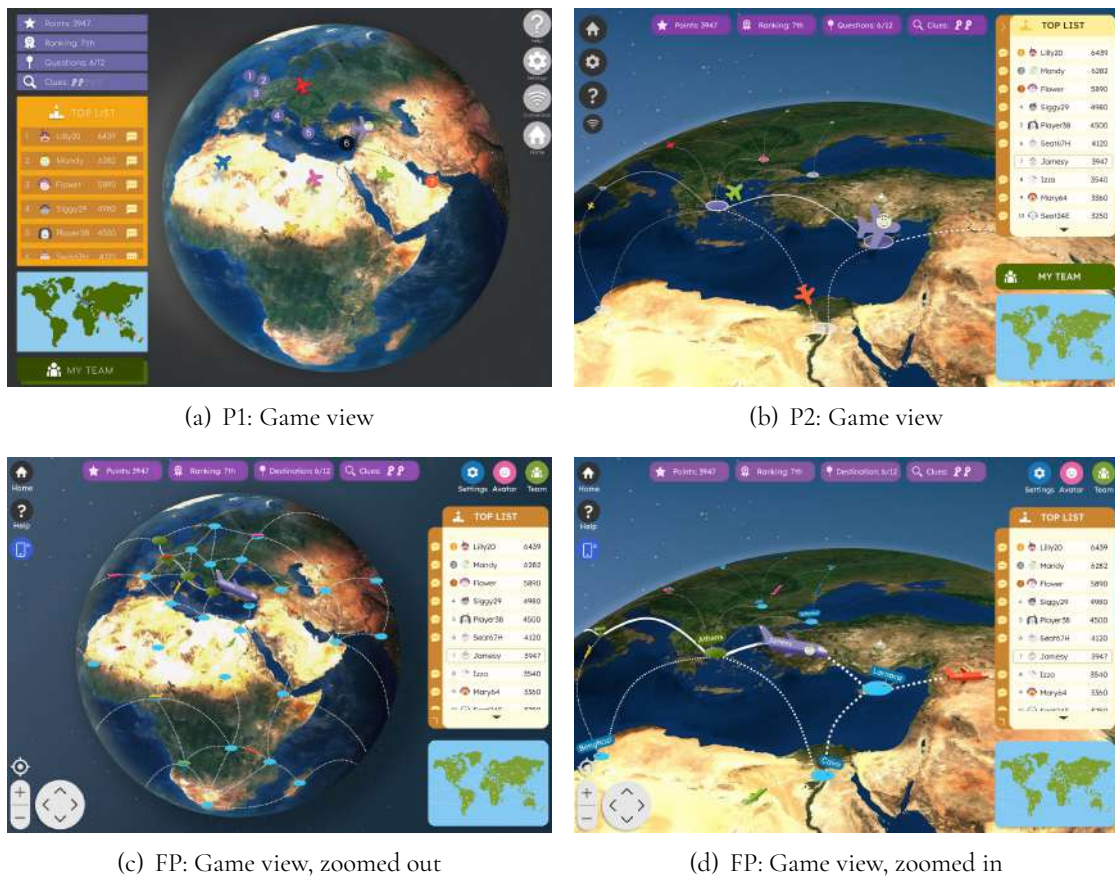


Figure 4.9: A comparison between P1's and P2's game view and the new, updated game view for FP.

Tutorial:

From the usability testing, it was clear that P2 was preferred for how the information in the tutorial was presented. However, the prototype had its weaknesses and needed to be updated for FP. For example, the information presented in the boxes is reduced to avoid information overload in FP. Additionally, the information is itemized, and the text is aligned to the left to enhance the readability for the user. Moreover, as previously mentioned in *Connect phone*, the purple color for the *exit*-button has changed, as well as the colors for the arrows placed in the lower parts of the boxes.

Minor adjustments have also been made to highlight what the user should focus on in the tutorial. In FP, the entire background of the game plan is darkened, and the relevant elements mapped to the information on the present slide are instead in focus. For example, when information about the *avatars* is presented, it is only the planes and the associated avatars that



Figure 4.10: Updated views of the game view in FP.

are in focus on the game plan. When information about the destinations instead is presented, the small dots and the lines between the destinations are in focus. Examples of this can be seen in Figure 4.11. By only showing the most relevant information in each view, it can be avoided that too much information is presented to the user simultaneously.

Quiz:

The quiz views from P2 were clearly the favorite among all the test participants. An example of a view from the quiz in P2 is seen in Figure 4.12(a). Therefore, not many changes have been made to FP. The significant change that has been made, however, is that the bar that shows the time and points has got a purple color to enhance the contrast, which can be seen in Figure 4.12(b). The last page of a quiz round summarizes the collected points from that destination. P1 received the best feedback on this page, seen in Figure 4.12(c). In FP, a result list is presented with the received points and if the user was correct or wrong, as well as the total points received on that destination, seen in Figure 4.12(d). A top list of the specific destination is shown to the right of the result list. Here the other players' scores are displayed and ranked. This feature allows the user to see how their points relate to the other players. Lastly, a green arrow with clarified text is displayed on the summary page to stay consistent throughout the design so the user knows how to continue the game.

Mobile view:

Not many changes to the mobile views have been made for FP. The changes that have been made are that the symbol for *Connection successful* is updated to the new one, and the text presented while the user is waiting has been updated. Moreover, the summary of the user's received score presented on the screen is also presented in the mobile view at the end of each quiz round. Additionally, the green arrow from the screen is also presented on the mobile view. The final mobile views can be seen in Figure 4.13.



(a) P2: Tutorial, page 1



(b) FP: Tutorial, page 1



(c) P2: Tutorial, page 2



(d) FP: Tutorial, page 2



(e) P2: Tutorial, page 3



(f) FP: Tutorial, page 3

Figure 4.11: A comparison between P2's tutorial and the new, updated pages for FP.

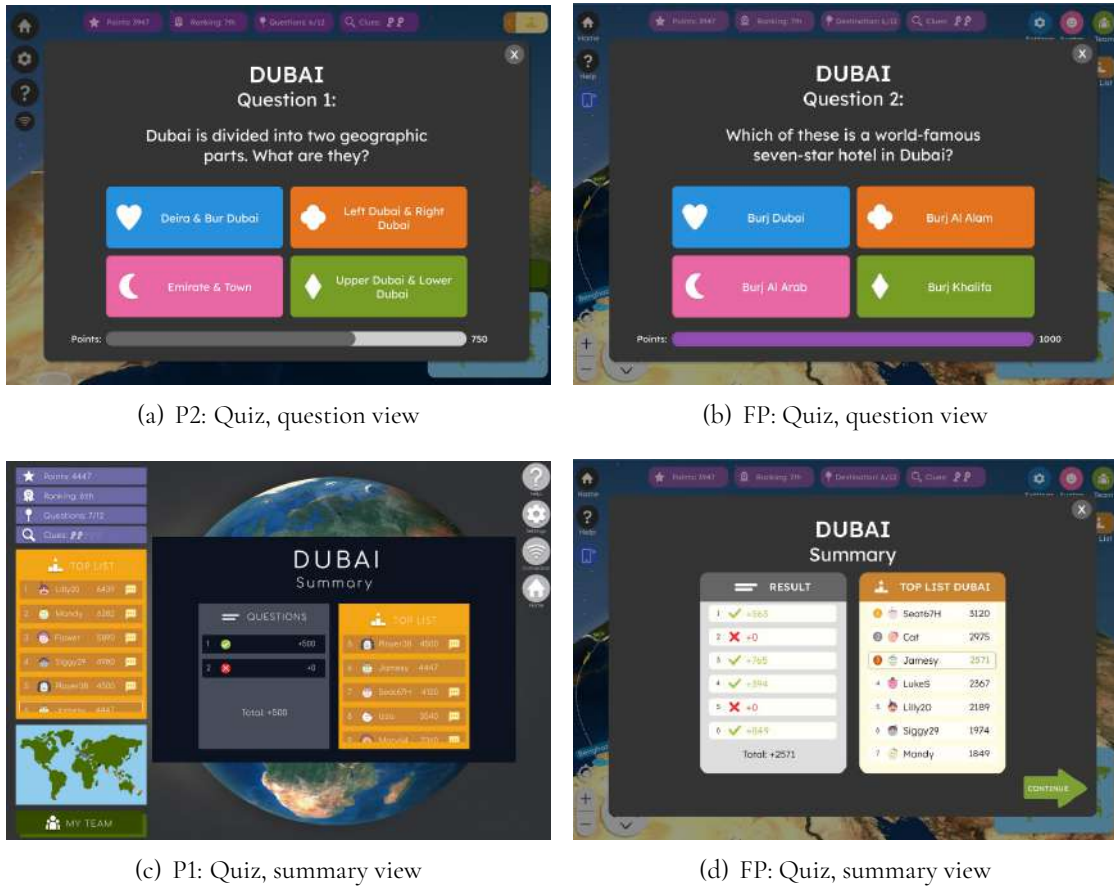


Figure 4.12: A comparison between P2's and FP's quiz view, and P1's and FP's summary.

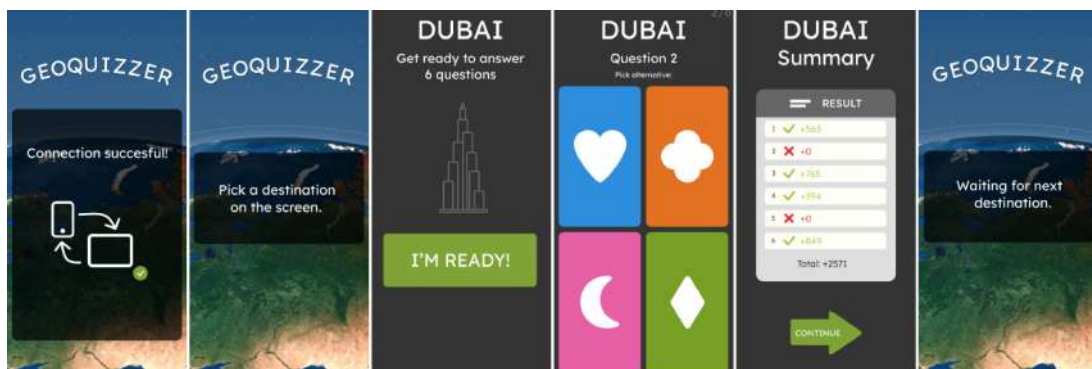


Figure 4.13: Updated views of the mobile version for FP.

4.3 Feedback Session with Designer

After updating FP based on the result from the usability testing, we wanted to validate the design by letting an experienced designer at Tactel give final feedback. The session was an hour and held remote. Overall, she was delighted with the updated design but still had some suggestions for improvements. For example, she gave feedback about the size and spacing of the buttons, especially on the *home page*. Most of the suggestions for improvement were otherwise regarding the game view. According to her, even though the design was updated, it still felt overwhelming. She suggested that the new buttons for *settings* and *avatar* could be considered unnecessary on the game view since they can be reached on the *home page*. Additionally, she also thought that the icon showing that the phone was connected was confusing and thereby unnecessary. Lastly, she gave some comments regarding improvements of the color on the summary of the quiz seen in figure 4.12(d). These minor suggestions for improvements were adjusted and can be seen in Figure 4.14. Moreover, the complete FP can be seen in Appendix C.2.



(a) FP: Updated home page

(b) FP: Updated game view



(c) FP: Updated summary in quiz

Figure 4.14: Updated views for FP based on feedback from a designer.

4.4 Further Improvements

Several improvements could be made to make FP more complete. Due to this project's scope, these improvements could not be implemented within the time frame. An essential part of the game is the multiplayer aspect. The interaction with the other players is a part of the multiplayer aspect and could be developed and investigated further. For example, the user should not have to set which phrases and emojis they want to use as interactions. There could be some pre-default choices and offer more opportunities to choose from. Another improvement linked to the interaction between players is that the user should get better feedback when sending an interaction to another player. A suggestion was to have a chat history where the different interactions could be saved. A notification could pop up when a new interaction is received. Also, the ability to turn off the interaction possibilities should be possible. A fun improvement could be to enable interaction with the other players directly on the game plan and not only in the top list. A feature could be to tap on the other planes on the globe and get direct information about the player and be able to send interactions to them. This improvement is also to clarify who is who on the globe and map the avatars better with their planes.

First and foremost, the purpose of the team needs to be clarified. A suggestion is that the team could work as a group that needs to complete all the destinations on the globe together or to complete different routes/challenges/areas on the globe. The team could then be rewarded with either trophies in the game or actual rewards from the airline if featured on the top list. The team could also work as a helping hand during a quiz round by having the opportunity to ask the team for help on a specific question. An appreciated idea would be if the users could pick their teams and have the possibility to play with their fellow travelers or neighbors on the plane. However, it should also be possible to play alone or be assigned to a random team to stay anonymous. Another improvement that could have been made was how to present the team and what kind of information that could be of interest on the *team page*. If the team aspect were developed further, as stated above, it would enhance the game experience and the multiplayer aspect.

Improvements could also be made regarding the avatar. For example, more options could be presented, and one user from the usability testing suggested that it would be fun to personalize the planes by customizing the design of the planes. This feature would make the game even more personalized and engaging.

Three additional slides for the tutorial could be developed to clarify the game concept even further. One slide should give the user instructions on receiving points and that the quiz is on time. The other slide could describe the purple elements presented on the top of the game plan. A result from the usability testing was that it was unclear what the number of clues, number of destinations, points, and ranking meant. Finally, the third slide could describe how to navigate the globe by showing how to pinch and zoom and showing the visual elements presented in the left-bottom corner of the screen.

Another further improvement would be to investigate the game concept. An idea from our first iteration was that the route on the globe would be the same as the user's actual journey. This idea was then removed from FP. However, the idea of starting with your own route on the globe to be then able to continue across the other routes on the globe is an idea we like, and that would be of interest to investigate further. A proposed idea from the usability testing was to have a final destination that the user should travel to. If the user gets

too many wrong answers, that destination gets blocked, and the user would have to take a detour.

Lastly, from a business perspective, it feels essential that there should be added value for the airlines. After all, they are the final stakeholders. Therefore, having the airlines' own travel destinations as the destinations on the globe feels like a good idea. Additionally, extra information about a destination could be displayed at the end of a quiz round. This information could, in turn, be retrieved from Arc's database. An appreciated idea was to get rewards if featured on the top list. From the user study, many suggested getting flight points, something from the tax-free shop, or discounts from the airline as rewards. That would have been desirable prices and a way to engage and motivate the players to be featured on the top list. A proposed idea from the usability testing was that even companies could sponsor the quiz with prices linked to destinations.

Chapter 5

Discussion

In the following chapter, the whole project and the final result will be discussed. First, an overall reflection with a discussion about how the goals and requirements are met are presented. After that, a discussion of the different design process activities will be presented. Moreover, the universal design principles and the research questions are discussed. Lastly, the potential future work for this project is presented.

5.1 Overall Reflection

This thesis allowed us to carry out a solid design process, which has been very rewarding and educational. We had the opportunity to immerse ourselves in theory and concepts related to interaction design and use the theory in practice during the process. It has been valuable for us to get hands-on experience, even though we have realized that putting so much time and effort into all activities related to interaction design probably is not possible to the same extent as a designer in the industry. Tactel has encouraged us during the thesis and is impressed and pleased with our final result. However, during the process, they have pointed out that it is seldom for them to have the resources to do such an extensive design process. This made us realize a gap between academics and how it works in the industry.

5.1.1 Goals

The project's purpose was to fulfill the overall goals mentioned in the introduction and the more specific goals established in the design process. All the overall goals have been fulfilled since the final result is a hi-fi prototype of a multiplayer game for the IFE that focuses on universal design and involves Arc. Additionally, a UCD process has been carried out. The more specific goals included the UX, usability, and efficiency goals.

The chosen UX goals can be equalized with some of the word pairs from the AttrakDiff questionnaire used in the usability testing. The AttrakDiff scores for each word pair for both

P1 and P2 were positive. Since FP is further developed based on the first two prototypes, it implies that this prototype also meets the AttrakDiff scores and fulfills the UX goals. It is difficult to measure that each goal is fulfilled when it comes to the usability goals. However, the SUS score can be used to measure the system's overall usability. Both P1 and P2 scored 83 on SUS in the usability testing. This implies that the usability in both prototypes is good but that there is still room for improvement to make them even better. As previously mentioned, since FP is further developed from the first two prototypes and improved based on feedback from the usability testing, we assume that the SUS score for FP would not be scored lower than 83. However, the users have not evaluated FP due to the project's time limit. Therefore, not evaluating FP with either SUS or AttrakDiff is a shortcoming. If we would redo the evaluation, this would, of course, have been prioritized. Despite this, the feedback and the qualitative data from the usability testing imply good usability in the prototypes, and thereby we suppose that the usability goals are met. Lastly, the efficiency goals are hard to measure. Nonetheless, the goals have been kept in mind when designing the prototypes. The conclusion is that there is a significant potential to fulfill them if FP is further developed and implemented.

