PATH VR

USER EXPERIENCE IN VIRTUAL REALITY

MED10-3

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Abstract

Nowadays, virtual reality has been considered one of the most fast-growing media, covering various well-known domains of applications such as healthcare, fashion, sport, education and many others (Virtual Reality Society, 2017). Apart from these common areas of applications, virtual reality has also been considered of great interest within user-centered design (UCD) which, for example, is leading towards the creation of virtual tours of university campuses for students (O'Brien, 2015).

Within the context of this study, a virtual reality promotional tool has been developed throughout a two-years collaboration with the Public Relations (PR) Department of Aalborg University Esbjerg. Its intended use was assigned to promotional purposes, and prototype implementation has covered personas as main UCD methodology, dedicated to fulfil the expectations of various users. Their contribution to the application's overall user experience and presence has been individually analysed. Results show that personas, as UCD methodology do not affect the level of presence but do affect the user experience within users' interaction with the virtual reality application.

Keywords: Virtual Reality, User-Centered Design (UCD), Presence, User Experience (UX)

Abstrakt

Virtual Reality tænkes at være en af nutidens hurtigst voksende medier som nu dækker mange kendte markeder såsom helbred, mode, sport og uddannelse for at nævne nogle få (Virtual Reality Society, 2017). Udover de her klassiske områder af brug, så har Virtual Reality fået betragteligt interesse fra user-centered design (UCD) fællesskabet, som for eksempelvis leder vejen for at skabe et virtuelt rundvisning af universiteter for studerende.

I løbet af dette studie er der blevet udviklet et værktøj til at kunne promovere i virtual reality, dette værktøj er blevet udviklet i et to års samarbejde med Public Relations (PR) afdeling på Aalborg Universitet Esbjerg. Værktøjet var designet til reklamering og implantationen af prototypen som har dækket personaer og dens hovedkomponent af UCD metodologi, er dedikeret til at opfylde de forskelige brugers forventninger. Brugernes bidrag til programmets overordnet brugeroplevelse og presence er blevet analyseret individuelt. Resultaterne viste at personaerne som UCD metodologi ikke havde nogen indflydelse på niveauet af presence af brugeroplevelsen, iforhold til brugers interaktion med VR programmet.

Contents

1. Introduction

As a result of the increase in popularity of virtual reality technologies, several industries have opted to use it for a multitude of different purposes. It is projected that by 2020 the number of headsets sold will reach 82 million with the overall virtual reality industry expected to reach 33.9 billion by 2022 (Walker, 2018). A particular business venture in which virtual reality has seen growing popularity is the marketing sector. Virtual reality offers an immersive experience - this can benefit businesses who want to present themselves in new ways or to create promotional material that creates more of a connection with its audience (Walker, 2018).

Although this study does not operate in collaboration with a business, the marketing aspect it serves could apply to one. Within this study, a virtual reality application (PathVR) was created in collaboration with the Public Relations (PR) Department of Aalborg University Esbjerg. This relationship started in autumn of 2017 and resulted in an almost two-year partnership which is ongoing. The PR Department intended to use this application mostly at career/educational fairs where they would supplement their traditional promotional methods such as pictures/flyers with a VR headset. Thus, a large emphasis was put on the portability and ease of use of the system. In a previous study, the system consisted of a Samsung Gear VR headset paired with a smartphone that would act as a standalone system. However, the lackluster quality and performance would hinder the experience for a lot of users. In the beginning of the current study, stakeholders represented by both ambassadors and members of PR Dept. of AAU, became interested in changing the hardware, as there was a possibility to choose between a headset such as the Vive or the Oculus Rift. While these HMDs could provide a better screen resolution and performance, the issue of portability came into question as both headsets require external trackers and a stationary computer to run properly. Thus, this study has decided to use the Windows Mixed Reality headset due to its ability to run optimally on a laptop, without the need of external trackers.

This master thesis has focused on the user-centered approach and methodology that comes with it and how it is applied to the design of a virtual reality application. The levels of presence generated by the application were also taken into account, as it has been a relevant part of virtual reality design in previous studies. In this approach, the design cycle of the prototype was followed closely with tests for each iteration, keeping track of design choices, and improving each iteration based on user feedback.

Therefore, the following problem statement was formulated:

How can a virtual reality promotional tool be created through a User-Centered approach?