5.1.2 Requirements

The established requirements have been focused on throughout all the different stages of the project. A motivation for how each requirement has been fulfilled will be presented below.

REQ.1: Aim for a challenging, entertaining, and motivating game

The qualitative data from the usability testing implies that this requirement is met. The potential users have given feedback that especially the feature of having a top list and potential rewards are motivating and challenging. Additionally, the team aspect and the interaction possibilities enhance the entertaining factor of the game. Furthermore, the concept of having a quiz was the main suggestion for the game idea from the user study. This is since a quiz is challenging and entertaining in itself.

REQ.2: Aim to be personal, but still preserve a traveler's integrity

This requirement is the underlying factor and motivation for providing the feature of having an avatar. The user can make the avatar personal by customizing it with color, smile, hair, hat, and choice of plane, as well as changing their name. At the same time, the avatar makes it possible to be anonymous, and in that way, the traveler's integrity can be preserved. Another feature in the game concerning this requirement is that the player can be personal and interact with other players. However, it is also possible for the player to play alone without involving or interacting with other players.

REQ.3: Present different levels

Since a T-prototype has been developed, other features have been in focus than the aspect of having different levels. Thus, the feature is presented but not yet developed and investigated further. This means that this requirement is partly fulfilled, but more effort about what the different levels should mean needs to be considered. Even though this aspect has not been in focus, it is still an essential requirement since offering different levels is a way to reach out to many users.

REQ.4: Interaction between players should be possible

There are interaction possibilities in the final prototype. The players can interact with each other on the top list by sending predefined phrases and emojis. Predefined phrases counteract the risk of players sending inappropriate messages. This feature could be further developed since it has much potential to make the game more personal and engaging. It is also a feature that could enhance the game's multiplayer aspect.

REQ.5: Offer different language possibilities

This requirement is fulfilled since the twelve most spoken languages are offered for the player to choose from. This is an important feature to reach out to a wide target group. However, seen from a business perspective, it could be very costly to implement.

REQ.6: Aim for an ergonomic seating position

By giving the users the opportunity and the recommendation to answer the quiz questions on their device, they can preserve an ergonomic seating position. This feature has the potential to be developed further. For example, there could be more possibilities to use the phone as an additional screen to perform other actions than answering the quiz. However, this is out of scope for this thesis. A more extensive user study and usability testing in an environment similar to an aircraft cabin are needed to draw any conclusion about this feature.

REQ.7: Aim to not disturb neighbors

By offering the players the possibility to answer the quiz questions directly on the phone, some potential disturbances for the neighbors can be avoided. Nevertheless, more comprehensive usability testing in an environment similar to an aircraft cabin is needed to ensure this requirement is fulfilled.

REQ.8: Involve Arc

Arc is involved since the whole game is based on interacting with the globe. Arc is the base for the graphical UI, and there is a possibility to include the 3D engine that Arc uses even more if implemented.

REQ.9: Should be suitable for a wide variety of users

This requirement can be met in many different ways. One motivation for fulfilling this requirement is that the seven UD principles are considered. Having these principles in mind when designing makes the solution suitable for a broad target group where everyone has different needs. The principles will be described more in section 5.3. Additionally, REQ.2, REQ.3, and REQ.5 are also related to this requirement.

5.2 Design Process

Having a UCD process was one of this thesis's overall goals, and the three main principles have been followed throughout the project. The first principle *early focus on users and tasks* has been achieved since the project started with a solid literature- and user study, among other

things. For example, in the user study, an SME interview with a flight attendant was held to understand the users better and complement the user interviews and the questionnaire. Additionally, valuable input from stakeholders has also helped to understand the users and their needs and challenges related to the particular environment in the aircraft cabin. The second principle, *empirical measurements*, has also been achieved in the project. The potential users have been involved throughout the project, for instance, in the user study, feedback session, and usability testing. However, when reflecting on the process, each iteration could have been shorter with more involvement of the users to get feedback more frequently. Consequently, the third principle of having *iterative design* has also been fulfilled to some extent. Nevertheless, as previously mentioned, the iterations could have been shorter. In that way, more iterations would have been possible to get feedback more often.

The design process has consisted of the four main activities of interaction design. The main insights from each activity will be further discussed below.

5.2.1 Establish Requirements

Establish requirements is the step where it should be decided what the product should do. We thought this activity was essential to understand the users and their needs and thereby determine the project's purpose. Due to this, this phase was carried out thoroughly and laid the foundation for the rest of the project. Especially the result from the questionnaire, with 425 responses, is something that we are proud of. Having that amount of data makes it easier to strengthen why our final solution is something the users want. It has been a valuable insight to realize the importance of involving the users in an early stage. This step in the process should not be underestimated. By creating personas based on the user study, it was also possible for us to get a common understanding of the users' needs. In addition to the user study, the literature study has been valuable in understanding the special circumstances related to the flight experience. The user study and the literature study have given a comprehensive understanding of the project's scope.

5.2.2 Designing Alternatives

This phase consisted of the conceptual design and the physical design. The most valuable activity in this phase was the workshop at Tactel with a group of designers. The workshop resulted in many interesting and innovative ideas that could be used as inspiration for the following steps in the process. Additionally, we used several theoretical methods that helped us to agree upon a mutual conceptual design. Some of the activities could have been sifted away when looking back at the entire process. Nevertheless, with that being said, it may have been essential activities since we were two designers. It made us more synchronized, and in that way, we ensured that we were striving for the same goals.

5.2.3 Prototyping

A braindrawing session that resulted in extensive sketches was held at the beginning of the prototyping phase. This was an excellent opportunity to explore and visualize different design alternatives. Braindrawing was an interesting and helpful method that was appropriate

to use. The selected sketches were then used in the feedback session, which helped us to narrow them down to two alternatives. These alternatives were then refined and redrawn to the two comprehensive lo-fi prototypes. Making the two lo-fi prototypes analog on paper took a very long time; hence, if we would redo the process, the sketches would have been made with the help of a digital tool instead to speed up the process. Despite the time and effort it took to produce the lo-fi prototypes, we are still delighted with the result and have not regretted spending so much time on this phase. Due to the solid work, the lo-fi prototypes could be used as wireframes when starting the initial hi-fi prototyping phase.

Also, improvements could have been made in the hi-fi prototyping phase if we redo the process. Firstly, a better and more detailed plan should have been made in the initial stage. In that way, we could have avoided some redundancy in the two prototypes, P1 and P2. Some of the components in the design system could have been reused better and more efficiently. Secondly, making two prototypes as interactive as they were was an unnecessary step since there was not enough time during the usability testing to test and show all the implemented functionalities. This means that the two prototypes should have been tested earlier. This would have given us more time to develop FP further. Due to different circumstances, FP is sadly not as complete as we wanted. Nevertheless, as stated above, we are happy with the results since we have learned a lot and have gotten valuable insights.

5.2.4 Evaluating

Throughout the process, we have been evaluating the design in different ways. In the lo-fi prototyping phase, a feedback session was held. Here we wanted to compare the several views drawn on different themes. We wanted the test participants to give their initial reactions and thoughts about the different design alternatives for each view. However, due to the number of detailed sketches, we were worried about causing cognitive overload for the test participants. We did not find any appropriate method to use to avoid this. Consequently, we created our own method, which turned out to be very suitable for our purpose. Through this approach, we hopefully avoided the test participants giving incorrect feedback due to being exposed to too much information at the same time.

The two developed hi-fi prototypes were evaluated in a usability test with 18 participants. Comparative usability testing firstly seemed like a suitable method to use since the usability in each prototype was to be evaluated. However, since the interaction possibilities are the same in both prototypes, it felt unnecessary to try the same scenarios on both prototypes. Therefore, half of the participants tested the usability on P1 and the other half on P2. In this way, it was still possible to compare the usability of the prototypes since the test participants filled out a SUS questionnaire for the tested prototype. This makes the SUS score for each prototype equitable. Instead of using the time to do a more classic comparative usability testing, comparison testing was instead used to evaluate the design of the two prototypes. To facilitate the test participant's short-term memory, the two prototypes were presented simultaneously next to each other. This setup aimed to get the test participant's initial thoughts and feedback on the designs. The test participant could point out specific details that they liked or did not like by comparing the designs. This gave us valuable insights and qualitative data, which would probably be missed out otherwise. It was also an opportunity for the test leader to ask more extensive questions and get detailed answers from the test participants. This method was very suitable for our purpose and had the potential to be

further investigated.

Even though we are happy with the outcome of the evaluation part of the project, we could have done some parts differently. For example, it might have been better to do a comparative design feedback session at an earlier stage with the two hi-fi prototypes. Since the test participants did not interact with the prototypes when evaluating and comparing the design, it was unnecessary to have two fully functional and interactive prototypes for getting this feedback. However, deciding which prototype to develop further based only on the design is insufficient. It is more critical to evaluate the prototypes in terms of usability. Therefore, to test the usability, the prototypes still needed to be interactive in some ways. From our perspective, usability should be rated higher than the design to be able to provide a product with a good user experience. The usability can be measured with SUS, and to decide which prototype to develop further, the prototype with the highest SUS score should be chosen. However, in this particular case, the SUS scores for the two prototypes were almost the same, which implies that the usability of each prototype is equally good. This means that we had the opportunity to choose which prototype to further develop into the final prototype based on qualitative data regarding the design instead.

In addition, it may have been valuable to spend more time on FP and make it as interactive as possible and then do another comprehensive usability testing in the end. In that way, it would have been easier to evaluate the final design by getting a SUS score and result from AttrakDiff, and thereby easier to motivate how the goals and requirements would have been met. Unfortunately, this was not accomplished because it would be very time-consuming and not reasonable to do within the time frame for this thesis. Thereby a delimitation had to be made. Furthermore, due to the project's time limit, no usability testing was conducted to evaluate FP in the end. However, a short feedback session with one designer at Tactel was held to validate the final result. In that way, we could at least validate that the updated design was more appealing and make some minor improvements based on the feedback.

Finally, the most crucial issue to consider is the limitations regarding involved users and test participants. This thesis aimed to make a suitable multiplayer game for various users, regardless of age, culture, and background. Unfortunately, the involved users and test participants were primarily Swedish. We are aware that this may have affected the result. Another outcome could have been possible if the involved users and test participants had reflected the broad target group better.

5.3 Universal Design

Since one of the overall goals of this thesis is to fulfill the principles of UD, these have been kept in mind during the whole design process. The overall ambition with UD is that new products being developed should not need any specialization. Every person should be able to use the product, regardless of background. This approach has been adapted in the project to some extent. However, personal preferences will always exist. Therefore customization of the UI is possible in *Geoquizzzer*. For example, graphical preferences can be adjusted in *Graphics*. Moreover, it is possible to choose the preferred language in *Language*.

Equitable Use

Equitable use is about having an inclusive mindset and avoiding stigmatizing when design-

ing. This approach has been kept in mind during the process and has laid the foundation for the rest of the UD principles presented below.

Flexibility in Use

Geoquizzer offers flexibility in several ways. It is possible to customize the graphical UI and choose the preferred language mentioned above. Additionally, it is possible to adapt the colors of the UI if needed. Furthermore, the players can decide whether to play alone or in a team, whether they want to be anonymous or not, and whether they want to interact with other players. Providing the players with different options regarding the social aspects makes it possible to preserve their integrity. Another flexibility is that different levels are offered in the game. A UX goal for the project, as well as *REQ.1*, is that *Geoquizzer* should aim to be challenging, entertaining, and motivating. The different levels enable the players to find their suitable degree of difficulty and thereby decide how challenging the quiz should be. By offering this flexibility, a broader target group can be reached. Moreover, physical flexibility is offered by giving the players the possibility to use their own phones to answer the quiz. There could be a potential issue for people that have problems with fine motor skills to navigate on the globe in the game by pinching and zooming with their fingers. Therefore, another alternative for navigation is offered in terms of a navigation wheel and buttons to zoom in and out.

Simple and Intuitive Use

Throughout the game, design guidelines have been followed. Consequently, this UD principle has been fulfilled, and the result is a UI that tries to be as intuitive and consistent as possible. An example of making the game intuitive is that all icons and elements have an accompanying and descriptive text. Additionally, informative feedback is given to the users when they perform an action. We have strived to make the interface simple by limiting the amount of text presented in each view. However, it is also important to give the user guidance and help if needed. This is why both introductions and tutorials are available to all game players. Moreover, WCAG's recommendations regarding color contrasts have been followed in the prototypes to make the interface simple and intuitive.

Perceptible Information

As previously mentioned, perceptible information is offered to the users by accompanying icons with descriptive text. Another way to fulfill this principle could have been to provide the information via audio to the users. In this way, multimodality could have been achieved since the information is presented through different senses. However, we decided not to focus on this feature due to *REQ.7*, since there is a risk that the audio would disturb neighboring passengers.

Tolerance for Error

In this type of system, this principle has not been prioritized. Nonetheless, the user can always exit an action if wanted or navigate back to previous views.

Low Physical Effort

To fulfill *REQ.7* about not disturbing neighboring passengers, it was decided that the game should be played in a sitting position without much movement needed. This, in turn, requires low physical effort. This principle is also fulfilled if the players use their own phones

to answer the quiz. Then good ergonomics can be maintained.

Size and Space for Approach and Use

This principle can have a different meaning depending on the product's circumstances. In this project, the focus of this principle is on the UI for the game and not on the environment in the aircraft cabin. In the UI, especially the size of interactive elements has been thought about. The users also have the opportunity to customize the graphical UI if wanted, to suit their personal preferences better.

5.4 Research Questions

The four research questions have been answered throughout the project. Below is a summary of the main takeaways for each research question.

RQ.1: Who are the users and how can their requirements be satisfied?

From the literature study, it was concluded that the users in focus for this project are adults traveling in economy class. The primary users are, therefore, the ones playing *Geoquizzzer*, while the secondary users are the indirect users who, in some way or another, are involved with the primary user's interaction with the game. The tertiary users are, for example, stakeholders and cabin crew. These conditions laid the foundation for the user study, which resulted in a better understanding of the user's needs. This, in turn, resulted in a set of requirements for the game. How the different requirements have been fulfilled has been discussed and motivated in section 5.1.2.

RQ.2: How should the solution be designed to ensure that the UD principles are covered?

The UD principles have, as previously mentioned, been in focus during the entire project and have to some extent, all been fulfilled. Especially having an inclusive mindset when designing has been vital for us. Due to the importance of these principles, they are presented in section 5.3.

RQ.3: How can the design of the interface ensure that the users can play together regardless of age, culture, and background?

By having the UD principles and the various design guidelines in mind when designing the UI, the aim of the game is that it should be suitable for a wide variety of users. However, a more comprehensive usability testing with a better representation of the target group would have been needed to ensure this. In addition, since the final result is based on the literature study and the user study, the user study should have been published on more international forums to reach a more diverse audience.

RQ.4: How should the interaction between potential players be designed?

This research question has not been the main focus of the thesis which means that it needs to be further researched to be answered more in detail. Despite this, some ideas for how multiple potential players should interact have been presented. In the current solution, the players can interact with each other by sending predefined phrases and emojis. The reason

for only providing predefined phrases is to avoid players sending inappropriate messages to each other. A future improvement could also be to make it possible for the players to interact within their team. In that way, they could exchange knowledge and enhance the entertainment factor and the multiplayer aspect. An important conclusion from the user study is that there should be an option for the players to decide if they want to be social with the other players or not.

5.5 Future Work

Geoquizzer has much potential to be a commercial product. However, several aspects need to be further developed and investigated to make this possible. Among other things, the game concept and the multiplayer aspect need to be considered. Many valuable ideas related to these aspects have been presented during this project. These are discussed more in depth in Section 4.4.

A comprehensive usability testing should also be performed on the final prototype. As mentioned before, finding test participants that better reflect the entire target group should be in focus for the usability testing. This is in order to get a more fair and accurate result.

Lastly, the main task for future work is to present the final idea to the stakeholders of Panasonic to see if it is a project of interest. Moreover, the final step is to implement the prototype and involve the 3D engine that Arc utilizes. The implementation will also include a database with appropriate questions for the quiz.

Chapter 6

Conclusion

This thesis aimed to investigate how to design a multiplayer game for long-haul flights. This process included designing a UI, the UX, and a game concept. During this development, the seven UD principles have been in focus. Moreover, it has been essential to consider the wide variety of users and the particular environment in the aircraft cabin in the design.

The result is a game concept named *Geoquizzer*, presented as a hi-fi prototype that is challenging, motivating, and engaging. A user-centered design process, including the four main interaction design activities, was followed to achieve this result. A comprehensive user study laid the foundation for the project and could be used to motivate the choice of designing and developing a quiz. Furthermore, all design decisions can be motivated with regard to the users' involvement. Potential users and experienced designers have been involved in the design process. In the lo-fi prototyping phase, a feedback session was held. In this session, a new method for comparing designs was established. Moreover, a comprehensive usability test with mixed methods was held in the hi-fi prototyping phase. The result from the feedback session and the usability testing has been used to update the design throughout the project. Therefore, the final result will hopefully fulfill most of the users' needs and requirements. A conclusion is that most goals and requirements for the project are met, but there are still areas that need more research and investigation to be fulfilled.

One key takeaway from this project is that UD is fundamental. However, it is a challenge to satisfy all the users without stigmatization. Another insight is that conducting a comprehensive user study is valuable to establish requirements and thereby design something that meets the users' needs. It has been educational to perform a solid design process. However, it may not be possible to go as deep in every phase out in the industry.

The long-term goal is to create a commercial product that utilizes existing hardware and software on long-haul flights to enhance the passenger's flight experience and make their time pass quickly. To reach this goal, further improvements and research concerning the design and the game concept have to be conducted. With that being said, we are still delighted with the final result and what we have learned throughout the project. There is much potential that *Geoquizzer* can be a commercial product.

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Appendices

Appendix A

User Study

In this appendix the result from the questionnaire and interviews done in the user study will be presented.

A.1 Questionnaire

Presented below are the script and the questions asked in the questionnaire for the user study.

A.1.1 Questionnaire Script

"Hello! We are two students at the Faculty of Engineering at Lund University writing our master's thesis this spring. Our research focuses on exploring the possibilities of improving the flight experience on long-haul flights. When answering the questions, please think about your flight habits before COVID-19. The survey is divided into short sections with alternatives to choose from. Your participation is anonymous and highly appreciated! Thank you for your participation!"

A.1.2 Questionnaire Questions

Presented below are the questions asked in the questionnaire for the user study. Under the questions, the different answering options are shown.

Background information:

- What is your age?
- To which gender identity do you most identify?

– *Female*

- *Male*
 - *Non-binary*
 - *Prefer not to answer*
- How confident are you in exploring new technologies?
 - *Scale 1-5 (not confident at all-completely confident)*
- Approximately how many times in the last ten years have you travelled by long-haul flights that are longer than five hours?
 - *0*
 - *1*
 - *2-4*
 - *5-10*
 - *11-20*
 - *21-50*
 - *51-100*
 - *Over 100*

The flight experience:

- Which travel class do you mostly fly in?
 - *Economy-class*
 - *Business-class*
 - *First-class*
 - *Other*
 - *Free-text answer*
- For what purpose(s) are you usually flying?
 - *Business*
 - *Holiday*
 - *Visit family and friends*
 - *Educational purposes*
 - *Backpacking*
 - *Other*
- Do you have problems sleeping or resting during long-haul flights?
 - *Yes*
 - *No*

- Do you have problems staying entertained during long-haul flights?
 - Yes
 - No

- What do you prefer to do during long-haul flights to stay entertained? Pick up to 3 alternatives.
 - Read
 - Play games on devices (mobile phone, tablet, computer, in-flight entertainment system)
 - Watch movies/series
 - Play physical games (board or dice games etc.)
 - Listen to music/podcasts
 - Play trivia quizzes
 - Have a conversation
 - Work
 - Play puzzles (crossword, sudoku etc.)
 - None of the above
 - Other

- According to you, what are the most annoying things your neighbour could do during long-haul flights? Pick up to 3 alternatives.
 - Taking a lot of space
 - Having the light on when it is dark
 - Talking too much
 - Playing games
 - Interacting with the in-flight entertainment system (the screen on the seat in front of you)
 - Playing loud music
 - Disturbing choice of movie/series
 - Reclining the seat
 - Leaving the seat often
 - Nothing
 - Other

Games:

- How big is your interest in games?
 - Scale 1-5 (not so interested-very interested)

- Have you ever played games on the in-flight entertainment system (the screen on the seat in front of you)?

- Yes
 - No
- What types of games have you played on the in-flight entertainment system (the screen on the seat in front of you)?
 - *Action/Adventure*
 - *Arcade*
 - *Board game*
 - *Cards*
 - *Education*
 - *Music*
 - *Puzzle*
 - *Quiz*
 - *Racing*
 - *Sport*
 - *Strategy*
 - *Word games*
 - *Other*

Multiplayer games and IFE:

- Do you ever play multiplayer games?
 - Yes
 - No
- What types of games would you like to play with others?
 - *Action/Adventure*
 - *Arcade*
 - *Board game*
 - *Cards*
 - *Education*
 - *Music*
 - *Puzzle*
 - *Quiz*
 - *Racing*
 - *Sport*
 - *Strategy*
 - *Word games*

- *Other*
- If possible, would you like to interact with the in-flight entertainment system (the screen on the seat in front of you) by using your mobile phone?
 - *Yes*
 - *No*
 - *Don't know*

Other:

- Which is your favorite game to play on your devices?
 - *Free-text answer*
- Anything else you want to add?
 - *Free-text answer*

A.2 Interviews

Presented below are the questions asked in the user interviews and the subject matter expert interview for the user study.

A.2.1 User Interview Questions

Background:

- Tell us a little about yourself, your profession and previous flight experiences.
- Do you feel confident with exploring new technologies?

Flight habits:

- How many times in the last ten years have you travelled by long-haul flights that are longer than five hours? To which destinations?
- Which travel class do you mostly fly in?
- For what purpose are you usually flying?
- Do you have problems sleeping or resting during long-haul flights?
- Do you have problems staying entertained during long-haul flights?
- What do you prefer to do during long-haul flights to stay entertained?

Flight experience:

- Is there a particular time during the flight when you feel most bored?

- What bothers you the most in the surroundings when you are flying?
- Have you ever been disturbed by what your neighbour is doing on the IFE?
- Have you ever been disturbed by a neighbour playing games?
- Have you ever been disturbed by a neighbour that is moving too much when playing a game?

IFE perspective:

- Do you use the IFE?
 - If yes, for what purpose?
 - If no, why?
- Is the IFE an important feature for you on long-haul flights?
- Do you usually explore what the IFE has to offer?
- Have you ever played games on the IFE?
 - If yes, what type of game?
- Have you ever connected your phone to the IFE during a flight?
 - If yes, what did you do with your phone?
 - If no, would you use a feature where you could connect your phone to the IFE?
- Have you ever used another device than your phone to connect to the IFE (e.g. a remote control)?

Game perspective:

- How big is your interest in gaming?
- What types of games do you like to play?
- What motivates you to play?
- What makes you try a new type of game?
- What factor is most important for you when choosing which game to play?
 - Should it go fast?
 - Should it be easy or challenging?
 - Should it be aesthetically pleasing?
- Do you ever play multiplayer games?
- What type of quiz do you like?
- What type of board games do you like?

Specific questions related to our game idea:

- Does the game idea spontaneously feel like something that you would like to play?
- If there was a multiplayer game on the IFE, would you try it?
 - If yes, what type of game would you like to play then?
 - If yes, who would you like to play with? Your travel company? Your neighbours? Anyone on the plane?
 - If yes, would you like to be able to interact with the other players?
 - If no, why?
- Do you have any spontaneous idea of how this game could work?

Other:

- If you could wish for anything, is there something that you wish you could do on the IFE that would make your flight experience better?
- Anything else you would like to add?

A.2.2 Subject Matter Expert Interview Questions

Background:

- Tell us a little about yourself, your profession and previous flight experiences.

Flight circumstances:

- What different types of moments do you as a flight attendant have on your schedule where you interact with the passengers?
- Is there a big difference in how well the passengers can rest depending on which class they are flying in?
- Is there a big difference in the facility offered within the different classes?
- Do you experience that passengers in economy-class find it difficult to stay entertained?
- What are the most common things that the passengers entertain themselves with in addition to watching movies, eating and sleeping?
- With your experience, what do most passengers get annoyed about that their fellow neighbours do?
- Can you notice culture clashes between passengers?

IFE perspective:

- Approximately how many percentages of the passengers use the IFE?

-
- Approximately how many percentages of the passengers use the IFE for other things than watching movies?
 - Is it possible to see the information on your neighbours' IFE?
 - Do the passengers have their own remote controls to control the IFE?
 - Is it possible for the passengers to connect their phones to the IFE? If possible, approximately how many passengers use this service?
 - Have passengers been less likely to touch the screens during the pandemic?
 - How often is there an interruption in the IFE for warnings, messages et cetera?

Entertainment perspective:

- Have you seen a lot of people playing games on their own devices?
- Are there a lot of passengers who bring their own computer or tablet on the plane to play games on?
- Are there a lot of passengers who bring physical games on the plane to play? If yes, what type of games are they playing?
- According to our literature study, most passengers get bored and find it difficult to stay entertained when it is two hours of the flight left. Is that something that you have experienced as well?

Specific questions related to our game idea:

- Does the game idea spontaneously feel like something that the passengers would like?
- Is it something that you already have?
- Do you think the game would be disturbing?
- Do you think the game would help the passengers to stay entertained?
- Do you have any spontaneous idea of how this game could work?
- Do you think the game will have a negative impact on the flight attendants' work?

Other:

- Anything else you would like to add?
- What flight circumstances should we keep in mind when designing the game?

A.3 Figures

A.3.1 Affinity Diagram

Presented below in Figure A.1 is the affinity diagram made from the user study.

A.3.2 Diagrams

Below, in Figure A.2-A.16 are the diagrams created based on the questions asked in the questionnaire for the user study.

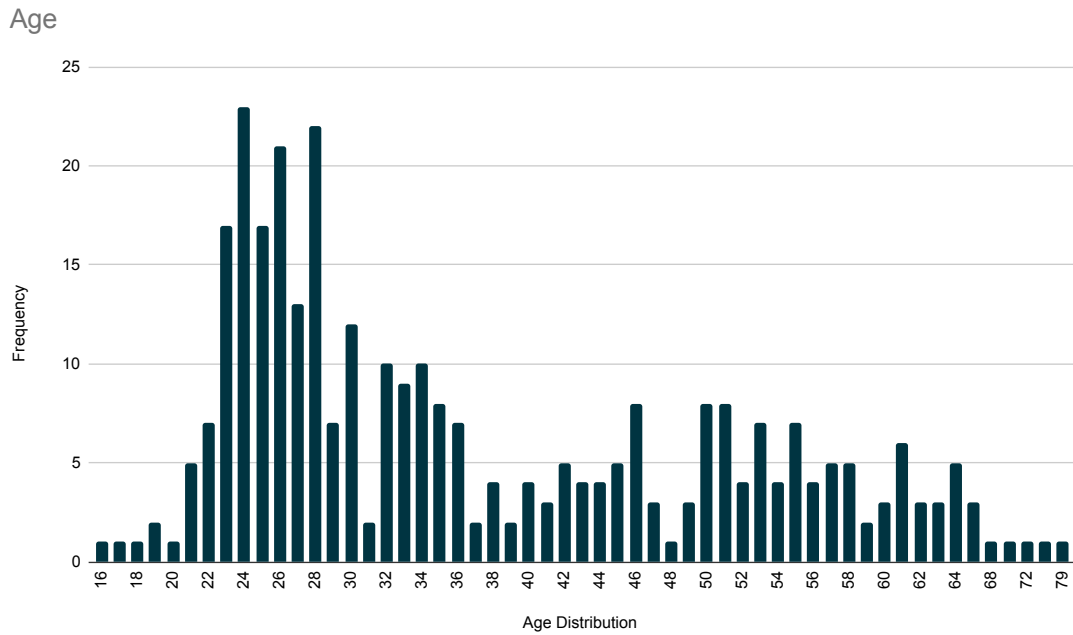


Figure A.2: Age distribution from user study.

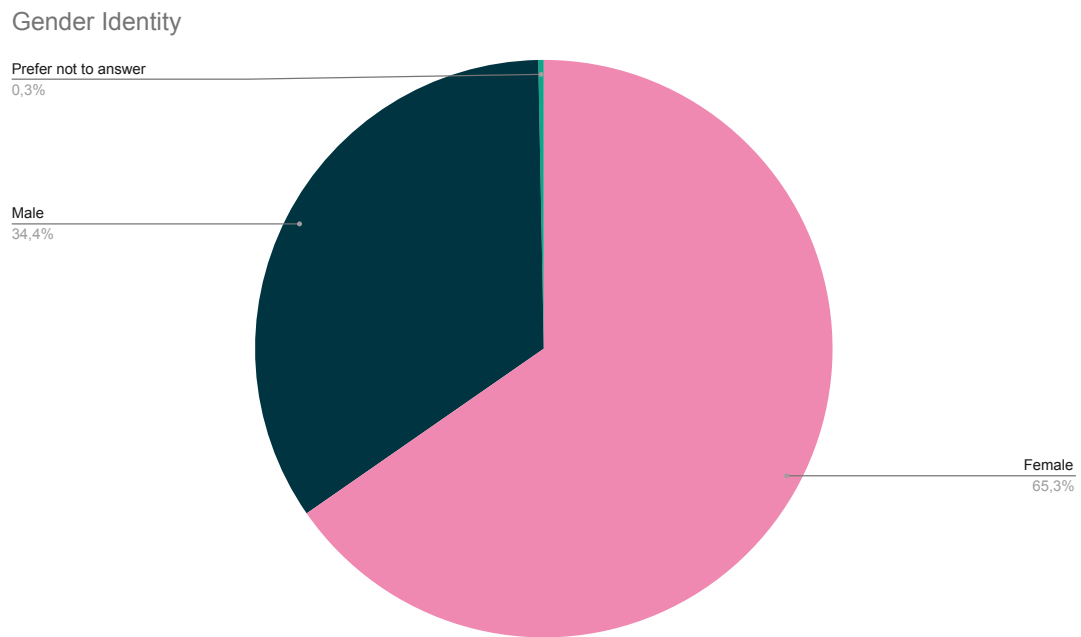


Figure A.3: Gender distribution from user study.

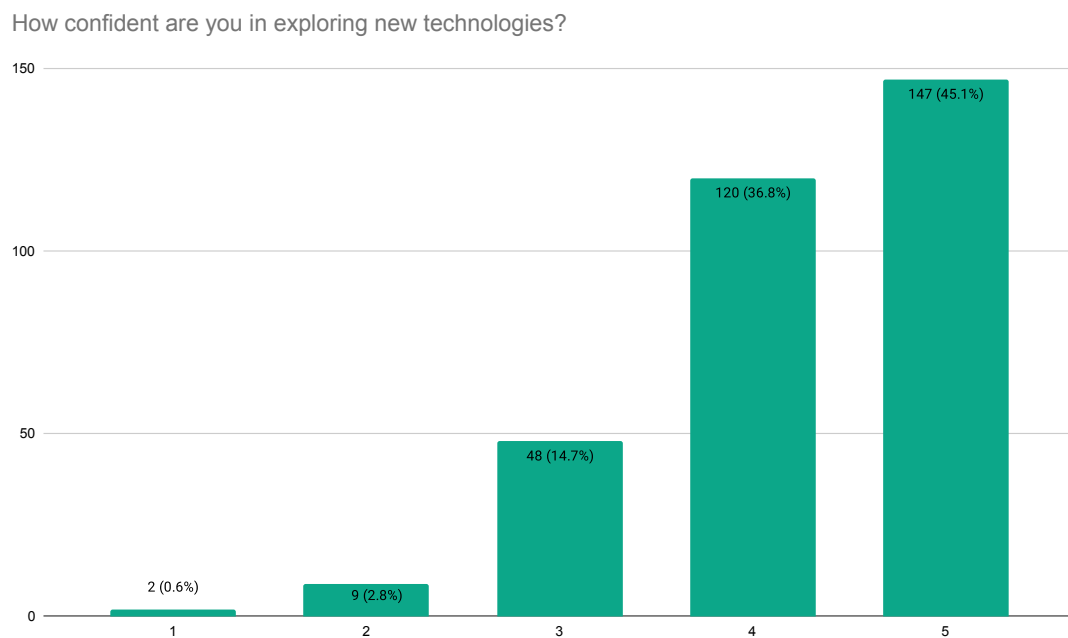


Figure A.4: Diagram regarding exploring new technologies from user study.