Including the two research questions:

- ***How would a User-Centered design approach contribute to the level of user experience, in a virtual reality environment?***
- ***How can the quality of a virtual reality application be measured?***

The work put into this project has also resulted in a StartUp project entitled PathVR. The StartUp was developed in collaboration with AAU Inkubator, Supporting Entrepreneurship at Aalborg University (SEA) and AAU Innovation, which help Aalborg University students manage and grow projects into prospective companies. This has resulted in projects with potential collaborators outside the study, who were interested in what the virtual reality application can offer. One of these clients was represented by the local fishery museum in Esbjerg (Fiskeri- og Søfartsmuseet).

Fig. 1 Showcase of PathVR at Fimus Fiskeri- og Søfartsmuseet

A virtual reality application was designed based on the project framework and acted as a demo for what it could provide. The application was showcased during a fundraising event placed on the 24th of April 2019 (Figure 1). Other events in which PathVR was involved are the AAU Case Competition and the National Start-up Competition.

2. Theoretical Framework

2.1. Presence

According to Steuer (1992) the concept of presence can be understood as mediated perception. However, when the environment is mediated by a technological component one must distinguish between the physical environment and the virtual environment.

Telepresence, as explained by Steuer (1992), refers to one feeling more present in the virtual environment than the actual physical environment, even though one exists in both simultaneously. Thus, virtual reality can be generally defined as "a real or simulated environment in which a perceiver experiences telepresence" (Steuer, 1992, p. 77). Witmer and Singer (1998) underlined a similarity between telepresence and selective attention.

According to Steuer (1992), telepresence is determined by two dimensions. The first, vividness refers to the sensory richness of the environment. The second dimension is interactivity and is defined by the level of change the user can bring to the environment. The question of sensory input, as it pertains to the PathVR application, has been studied in previous semesters through the addition of audio. However, due to the specific nature of the interaction between the end-user, the HMD and the ambassador, there had to be an audio channel between the two. Hence, the current version only conveys the information through visual stimuli. Zeltzer (1992) describes presence as the summary of input and output based on an informatic approach, as mentioned in Steuer (1992). Therefore, the experience should only target the sensory stimuli necessary to convey certain information (Steuer, 1992).

Vividness can be better understood in terms of its breadth and depth factors. Sensory breadth refers to the "number of sensory dimensions simultaneously presented" (Steuer, 1992, p. 8). It is the totality of all sensory dimensions, cues and sensors present in a system (Fortin & Dhalakia, 2005). In the case of PathVR, the user is presented with a full range of visual stimuli ranging from minimalist settings to an elaborate recreating of the university entrance. Sensory depth refers to "the resolution within each of these perceptual channels" (Steuer, 1992, p. 8). The term can be understood as the quality of the information transmitted through each sensory channel. The more information available within an image or sound, the greater the

. 356).

Presence can be seen as the failure of the virtual environment to deliver a perfect illusion of reality. Presence acts as a global "currency" for different applications. The value the

presence of a specific device can be determined by the factors known to influence presence. In turn, these factors can be determined by which definition of presence the paper agrees upon (Sanchez-Vives and Slater, 2004).

According to Witmer and Singer (1998), presence is the attention of the user shifting from the real space to a virtual one. However, they further elaborate that a user does not have to be completely detached from the physical world in order to experience presence in the virtual space. They argue that humans already live simultaneously both in the physical space and in their mental space so they already have experience around multiple planes. This is a factor which is very relevant to consider in this study, as it proves that users can interact with both the HMD (virtual environment) and the ambassadors (real environment) at the same time.

Moreover, Witmer and Singer (1998) further advise on what makes a user feel more present in a virtual environment. They argue that one should be able to focus on the more meaningful stimuli. In other words, if the experience has a coherence to it and the user can follow the set of rules within the world, then the system can generate better levels of presence.

The coherence of the application factors into involvement. The ability of an environment to focus the attention of the user through a set of stimuli is called involvement. Another component is immersion. This refers to the amount of control the virtual system has on the human senses (Draper et al., 1998). If the users feel immersed, they have direct interaction with the virtual environment, which is why it is uncommon outside of virtual reality. Both immersion and involvement are necessary factors for achieving presence, as stated by Witmer and Singer (1998).

When it comes to measuring presence, Sheridan (1992) argues against it calling presence a “subjective sensation” and a “mental manifestation” (p. 3). Witmer and Singer (1998) propose to observe the factors that influence presence within the environment and how they affect the relationship between the user and the system.

2.2. Virtual Reality in Marketing

Since the establishment of affordable virtual reality headsets, several types of industries have shown interest in the potential of virtual reality.

Presented by Grand View Research (2017), the virtual reality market is divided based on multiple criteria, one being the type of hardware used. In 2016, the leading class was the HMD (Head Mount Display) over the GTD (Gesture Tracking Devices) and PDW (Projectors and Display Walls). The market has also been segmented based on the practical application of

virtual reality into aerospace & defense, commercial, consumer electronics, industrial and medical (Grand View Research, 2017).

The commercial sector is where the application developed for this study (PathVR) fits the most, based on its intended use and user. Kerrebroeck, Brengman and Willems (2017) studied the relationship between vividness, customer attitude towards ads and presence. Their findings indicated that vividness and overall presence was higher in a virtual reality system as compared to a traditional 2D system. This also confirms the works of Steuer (1992), which were mentioned above. Presence also seems to have "a mediating effect in the relationship between vividness and attitude toward the ad" (Kerrebroeck et al., 2017).

2.3. User Experience (UX)

According to Rebelo, Noriega, Duarte and Soares (2012), the concept of User Experience (UX) has been offered considerable attention since the emerging of interactive tech-oriented products. Its importance has caught the attention of both industry and scientific communities, by focusing on aspects that are essential for the human-computer interaction (HCI) research. Although, despite its heavy influence on the HCI, its proper definition has still not been assigned.

Concerning this, Rebelo et al. (2012) mention that nowadays, UX covers a wide range of aspects that are related to HCI, such as "usability and task-oriented instrumental values" (p. 964). Particularly, Forlizzi and Battarbee (2004) define UX as a process that occurs in the present and carves users' experiences and future expectations, as stated by Rebelo et al. (2012). Furthermore, they mention that UX relies on user's reactions and responses as they interact with the product, starting from their very first contact with it to the moment when the product is used with a certain purpose. These reactions are mainly influenced by the users' expectations, but they also depend on cultural background (Rebelo et al., 2012).

Throughout existent research, UX Design is considered to represent the merging between "what is good for the user and what can be accomplished" within various design constraints, such as time and budget (Allanwood & Beare, 2014, p.14). The quality of user's life experiences depends on the product's design with which they interact on a daily basis; hence designers should keep in mind how big of an impact they have when creating goods that reflect their user's needs and preferences. Moreover, when designing interactive experiences for other users than themselves, designers are required to limit their own creative input and focus more on the context in which the product is going to be used (Allanwood & Beare, 2014).

The same concern is also shared by Rebelo et al. (2012) who furthermore argue that UX occurs "as a consequence" of the user's interaction with the product within various contexts (social, physical) which represent a major challenge for designers to overcome.

When designing for user experiences, an early user analysis would help in paving the path towards a successful interactive product. Rohrer (2014) argues that while designers have access to a wide range of user research methods, it is essential to keep in mind that there are certain techniques designed to be implemented within particular circumstances. Therefore, he categorizes UX methods across three dimensions: *attitudinal* vs. *behavioral*, *qualitative* vs. *quantitative*, and their *context of use*, as well as the possible questions answered by those techniques: "what people say?", "what people do?", "why & how to fix?" and "how many & how much?".

Focusing on the first dimension, Rohrer (2014) brings designers a clear distinction between the two concepts, as well as which methods are to be used, depending on the proposed goal. The *attitudinal* dimension aims to understand what users "say", whereas the latter focuses on what users "do" with the interactive product (Rohrer, 2014). Considered of great importance in the marketing industry, attitudinal research aims to gather as much user insight as possible, helping designers better understand how their users perceive interaction. Common techniques rely on surveys, focus groups, interviews, various studies (diary or camera) or even on customer feedback. On the other side, *behavioral* research seeks to understand what are the users' interactions with the product. In order to collect such data, designers can conduct ethnographic field studies as well as usability studies (Rohrer, 2014).

The most suitable choice of dimension applied within the context of this project is reflected by the *attitudinal* component of UX, with particular focus on what end-users believe in regard to the design and performance of the virtual reality application.

Rohrer's (2014) second dimension outlines two distinct manners of conducting a user analysis from which researchers can benefit. When performing *qualitative* studies, users are directly analysed by researchers and the information obtained from such observations is not analysed from a mathematical perspective, but is freely interpreted by researchers. The UX research methods implemented in such circumstances involve the use of interviews, Participatory Design and ethnographic field studies (Rohrer, 2014). *Quantitative* studies, on the other hand, aim to gather data about users' behaviour through different measurements tools (e.g. questionnaires) that researchers use in order to gain a better insight on quality of the experience provided by the interactive product (Rohrer, 2014).