Approximately how many times in the last 10 years have you traveled by long-haul flights that are longer than 5 hours?

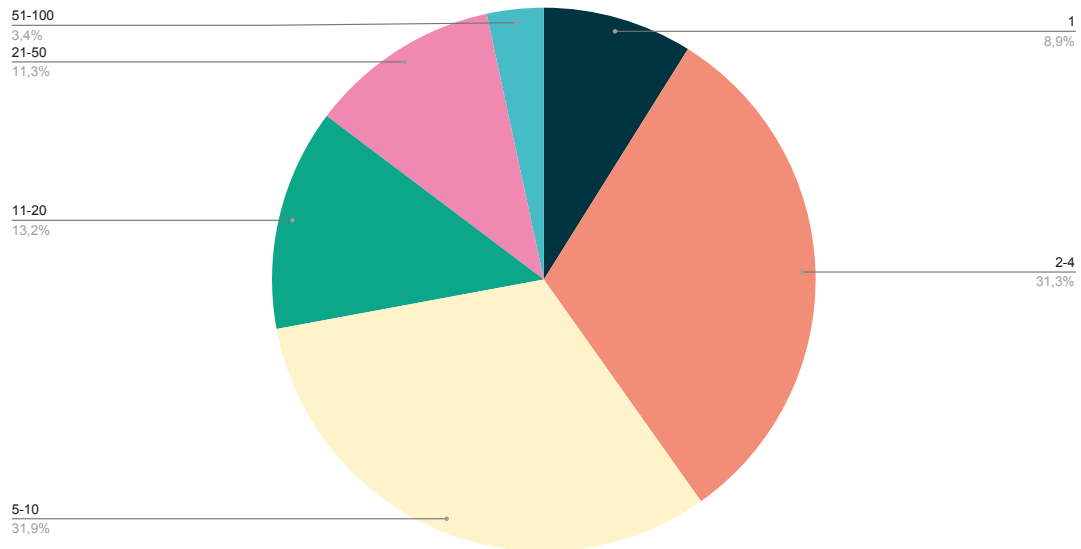


Figure A.5: Diagram showing frequency in flying long-haul flights from user study.

For what purpose(s) are you usually flying?

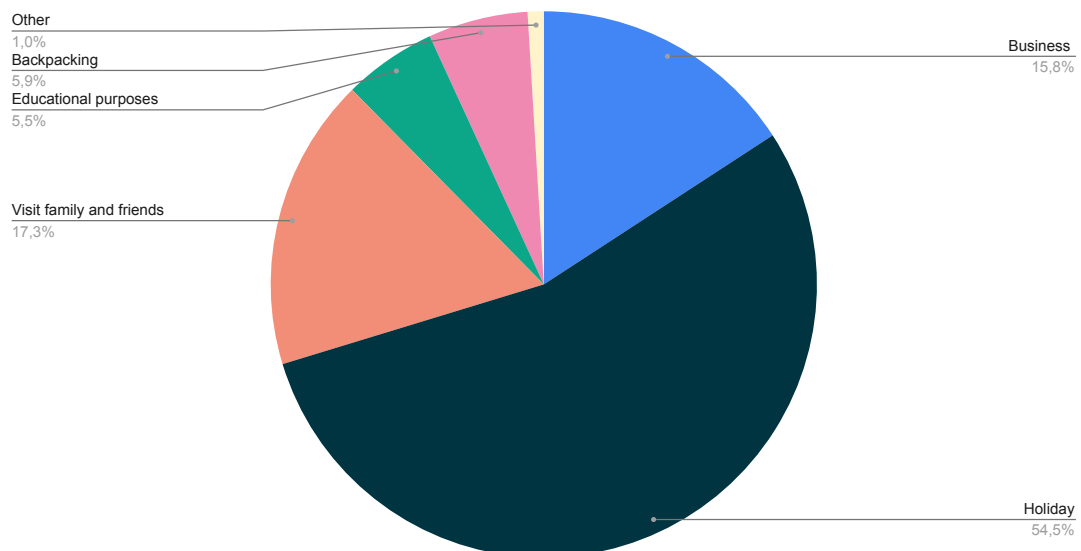


Figure A.6: Diagram showing purpose of flying from user study.

Do you have problems sleeping or resting during long-haul flights?

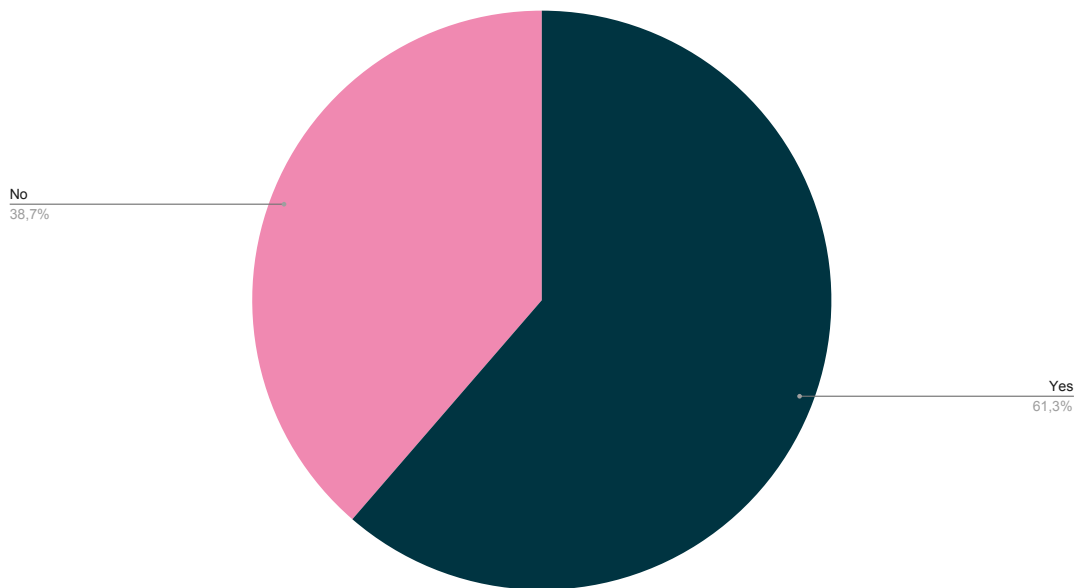


Figure A.7: Diagram showing sleeping and resting habits when flying from user study..

Do you have problems staying entertained during long-haul flights?

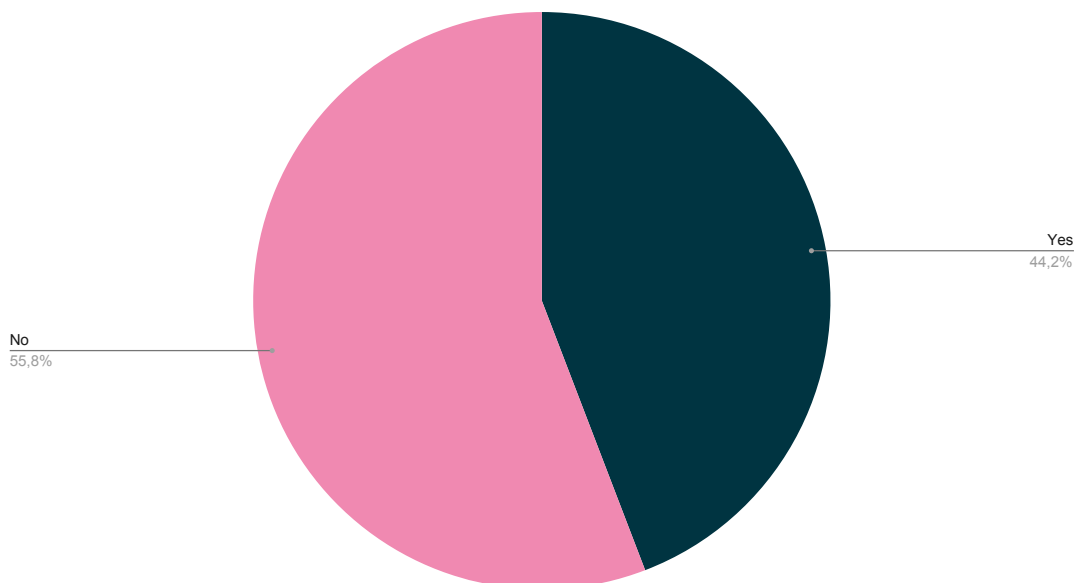


Figure A.8: Diagram showing entertainment habits when flying from user study.

What do you prefer to do during long-haul flights to stay entertained? Pick up to 3 alternatives.

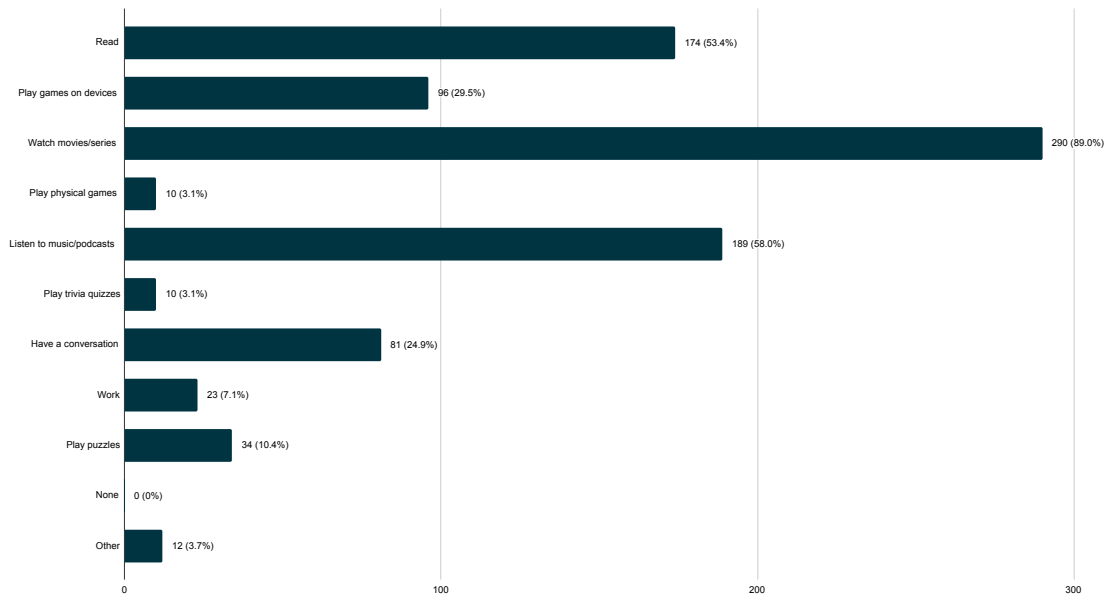


Figure A.9: Diagram showing what users prefer to do during a flight from user study.

According to you, what are the most annoying things your neighbor could do during long-haul flights? Pick up to 3 alternatives.

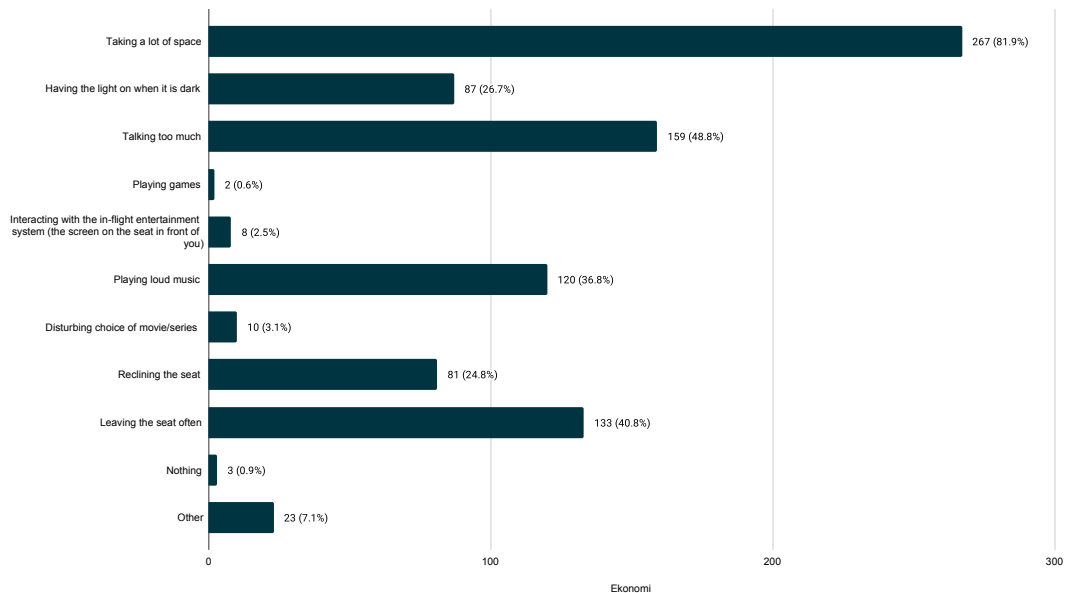


Figure A.10: Diagram showing what users think is annoying from user study.

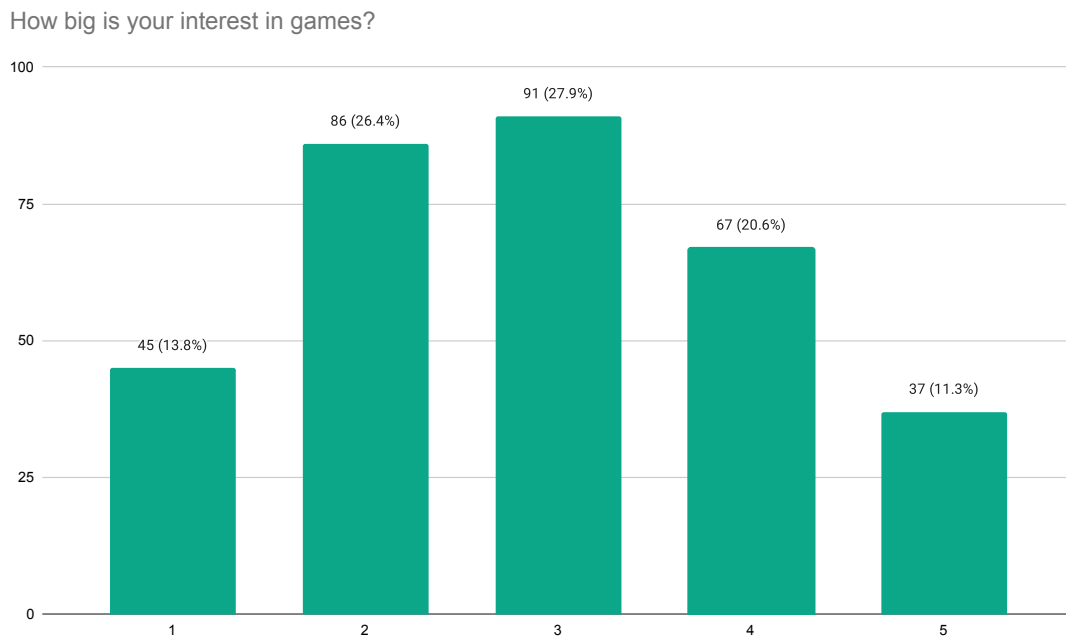


Figure A.11: Game interest from user study.

Have you ever played games on the in-flight entertainment system (the screen on the seat in front of you)?