The study conducted within this project can be characterized as both qualitative and quantitative for the following reasons: during early stages of development, interviews were conducted with the intended future end-users of the prototype (in order to build the application's design base and create personas) and they have also been involved throughout the design process (which helped in maintaining the prototype's requirements up-to-date). Additionally, the quantitative aspect of this study lays within the prototype's testing procedures, during which the user-product interactions were analysed and collected desired data through the use of questionnaires and measuring scales. In this case, the Presence Questionnaire, the User Experience Questionnaire and the System Usability Scale (SUS).

The third and last dimension that Rohrer (2014) expands upon is the product's context of use, which can be categorized as natural, scripted or hybrid. The UX research methods adopted within a product's *natural* use consist of ethnographic studies, diary studies or even customer feedback. In *scripted* scenarios, users' express concerns with regards to the product's performance, which can reflect aspects concerning its design and level of usability. Lastly, *hybrid* research methods "use a creative form of product usage to meet their goals" (Rohrer, 2014). Within this context, researchers can take advantage of techniques such as Participatory Design where end-users are allowed to interact with the product and are offered a voice in its development process (Rohrer, 2014).

The user interaction with PathVR occurred within two different circumstances, *scripted* and *hybrid*. In the *scripted* scenario, the prototype was placed under a series of usability studies, where ambassadors of Aalborg University Esbjerg who represent the prototype's main operators, have identified potential functionality and performance issues, as well as design flaws. Moreover, users have also interacted with PathVR within a *hybrid* context, by actively participating in the development and assessment process of the prototype. More details regarding the above mentioned scenarios and their implementation can be found in section **4. Methods** of this report.

In addition to Rohrer's research on the various implementations of UX methodologies, Farrell (2017) points out specifically when to use which method, when following a product design cycle. This consists of four different design stages, each one having its own compartmentalized set of UX analysis techniques: discover, explore, test and listen. Most of UX design techniques fall under the category of qualitative research methods.

According to Farrell (2017), in the *discovery* stage, designers are given the opportunity of a better user understanding by conducting field studies and interviews (with stakeholders and other end-users), with attention dedicated towards needs and behavior. This stage aims for

a validation of the collected data, as researchers must first understand their users before starting on the actual product implementation (Farrell, 2017).

In the *exploration* stage, the focus shifts towards building user personas and designing accordingly to their needs. Thus, various design possibilities need to be addressed and this can be achieved either by organizing brainstorm sessions or implementing an iterative design cycle of the product in question. The third stage which proceeds exploration is the *test* stage, during which early iterations of the prototype are evaluated in order for designers to guarantee a proper system functionality and to ensure that the product's design fulfills users' expectations (Farrell, 2017). The final stage in a product's design cycle requires designers to *listen* to their users throughout the entire design cycle, in order to solve existent design issues or even plan future iterations (Farrell, 2017).

Having this in mind, it has been decided to create and follow an adaptation of Farrell's (2017) product design cycle (detailed in section **3. Design and Implementation**), which provides readers with a better and clear understanding of the development process that lays behind PathVR.

2.4. "Think-Aloud": A UX Research Method

Farrell (2017) depicts a rich variety of UX research methods which strongly depend on the product's intended users and context of use. These techniques share two common goals: first, understand the individuals for whom the product is designed and second, asses the system's overall quality (does it fulfill its user requirements/preferences) and performance as studied by Farrell (2017). For performing evaluations on a product's usability level, measurements were made using questionnaires or scales (e.g. the SUS questionnaire, developed by Brooke in 1996). Apart from these traditional methods, other practices asses the level of usability directly through their product's users, by having them "Think-Aloud" every interaction with the system. While "Thinking Aloud" serves many usability purposes, designers often combine it with other user research methods, such as field/diary studies, participatory design, UX assessment and many more (Nielsen, 2012a).

In his "Usability Engineering" (1993) study, Nielsen (2012a) considers that "Thinking Aloud may be the single most valuable usability engineering method". While still standing by his early evaluations, he defines this technique as a test where participants are asked to use a system while thinking out loud, by verbalizing their thoughts and actions as they interact with the product's user interface. In his research, Nielsen (2012a) brings designers several

advantages that would help them better understand the users' thoughts, as well as downsides that reflect potential and unnatural situations which sometimes designers confront.

Benefits of implementing “Think Aloud” as part of usability testing, center around its flexibility and affordance in terms of equipment. Designers can accompany the uses and take notes based on their interaction with the product. This procedure can occur at any development stage, from Low-Fi to High-Fi prototypes, and is suitable for any form of technology (Nielsen, 2012a).

On another hand, it is believed that the “Think Aloud” technique does not supplement enough statistical data in order to sustain and strengthen the raw information gathered from users, when used in smaller studies. Moreover, this usability technique mildly restricts the users’ stream of thoughts when it comes to verbalizing their actions. In situations as such, it is recommended to “prompt” users, in order to keep them engaged in the conversation (Nielsen, 2012a).

According to Charters (2003), prompting is the action where the researcher reminds the participant to keep expressing their thought process during the experiment to ensure that that there is a constant stream of data. “Unfortunately, without some demonstration and practice, users may not report their thought processes frequently or thoroughly enough to meet the researchers need” (p.72), as declared by Charters (2003).

In order to run a basic Thinking-Aloud user study, a clear protocol needs to be followed, consisting of three clear instructions: “(1) recruit representative users, (2) give them representative tasks to do and (3) shut up and let the users do the talking” (Nielsen, 2012a). While it may appear as an easy procedure, the established course of action can be interrupted and even affect the flow of data. Such situations might involve: *Biasing user behavior* through an untrained moderator verbally interrupting the interaction, resulting in affecting the user behaviour. *Unnatural situations* can make it difficult for participants to maintain a constant monologue, especially when required to do so (Nielsen, 2012a).

In this current study, the “Thinking Aloud” procedure was used by researchers as main usability assessment tool for the virtual reality application, in one of the early field studies conducted in the beginning of the product’s iterative design cycle. Details regarding its application are presented in section **4.3.8. Field Testing - Open House (23th February).**

2.5. Personas

For the Swiss psychiatrist Carl Jung (1966), a "persona" serves as the face an individual present to the world - "a kind of mask" whose design purpose is "to make a definite impression upon others", and "to conceal the true nature of the individual" (Jung, 1966, paragraph 305).

In line with Chang, Lim and Stolterman (2008), the concept of "personas" within the HCI industry was initially introduced by software designer and theorist Alan Cooper, during his earlier studies (1999, 2003, 2007) and was considered to describe a clear characterization of users and of their desired achievements. In addition to this, it is argued that personas "have become a well-handed method" of helping designers prioritize their targeted user's needs throughout the entire design process (Friess, 2012, p. 1209).

On a similar note, Marsden, Pröbster, Haque and Hermann (2017) furthermore agree that the purpose for which personas have been created was to serve various functions within the design process, such as focusing on the audience, and making user requirements a priority. Even though substantial research has been conducted on personas and their role within design, their proper definition has not been yet formulated. Cooper's (1999) interpretation of a persona is vague, due to its generous purpose of representing a group of subjects with common traits; it is considered a "hypothetical archetype" (p.1209) which allows designers to concentrate more on the user's clarified goals and requirements, as mentioned in Friess (2012).

With respect to the personas' influence on the Human-Computer Interaction (HCI) research, Marsden et al. (2017) explain that empathy also plays an important role in allowing designers to better understand users and their interactive experiences, as this is also implied by the methods and tools used throughout a product's development process. Behind the implementation of such methods, the action of understanding the user becomes itself an "individual component", as it usually depends on designers' will to empathize and accept the users' mind-set and attitudes (Marsden et al., 2017, p.452).

Moreover, Cooper (1999, 2007) believes that a persona should speak only for one an individual, as this would help designers focus more on each particular user and not on creating a single product destined to fulfill all users' requirements, as mentioned in Chang et al. (2008). However, the latter study claims that it is not necessary for a persona to represent just one person, as it can be built on an amalgam of prospective users (Chang et al., 2008).

Friess (2012) argues that personas represent the intermediate agents of a large number of potential users, who might share similar attributes and objectives. Despite the variation present throughout their creation process, some particular persona attributes remain consistent across most theories. Such aspects involve names, expectations and a series of other subjective factors that play a key role in understanding the user's "behaviour pattern" (p. 1210).

In her study, Friess (2012) concludes that a persona may often be developed based on designers' anticipations and assumptions of their stakeholders, due to possible constraints of time and/or budget. When facing such challenges, experts advise researchers to conduct additional empirical fieldwork (interviews or field observations) in order to design data-driven personas (Friess, 2012). The collected data is afterwards merged together with the fictitious attributes into a harmonized form, in order to create a persona that reflects a real individual and not just some series of written traits (Marsden et al., 2017). This way, designers are inclined to feel more empathy towards the resulted persona, by using their own emotions as basis for appreciating others' beliefs. Thus, in order to obtain an effective persona, designers should first learn to empathize with the fictional users (Marsden et al., 2017).