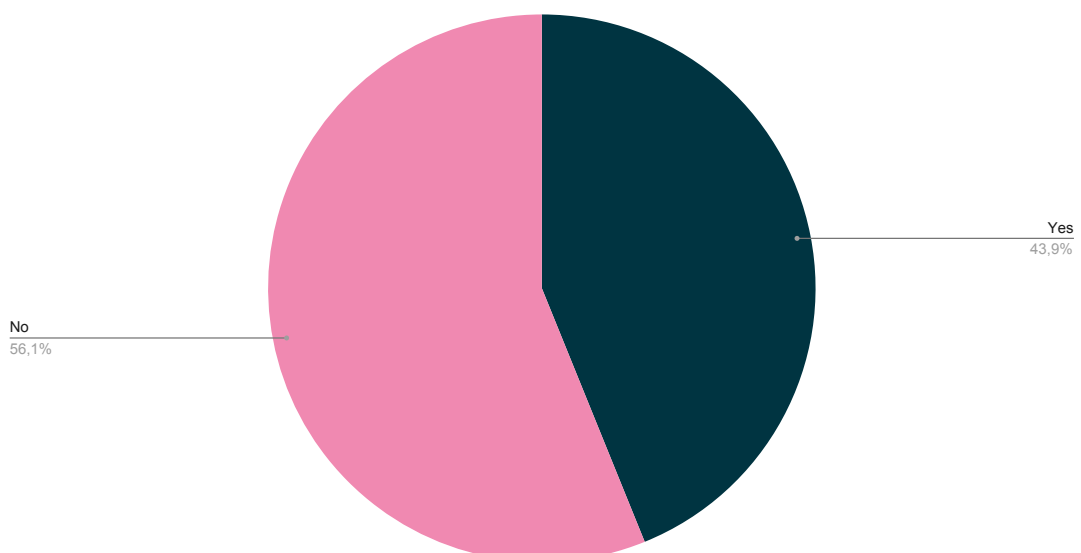


Figure A.12: Diagram showing how many users that have played games on the IFE from user study.

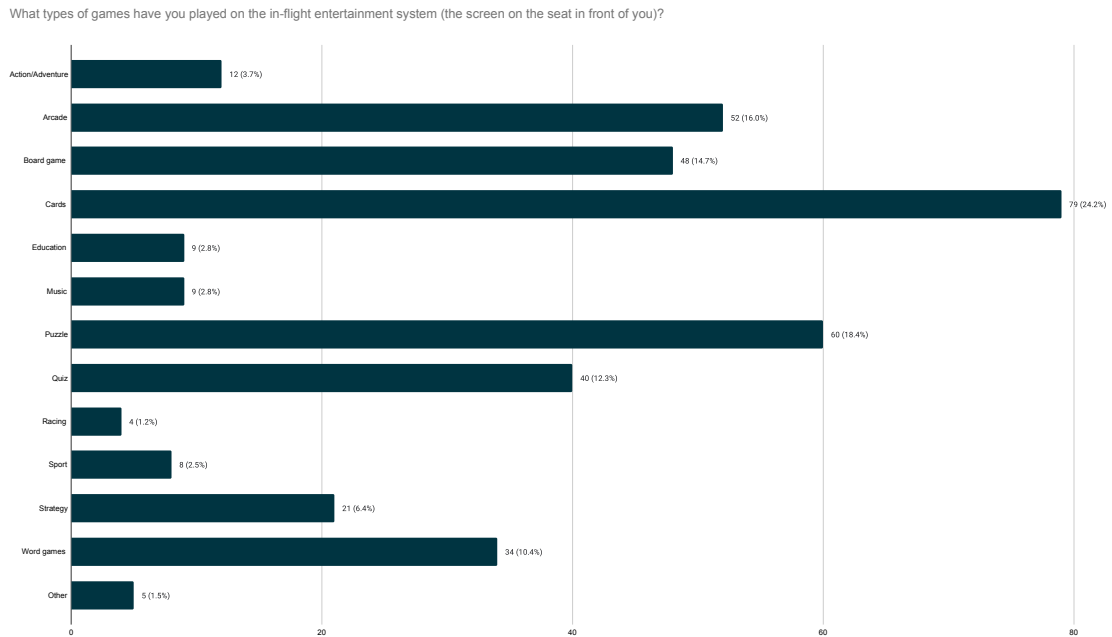


Figure A.13: Diagram showing which type of games people have played on the IFE from user study.

Do you ever play multiplayer games?

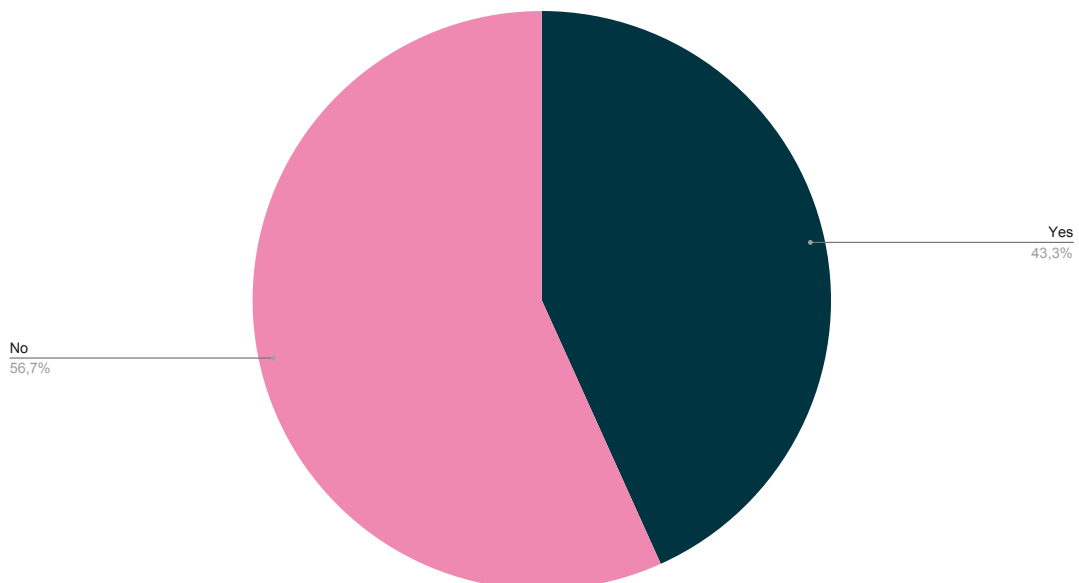


Figure A.14: Diagram showing if the user have played multiplayer games from user study.

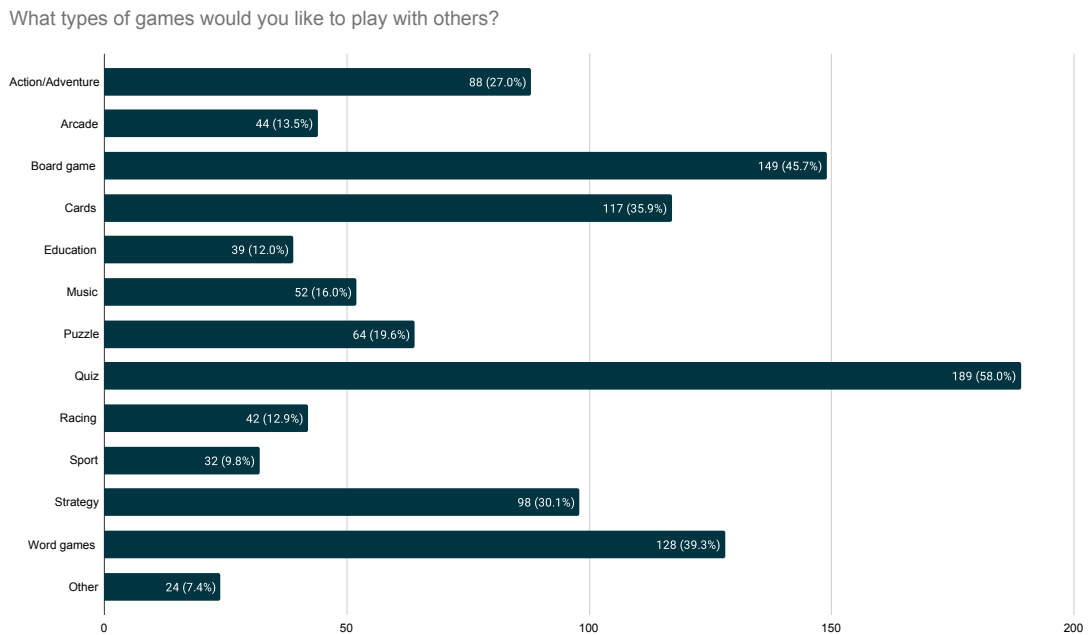


Figure A.15: Diagram showing what type of games the users would like to play with others from user study.

If possible, would you like to interact with the in-flight entertainment system (the screen on the seat in front of you) by using your mobile phone?

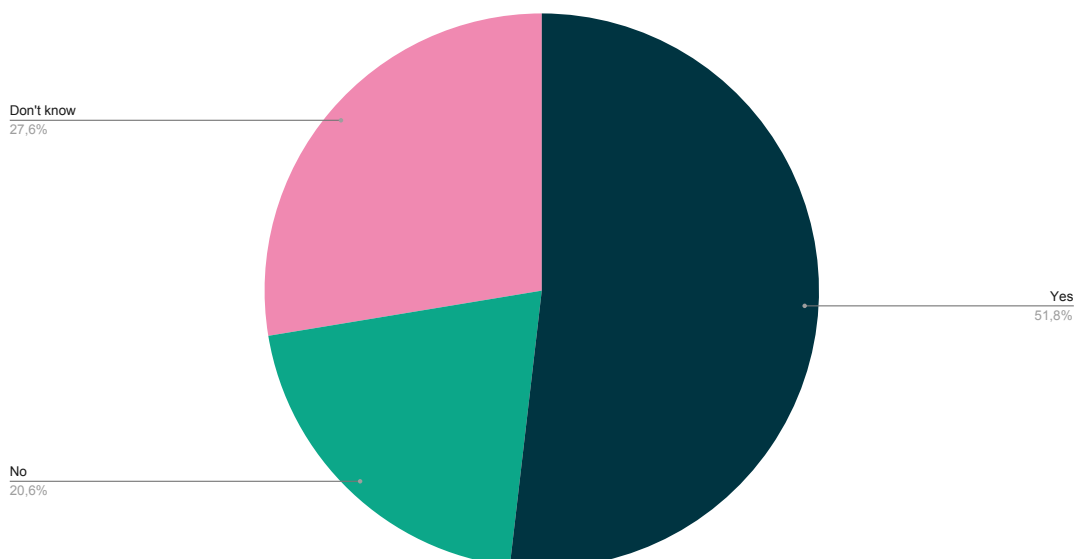


Figure A.16: Diagram showing whether or not the user is interested in using the phone to interact with the IFE from user study.

Appendix B

Designing Alternatives

In this appendix the affinity diagram from the brainstorming session will be presented.

B.1 Affinity Diagram

Presented below in Figure B.1 is the affinity diagram made from the brainstorming session.

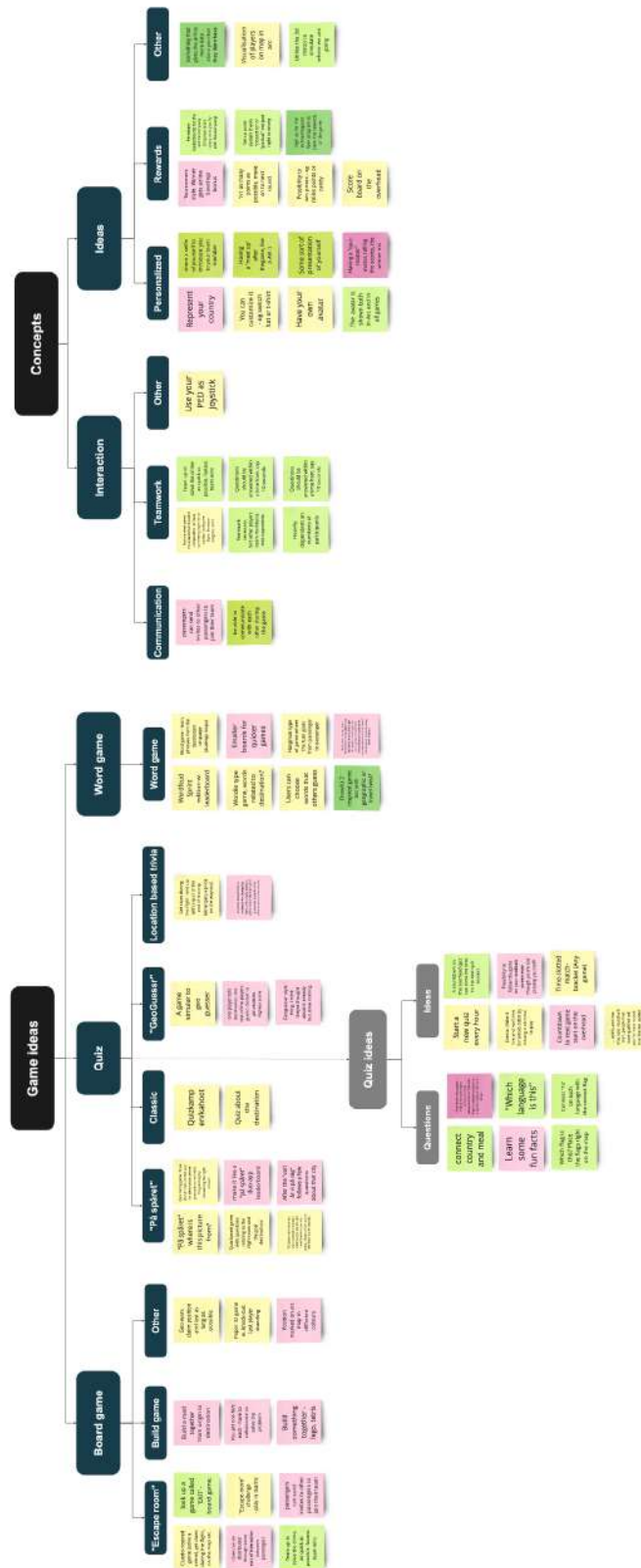


Figure B.1: The affinity diagram from the brainstorming after card sorting.

Appendix C

Prototyping

In this appendix the complete lo-fi prototypes and hi-fi prototypes are shown.

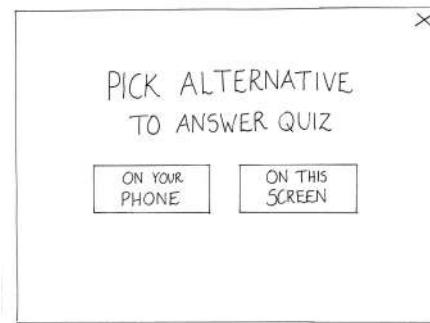
C.1 Low Fidelity Prototyping

Presented below are the two final low fidelity (lo-fi) prototypes made for the project. The first lo-fi prototype is presented in Figures C.1-C.3 and the second in Figures C.4-C.6.