Like every other user research method, implementing the "persona" technique within a product's development process can either be beneficial for the design or prove to be unrewarding. There are few disadvantages of using personas (such as the difficulty designers face in relating to them), mainly due to their fictional nature and complications when being verified in terms of accuracy (Friess, 2012). Besides this, researchers have also expressed concern with regard to the significant amount of time one needs to spend in order to create an accurate persona representation, which often tends to be ignored "during conversations about product decisions" (Pröbster, Haque & Marsden, 2018, p. 156).

However, the advantages of using such technique in a product's design process are numerous. Miaskiewicz and Kozar (2011) have actually implemented tables containing both "benefits of persona use suggested in literature" and their corresponding definitions. Thus, Cooper (2009, 2002), Grudin and Pruitt (2002), Long (2009), Ma and LeRouge(2007), and Pruitt and Adlin (2006) all agree that personas "facilitate effective communication about the users", as well as they "make more explicit assumptions" about them, as mentioned in Miaskiewicz and Kozar, (2011). In addition to this, personas are also considered to be of great help in "building empathy for users" (Pruitt & Adlin, 2006), "increase focus on users or specific audience" (Cooper, 1999, Grudin & Pruitt, 2002, Ma & LeRouge, 2007) and many more, as cited in Miaskiewicz and Kozar, (2011).

Within the context of this project, "personas" have been implemented as the main, user-centered design methodology of PathVR, whose intended end-users belong within three separate categories due to the variety of user requirements and preferences expected from the virtual reality application. Collecting the necessary user input was done by performing a series of interviews, which were further interpreted and analysed from a thematic point of view.

2.6. Thematic Analysis

It is believed that qualitative studies play an important role within research literature, due to their intentions of evoking knowledge heavily influenced by human experiences (Sandelowski, 2004). Moreover, Nowell, Norris, White and Moules (2017) have also noticed that the interest in qualitative research has seen a considerable growth within nowadays social sciences, and so did the need of tools that could facilitate such studies. Therefore, Guest, MacQueen and Namey (2012) suggest to first define what is meant by "qualitative research" before delving into the actual process. From the very beginning, Guest et al. (2012) provide analysts with a clear terminology outline, which defines five basic terms used within the context of qualitative analysis: data - "textual representations of a conversation" (p.3), theme - "the unit of meaning of a text" (p.3), code - "textual description of a theme component" (p.3), codebook and coding - "associate codes to specific data segments" (p.3). By considering all these aspects, it is possible to achieve a base understanding of what one implies by qualitative research.

There are various influential factors which contribute in building a potential definition of qualitative research. As studied by Guest et al. (2012) they depend on how researchers interpret data analysis, the type information used within the study, and the different kinds of analysis conducted on the data. When discussing about qualitative research, analysts generally refer to the "textual data gathered from in-depth interviews" (p. 10) which is often obtained through transcription of audio recordings (Guest et al., 2012).

In order to be accepted as a reliable technique, researchers need to assure that data analysis is carefully performed by "recording, systemizing, and disclosing the methods of analysis" (p.1) in a detailed manner, so that users can reflect on their credibility. Despite access to a variety of design possibilities for performing qualitative studies, there are hardly any advanced techniques available for conducting an exhaustive thematic analysis (Nowell et al., 2017).

In line with Evans and Lewis (2018), thematic analysis is considered a very useful qualitative research technique, especially when one is interested in studying how individuals "make meaning out of their experiences"/build their "social worlds through meaning-making" (p. 2). Although current research claims thematic analysis to strongly cover a wide range of usage, there is no distinctive description of what it actually represents or of its performance (Braun & Clarke, 2006). By comparison with other qualitative research methods (e.g. ethnography, grounded theory) upon which various studies have reported, Nowell et al., (2017) wishes to point out the lack of existing literature when it comes to conducting accurate thematic analysis.

Despite being characterized as a "poorly branded method" (Braun & Clarke, 2006, p. 79), thematic analysis has a flexible design which, depending on the purpose of the study, may provide significant amounts of data (Braun & Clarke, 2006). This represents an important advantage, as further research also considers thematic analysis to be an effective tool in outlining essential features of a rich data set (Nowell et al., 2017). While thematic analysis is being perceived as an asset in the analysis, Holloway and Todres (2003) observe that the method's flexibility component might tend to cause "inconsistency and lack of coherence" when extracting themes from the collected data (Nowell, et al., 2017, p.2).