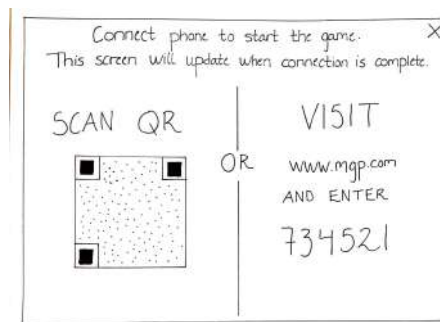
GEOQUIZZER



(a) Welcome page



(b) Connect phone - page 1

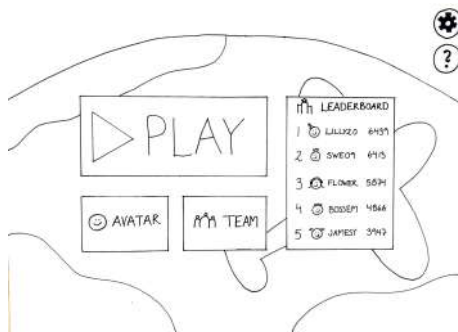


(c) Connect phone - page 2

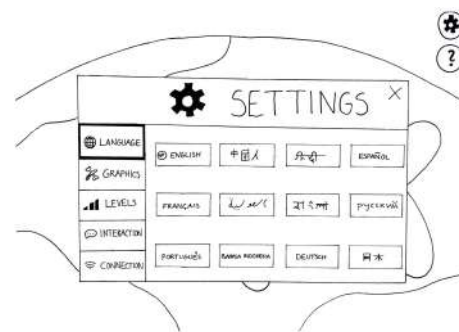
CONNECTION SUCCESSFUL



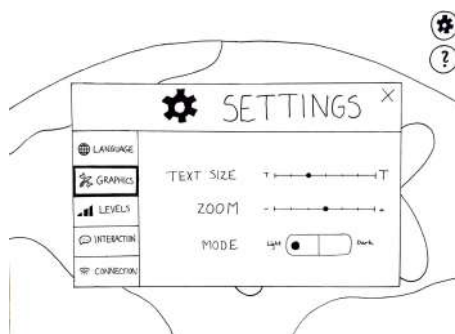
(d) Connect phone - page 3



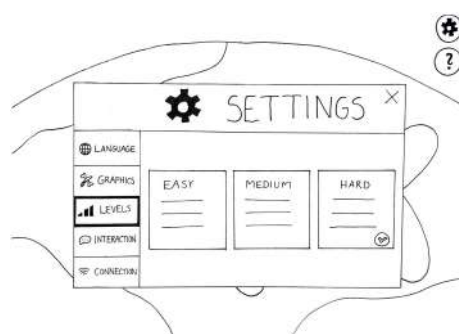
(e) Home page



(f) Settings - page 1

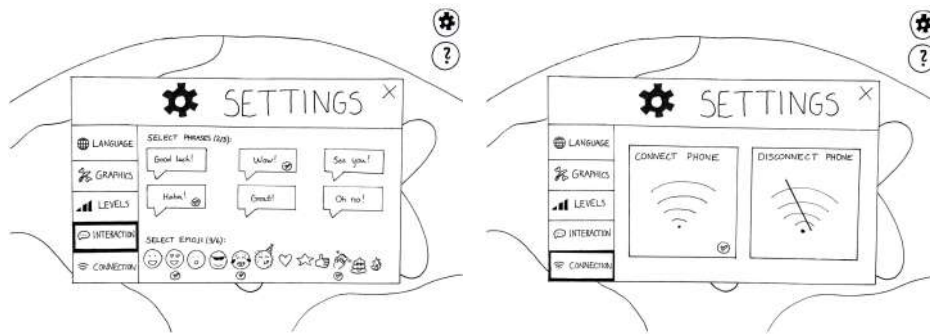


(g) Settings - page 2



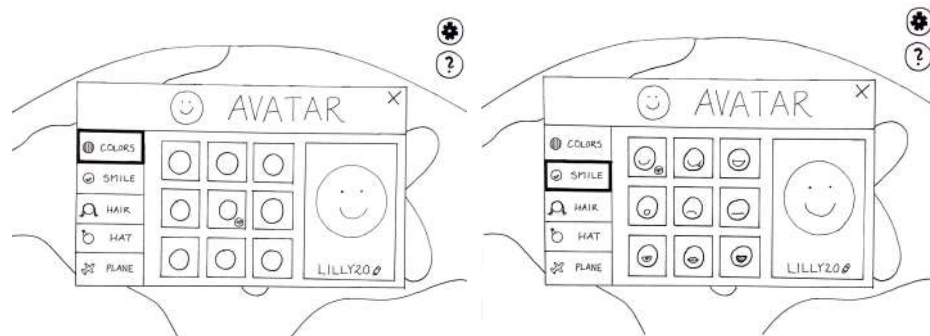
(h) Settings - page 3

Figure C.1: Lo-fi prototype 1 - page 1.



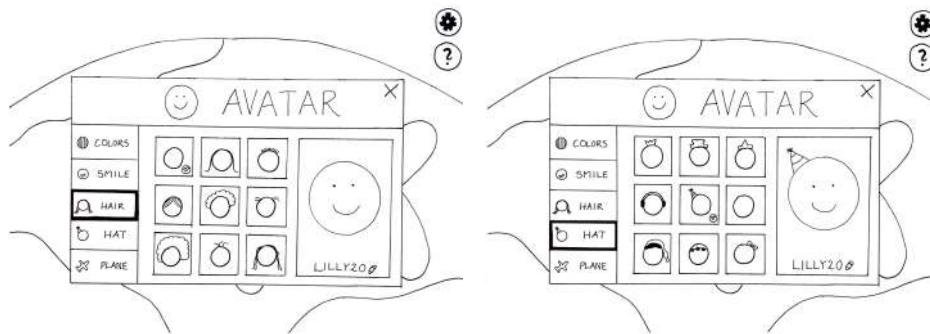
(a) Settings - page 4

(b) Settings - page 5



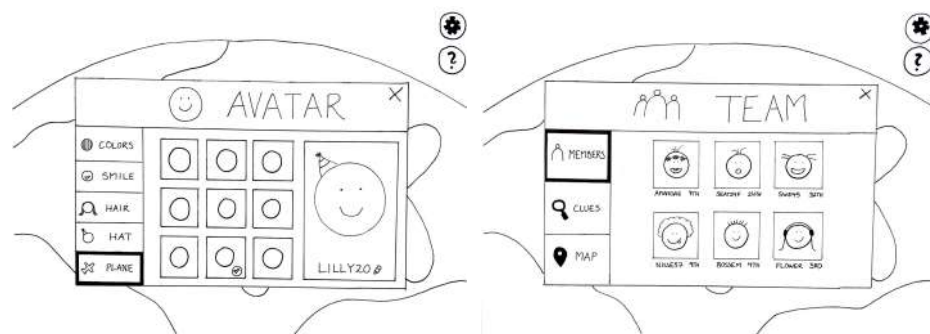
(c) Avatar - page 1

(d) Avatar - page 2



(e) Avatar - page 3

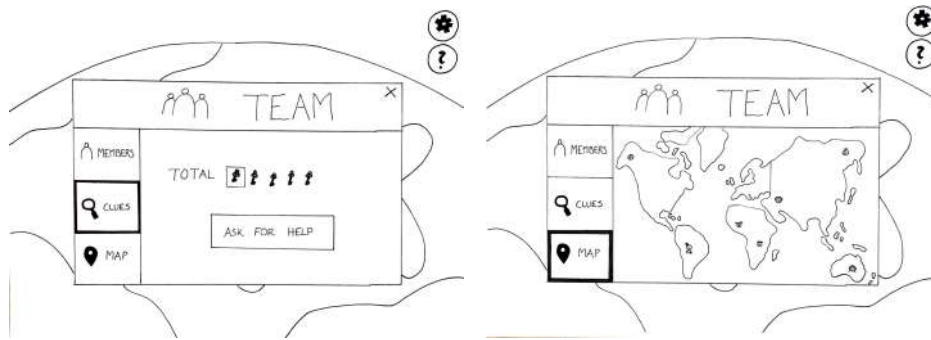
(f) Avatar - page 4



(g) Avatar - page 5

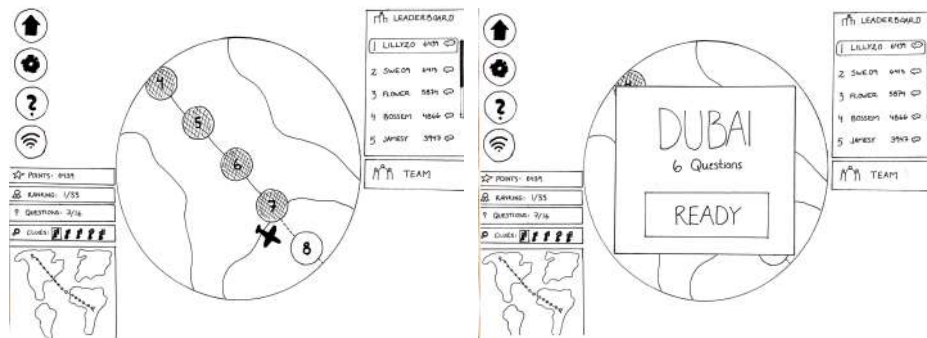
(h) Team - page 1

Figure C.2: Lo-fi prototype 1 - page 2.



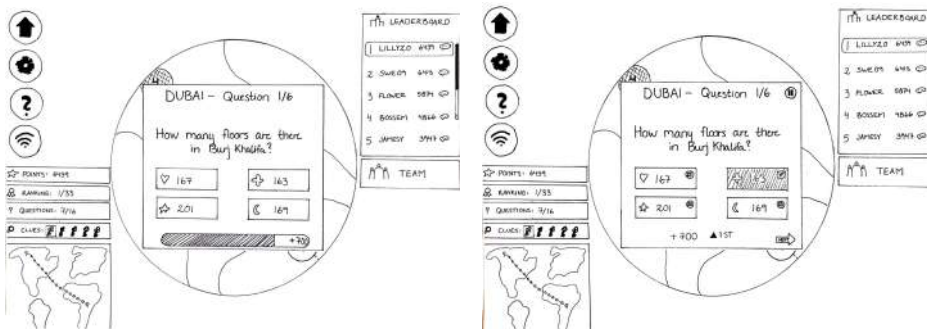
(a) Team - page 2

(b) Team - page 2



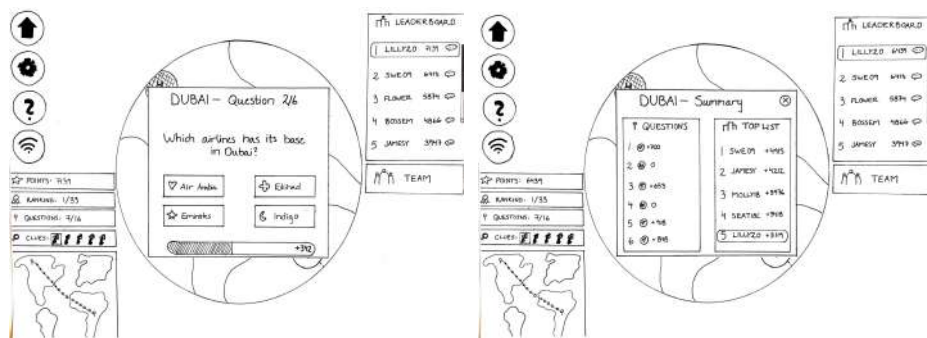
(c) Game view - page 1

(d) Game view - page 2



(e) Game view - page 3

(f) Game view - page 4



(g) Game view - page 5

(h) Game view - page 6

Figure C.3: Lo-fi prototype 1 - page 3.

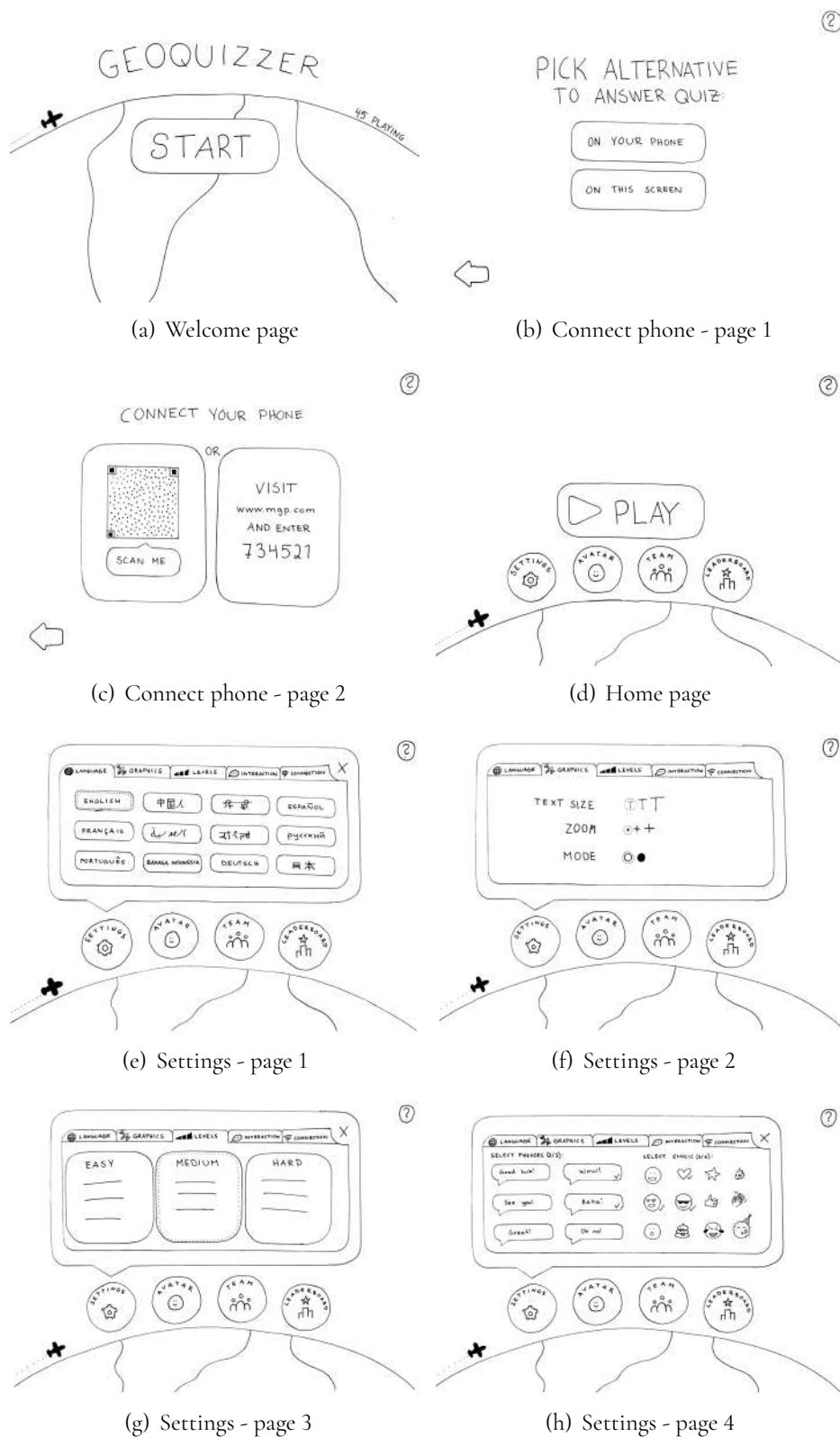


Figure C.4: Lo-fi prototype 2 - page 1.

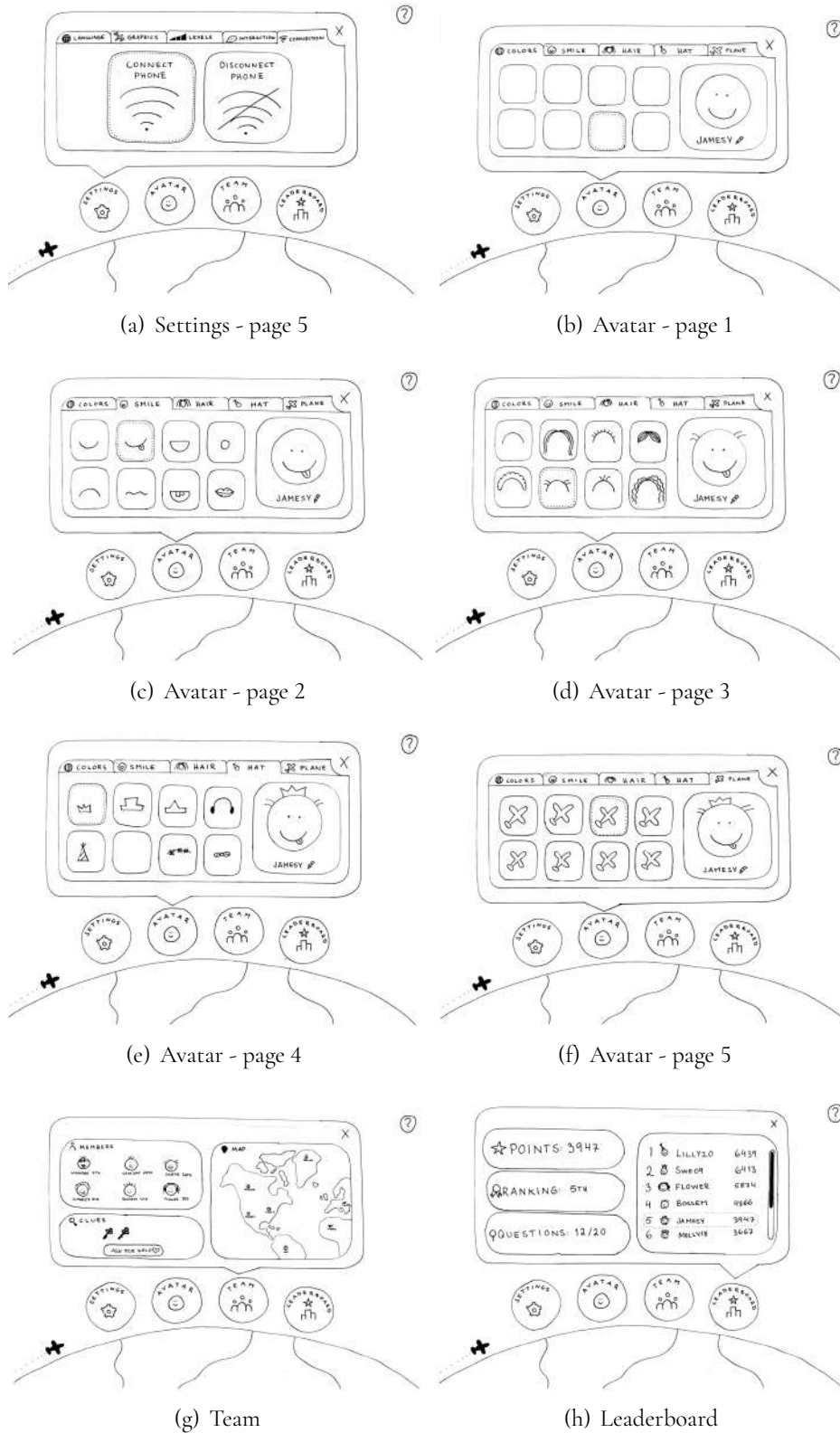


Figure C.5: Lo-fi prototype 2 - page 2.

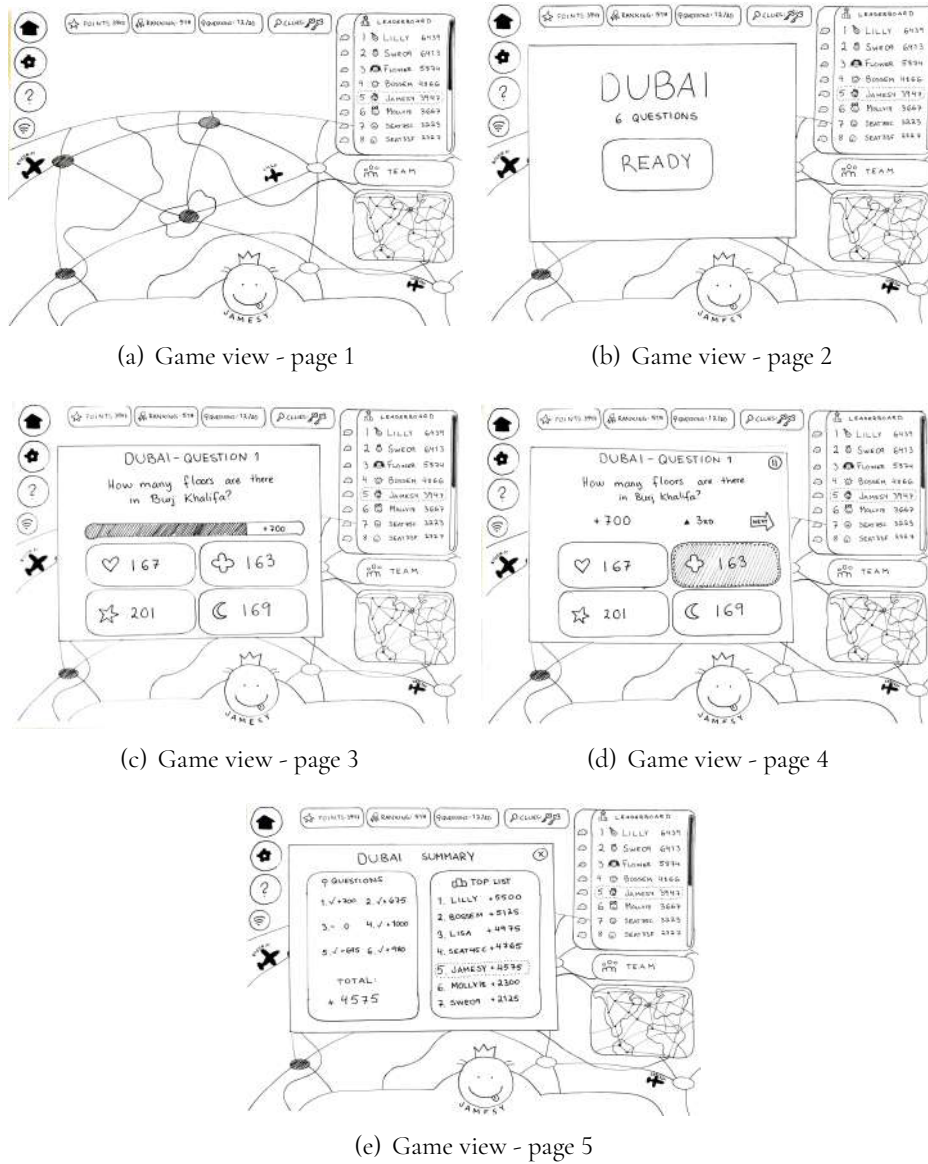


Figure C.6: Lo-fi prototype 2 - page 3.

C.2 High Fidelity Prototyping

Presented below are the two hi-fi prototypes made in the first iteration. The prototypes are called P1 and P2 and presented in Figures C.7-C.11 and C.12-C.16, respectively. The final prototype is called FP and is presented in Figures C.17-C.21.



(a) P1: Welcome page



(b) P1: Instructions - page 1



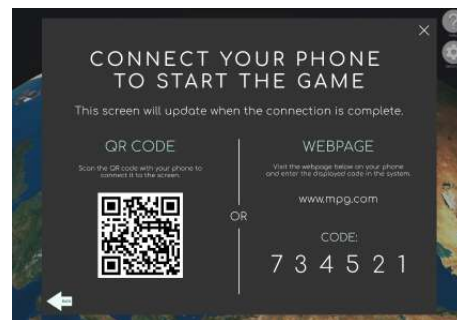
(c) P1: Instructions - page 2



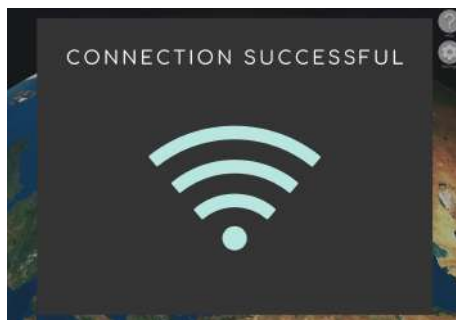
(d) P1: Instructions - page 3



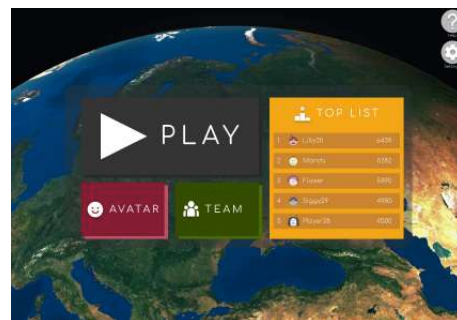
(e) P1: Connect phone - page 1



(f) P1: Connect phone - page 2



(g) P1: Connect phone - page 3

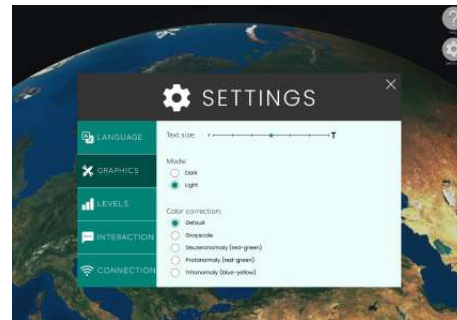


(h) P1: Home page

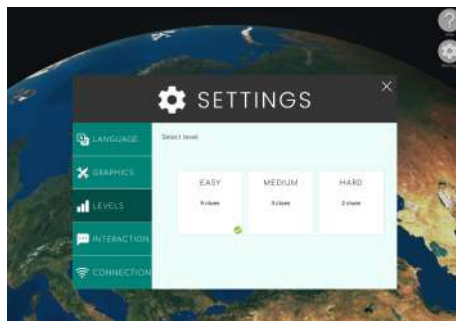
Figure C.7: Hi-fi prototype 1 - page 1.



(a) P1: Settings - page 1



(b) P1: Settings - page 2



(c) P1: Settings - page 3



(d) P1: Settings - page 4



(e) P1: Settings - page 5



(f) P1: Avatar - page 1



(g) P1: Avatar - page 2



(h) P1: Avatar - page 3

Figure C.8: Hi-fi prototype 1 - page 2.



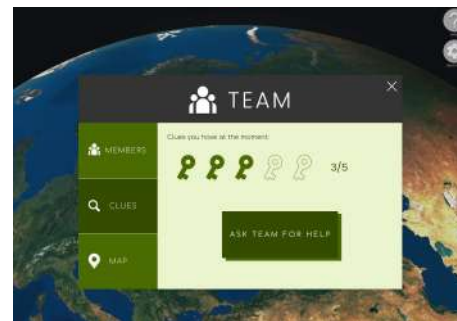
(a) P1: Avatar - page 4



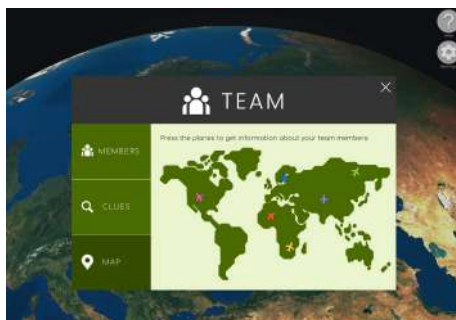
(b) P1: Avatar - page 5



(c) P1: Team - page 1



(d) P1: Team - page 2



(e) P1: Team - page 3



(f) P1: Game view



(g) P1: Tutorial - page 1



(h) P1: Tutorial - page 2

Figure C.9: Hi-fi prototype 1 - page 3.



(a) P1: Tutorial - page 3

(b) P1: Tutorial - page 4



(c) P1: Tutorial - page 5

(d) P1: Send interaction - page 1



(e) P1: Send interaction - page 2

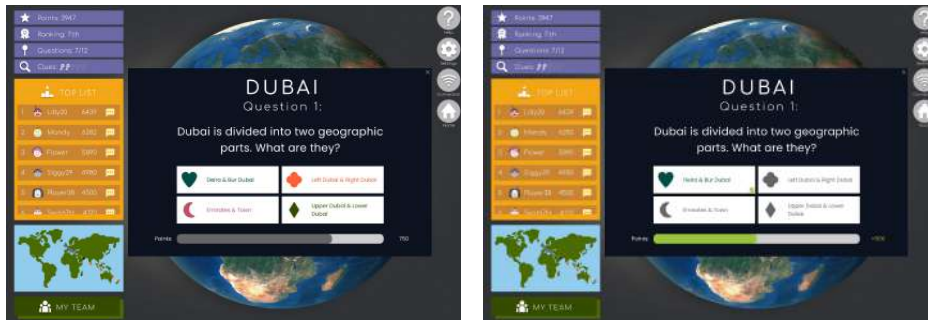
(f) P1: Map



(g) P1: Quiz - page 1

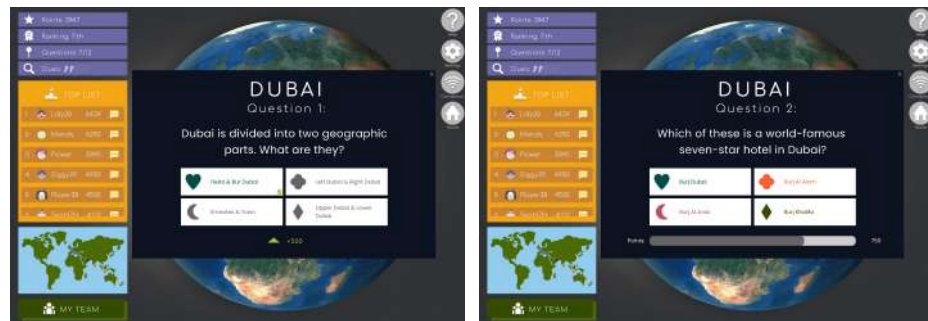
(h) P1: Quiz - page 2

Figure C.10: Hi-fi prototype 1 - page 4.



(a) P1: Quiz - page 3

(b) P1: Quiz - page 4



(c) P1: Quiz - page 5

(d) P1: Quiz - page 6



(e) P1: Quiz - page 7

(f) P1: Quiz - page 8

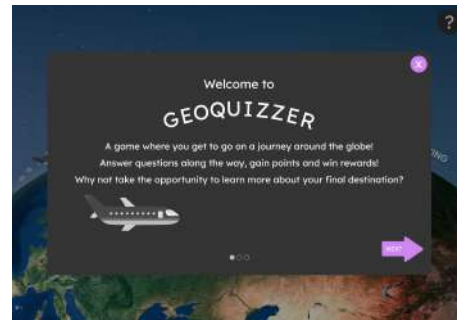


(g) P1: Quiz - page 9

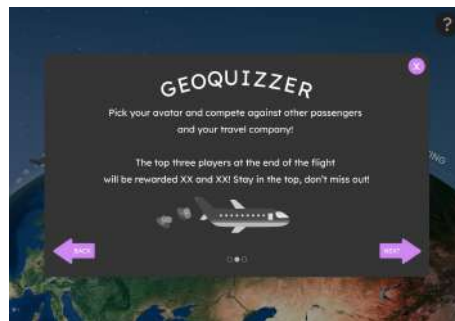
Figure C.11: Hi-fi prototype 1 - page 5.



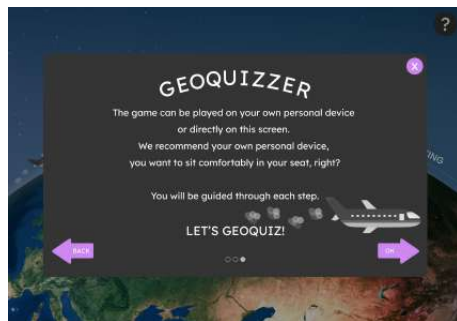
(a) P2: Welcome page



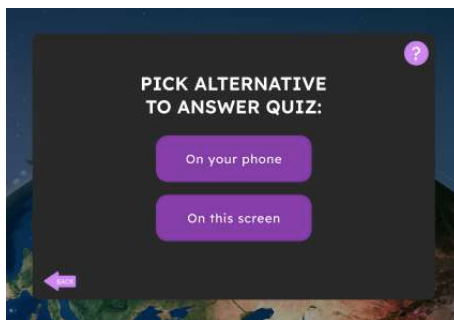
(b) P2: Instructions - page 1



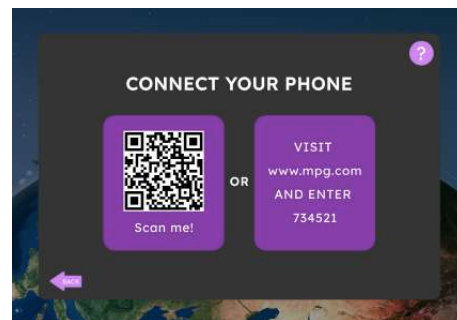
(c) P2: Instructions - page 2



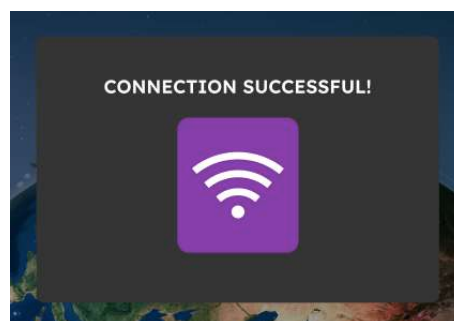
(d) P2: Instructions - page 3



(e) P2: Connect phone - page 1



(f) P2: Connect phone - page 2



(g) P2: Connect phone - page 3



(h) P2: Home page

Figure C.12: Hi-fi prototype 2 - page 1.



(a) P2: Settings - page 1



(b) P2: Settings - page 2



(c) P2: Settings - page 3



(d) P2: Settings - page 4



(e) P2: Settings - page 5



(f) P2: Avatar - page 1



(g) P2: Avatar - page 2

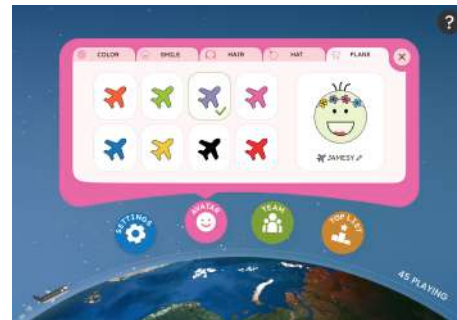


(h) P2: Avatar - page 3

Figure C.13: Hi-fi prototype 2 - page 2.