As settled by Braun and Clarke (2006), thematic analysis is categorized as a subjective research method, whose implementation can vary from one individual to another. In order to support their statement, Braun and Clarke (2006) claim that thematic analysis on interview transcriptions can be performed through two different approaches: bottom-up - the analysis starts with the interview transcription, which later on is abstracted into general themes, or top-down - which applies a theoretical structure to all data in question (Braun & Clarke, 2006).

2.6.1. Thematic Analysis of Semi-Structured Interviews

In their study of "Semi-Structured Interviews Using Thematic Analysis", Evans and Lewis (2018) discuss some important factors that should be taken into consideration when performing thematic analysis on data gathered from semi-structured interviews. Considered one of the most predominant techniques in research, Flick (2009) argues that such qualitative interviews not only allow for an exploration of subjective matters, as defined in Evans and Lewis (2018), but also help gain a deeper understanding on people's stated experiences and beliefs. In addition to this, Evans and Lewis (2018) suggest that when conducting a thematic analysis on semi-structured interviews, analysts need to reflect on three important concerns: how useful is thematic analysis within its context of use, how are themes generated, and how can they be represented.

Regarding its beneficial use, thematic analysis is considered to be "the first qualitative methods of analysis" (p.78) that researchers should study, as it offers a set of essential skills, useful in future analysis implementations (Braun & Clarke, 2006). Evans and Lewis (2018) define thematic analysis as an identification process of "patterns and themes" (p.3), which starts in the early stages of data gathering, and is considered to last throughout the entire procedure, during which the data is transcribed, analyzed and interpreted. Within this particular timeframe, researchers are reminded to identify elements worth representing main aspects of analysis in

the study. Moreover, Evans and Lewis (2018) wish to point out that even though similar themes might occur multiple times, their frequency should not affect their level of importance.

According to Boyatzis (1998), it is important to keep in mind that the level at which the data (or theme) is identified may vary from a semantic (or explicit) to a latent (interpretive) one, as mentioned in Braun and Clarke, (2006). Patton (1990) argues that the semantic approach studies the interviews' explicit meaning, whose content is afterwards summarized in order to identify recurring patterns or themes, as studied in Braun & Clarke (2006). The latent approach, on the other side, focuses on the underlying themes of the discourse (Braun & Clarke, 2006).

Within applied thematic analysis, Ryan and Bernard (2003) point out that themes can also be generated if one pays careful attention to "thematic or linguistic cues" (p. 20), often represented by "repetitions [...], metaphors and analogies [..], constant comparison/similarities and differences [...]" (p. 21) and many others, as cited in Guest, MacQueen and Namey (2012).

2.7. Related Works

During both the research for this study and also the market research done for the PathVR StartUp company, several examples were discovered of companies who served almost the exact function as the PathVR app with similar technologies. They provided a source of inspiration in terms of their design, presentation and it was also interesting to observe how these companies and projects tackled the use of their application.

In Denmark there are two major companies which provide virtual reality applications for advertising and marketing purposes: Khora-VR, (2019) and Virsabi, (2019). The two have created several projects used as promotional, training and communication tools. Both of these companies have become successful by collaborating with others in the fields, and working on sending a message to a broader audience. One of the products from Khora-VR (2019) is a VR application showcasing the city of Copenhagen for tourists by visiting major attractions across the city. In this application they've also mounted a 360 camera on top of a tripod next to the more famous location of Copenhagen, such as the little mermaid or the boat ride along the docks. Khora-VR (2019) has also worked on a tour of the M/S Maritime Museum of Denmark located in the city of Helsingør. All Khora-VR applications take advantage of 360 images and videos, as well as incorporating some computer graphics. Virsabi has also created an experience in collaboration with B&O where they set up a camera on a chair and recorded a

seated experience of a performance (Virsabi, 2019). The PathVR developed for this study can also be modified to fit within the same market.

There are other universities that have employed a similar model to the one of Aalborg University which enable users to visit a campus and let them freely navigate around the university (Ideal 360, 2019). Like this study, the Ideal 360 tour showcases the school or university in 360 images through a navigation system. Another company called You Visit (2019) also gives universities a tool to promote their facilities. It uses 360 footage on both a phone and in a headset. While the shots are static they are accompanied by an overlay interface and a narrator. The fact that the application is web based offers the ability to users to use it at any point. This works on the same principles as the ideal tours app (2019) where the user can navigate with arrows around the campuses. Each of these have their own benefits and disadvantages. Both of them are web based, but Ideal 360 acts more as a database for 360 images while You Visit is more of a compact app with an overall design. The idea of a web-based application was considered in the early stages of this study, but it was considered to deviate too much from the requirements of the stakeholders who still required an application for a specific headset.