(a) P2: Avatar - page 4



(b) P2: Avatar - page 5



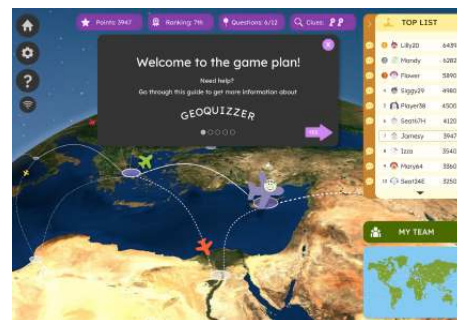
(c) P2: Team



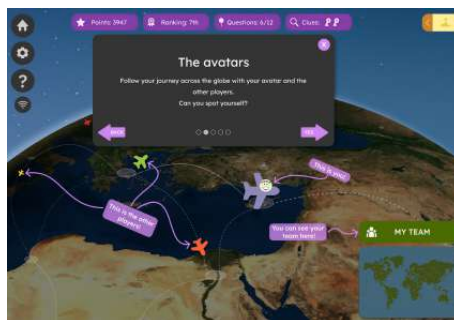
(d) P2: Top list



(e) P2: Game view



(f) P2: Tutorial - page 1



(g) P2: Tutorial - page 2

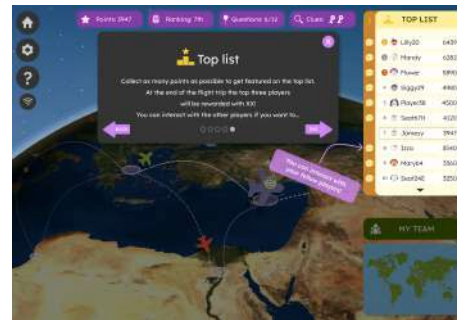


(h) P2: Tutorial - page 3

Figure C.14: Hi-fi prototype 2 - page 3.



(a) P2: Tutorial - page 4



(b) P2: Tutorial - page 5



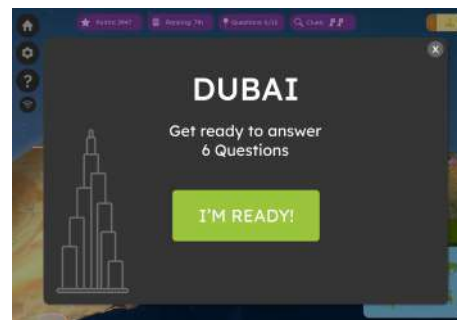
(c) P2: Send interaction - page 1



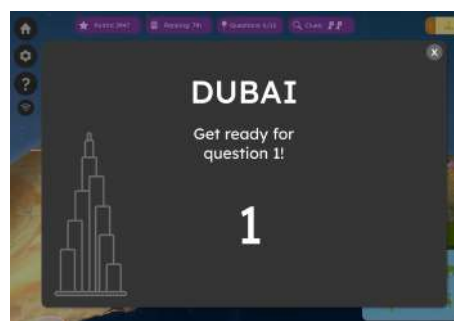
(d) P2: Send interaction - page 2



(e) P2: Map



(f) P2: Quiz - page 1



(g) P2: Quiz - page 2

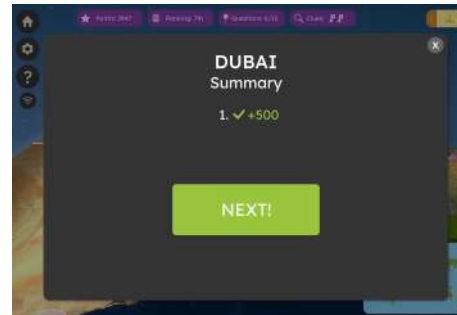


(h) P2: Quiz - page 3

Figure C.15: Hi-fi prototype 2 - page 4.



(a) P2: Quiz - page 4



(b) P2: Quiz - page 5



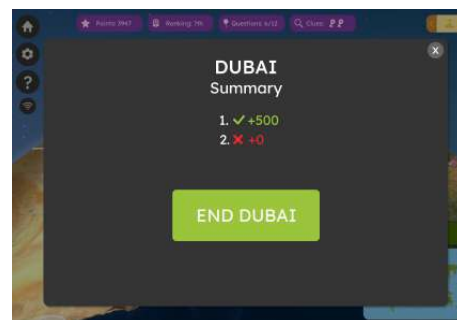
(c) P2: Quiz - page 6



(d) P2: Quiz - page 7

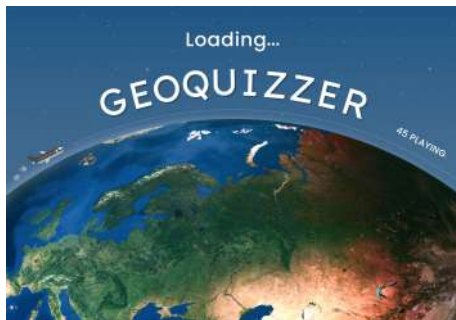


(e) P2: Quiz - page 8



(f) P2: Quiz - page 9

Figure C.16: Hi-fi prototype 2 - page 5.



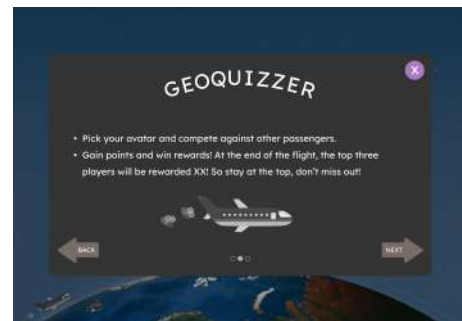
(a) FP: Splash screen



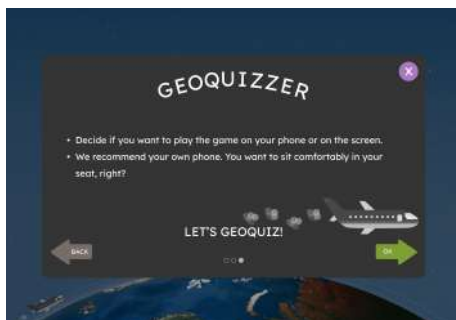
(b) FP: Home page



(c) FP: Introduction - page 1



(d) FP: Introduction - page 2



(e) FP: Introduction - page 3



(f) FP: Settings - language



(g) FP: Settings - graphics



(h) FP: Settings - graphics grayscale

Figure C.17: Final prototype - page 1.



(a) FP: Settings - social



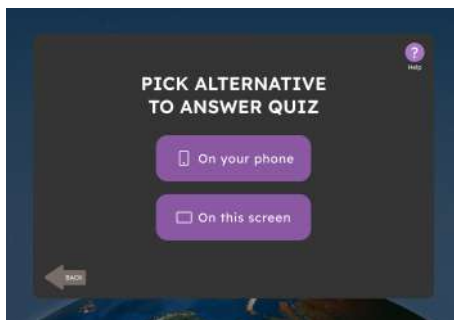
(b) FP: Avatar



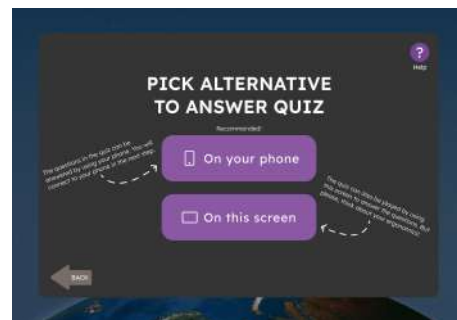
(c) FP: Team



(d) FP: Top list



(e) FP: Connect phone - page 1



(f) FP: Connect phone - page 2



(g) FP: Connect phone - page 3



(h) FP: Connect phone - page 4

Figure C.18: Final prototype - page 2.



(a) FP: Connect phone - page 5



(b) FP: Game view - zoomed out



(c) FP: Game view - zoomed out, minimized elements



(d) FP: Game view - zoomed in 1



(e) FP: Game view - zoomed in 1, minimized elements



(f) FP: Tutorial - page 1



(g) Tutorial - page 2



(h) Tutorial - page 3

Figure C.19: Final prototype - page 3.



(a) FP: Tutorial - page 4



(b) FP: Tutorial - page 5



(c) FP: Game view - map



(d) FP: Game view - sending interaction



(e) FP: Game view - zoomed in 2



(f) FP: Quiz - page 1



(g) FP: Quiz - page 2 countdown 1



(h) FP: Quiz - page 3 question 1

Figure C.20: Final prototype - page 4.

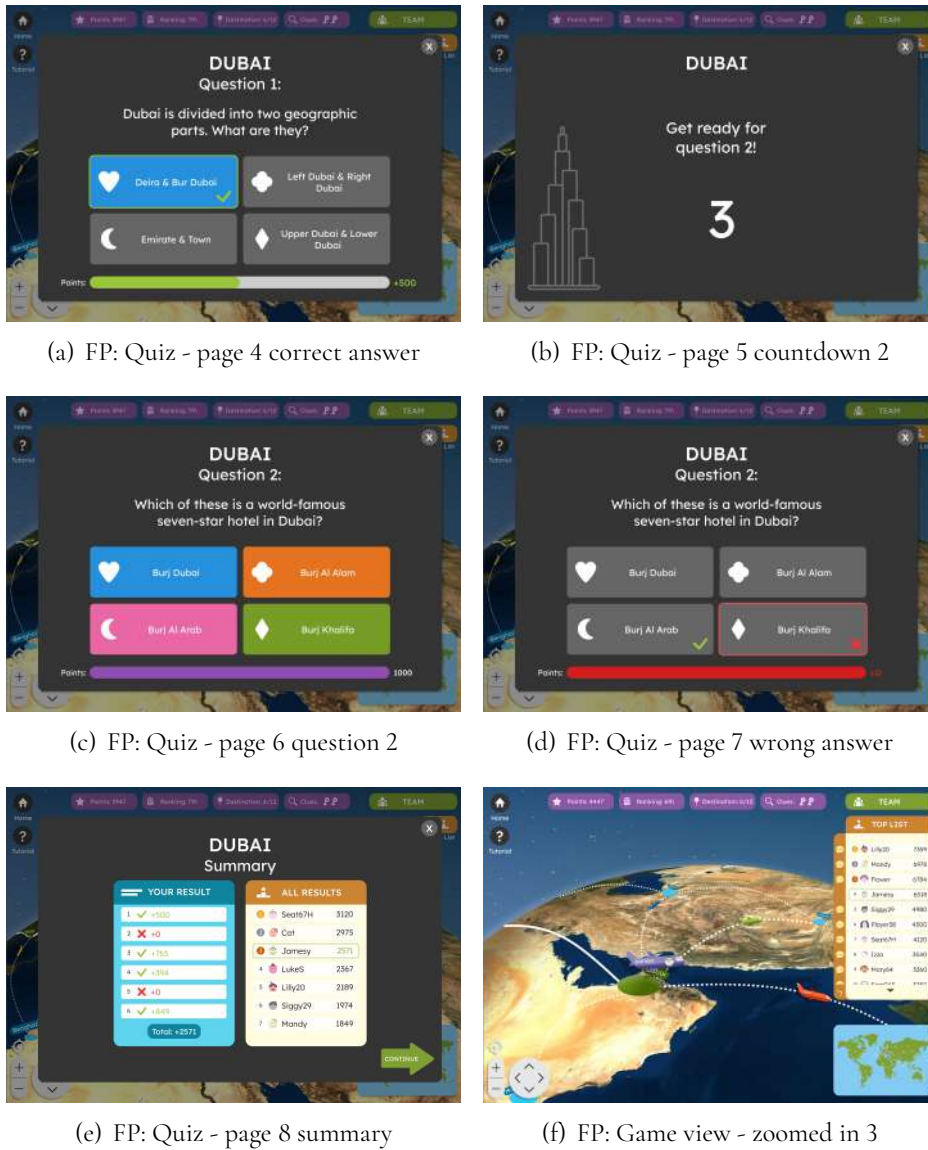


Figure C.21: Final prototype - page 5.

Appendix D

Usability Testing

In this appendix the scenarios and the questionnaire used in the usability testing are presented.

D.1 Scenarios

Presented below are the scenarios used in the usability testing. The scenarios were the same regardless of the prototype tested. The scenarios are presented in Swedish.

- *Scenario 1:* Du tycker Geoquizzer verkar roligt och vill nu börja spela. Dock är du lite osäker på vad spelet går ut på och vill därför först se om du kan få någon information om detta.
- *Scenario 2:* Du känner dig redo för spelet och tänker att du vill använda din telefon för att svara på frågorna. För att connecta din telefon väljer du att använda telefonens kamera och scannar QR-koden.
- *Scenario 3:* Innan du börjar spela vill du utforska vad spelet har att erbjuda. Du blir nyfiken på vad Avatar innebär. Du tycker din avatar ser lite tråkig ut, så du vill byta utseende enligt följande (du behöver välja dem i rätt ordning).
- *Scenario 4:* Du vill nu gå in på Settings för att se vad det finns för alternativ för att göra spelet mer personligt. Du upptäcker att färgskalan på spelet går att ändra färg på och testat att byta till gråskala.
- *Scenario 5:* Du gillar dock spelet bättre i färg och ändrar tillbaka. Du vill nu undersöka Interaction och väljer följande förbestämda fraser och emojis (du behöver välja dem i rätt ordning).
- *Scenario 6:* Du vill nu börja spela! Du känner dig osäker på hur du ska göra väl inne på spelplanen. Du undersöker därför om det finns någon hjälp att få.

- *Scenario 7:* Nu har du koll på läget! Du ser att din kompis Lilly20 är i ledning i spelet och detta vill du såklart fira! Du vill därför skicka en interaktion till henne.
- *Scenario 8:* Du vill ta dig vidare i spelet. Din nästa destination är nu Dubai. Nu är det dags att testa att svara på två frågor. Läs respektive fråga och svara sedan hjärta på första frågan och diamant på andra. (På första frågan kommer du få 500 poäng och på den andra får du 0 poäng).
- *Scenario 9:* Du är nu klar med testet av interaktionen för den första prototypen!

D.2 Questionnaire

Presented below are the questions asked in the questionnaire that the test person had to fill in after testing one of the prototypes.

D.2.1 SUS

These are the ten questions in the questionnaire that are based on SUS. Each question had a rating scale between 1-5, where 1 corresponds to *strongly disagree (instämmer inte alls)* and 5 corresponds to *strongly agree (instämmer helt)*. The questions were asked in Swedish.

- Jag tror jag skulle använda spelet regelbundet vid flygning (*Instämmer inte alls - instämmer helt*).
- Jag tycker att spelet är onödigt komplicerad (*Instämmer inte alls - instämmer helt*).
- Jag tycker att spelet är enkel att använda (*Instämmer inte alls - instämmer helt*).
- Jag tror att jag kommer behöva hjälp av en teknisk kunnig person för att kunna använda spelet (*Instämmer inte alls - instämmer helt*).
- Jag tycker att de olika funktionerna i spelet är väl samordnade (*Instämmer inte alls - instämmer helt*).
- Jag tycker att det är för mycket inkonsekvens i spelet (*Instämmer inte alls - instämmer helt*).
- Jag tror att de flesta skulle lära sig att använda spelet snabbt (*Instämmer inte alls - instämmer helt*).
- Jag tycker att spelet är besvärligt att använda (*Instämmer inte alls - instämmer helt*).
- Jag känner mig trygg i att använda spelet (*Instämmer inte alls - instämmer helt*).
- Jag kommer att behöva lära mig många nya saker innan jag bli produktiv med spelet (*Instämmer inte alls - instämmer helt*).

D.2.2 AttrakDiff

These are the ten questions in the questionnaire that are based on AttrakDiff. The questions had a rating scale between 1 to 7. The questions were asked in Swedish.

- Välj din åsikt på skalan: 1-7.
 - Otrevlig - trevlig
 - Bortstötande - inbjudande
 - Motbjudande - tilltalande
 - Avskräckande - motiverande
 - Smaklös - stilig, flott
 - Fjärmande - förenande
 - Konventionell - nytänkande
 - Fantasilös - kreativ
 - Konservativ - innovativ
 - Uttråkande - spännande
 - Harmlös - utmanande
 - Komplicerad - enkel
 - Förvirrande - tydlig