Countries like Australia have also started using 360 images and videos for tourism purposes (Tourism Australia, 2019). These short videos can be viewed both with a headset and on a webpage through the Youtube interface. While, Tourism Australia (2019) mostly just gives advertisement through traditional means, like Youtube videos and blog posts, they have also expanded to 360 videos. All of their content is available through a downloadable application and viewable using a smartphone with a VR cardboard or other mobile headsets. There have also been several other methods of advertising vacation areas, such as Thomas Cook's (2015). In this case a traveling agency used VR headsets with filmed 360 footage of vacation areas to observe whether or not potential customers would opt for a vacation if they saw a preview first. Their study showed that sales increased by a total of 190% to the destinations advertised with VR.

VR tourism has also become more popular in the gaming sector. Games have recreated the Grand Canyon and used the destination to frame the unique experience of sailing a canoe through it (O'Donnell, 2019). The Grand Canyon canoe ride is meant to be a relaxing experience wherein you slowly sail around and get to feel what it is actually like to be at the bottom of the Grand Canyon. A similar Mount Everest trip is meant as a look into the dangers of mountain climbing (O'Donnell, 2019).

According to O'Donnell (2019) Google Earth VR is a must see experience. In this application users can fly around the earth and see cities in a 3d layout and get a good overview of how a given city, landscape, beach or even mountain would be viewed from a bird's eye point of view. This view acts as an interface which can be used to access 360 images (O'Donnell, 2019). The navigation of Google Earth is perhaps the most similar in design to the one of PathVR as it also uses controllers to move to different locations and an overview map.

3. Design and Implementation

PathVR is a virtual reality application created as a promotional tool for Aalborg University Esbjerg in collaboration with the PR Department. Thus, the application contains 360 footage shot on a Samsung 360 camera combined with 3D objects generated within the Unity game engine. The users would interface with the application using the Dell Windows Mixed Reality headset which is connected to a laptop.

3.1. Iterative Design

The current design state of PathVR is the result of multiple iterations, each of them with its own design cycle. To best outline the design methodology of this study, a user experience cycle will be followed (Figure 2).

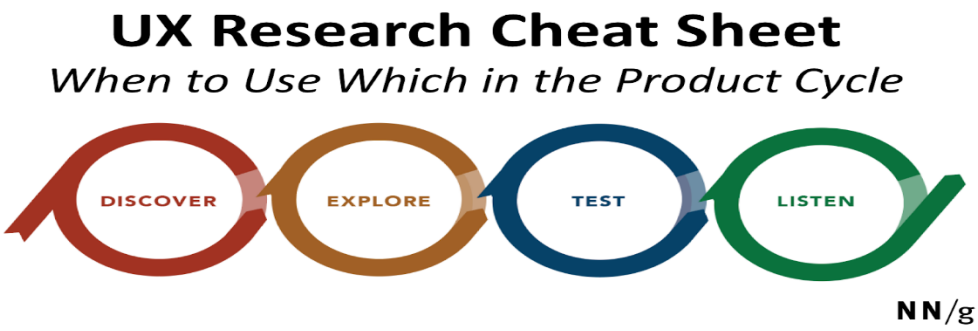


Fig 2. UX Activities in Product and Service Design Cycle (from Farrell, 2017)

3.1.1. Discover

During the Discover section interviews were performed with several gymnasiums both in Esbjerg and Copenhagen, to ask and listen on what their requirements were, when looking for a university education.

During this stage there were also considerations on what software and hardware should be used for implementing the prototype. Based on the requirements of the stakeholders a relatively portable system was chosen for easy transportation and set up. The Windows Mixed Reality headsets uses inside out tracking with no external tracking (Microsoft, 2019). Thus the system only requires the headset to be plugged into a laptop/PC capable of running virtual reality applications and Windows OS. The difference between inside out tracking and outside in tracking (Vive, Oculus) revolves around the placement of the trackers themselves. With the Windows Mixed Reality headset the tracking is done with two sensors attached to the front of the headset which tracks the placement of the motion controllers, which are connected to the PC through Bluetooth. The tracking of the headset itself in terms of movement and rotation is done through the gyroscope sensors within it. Other headsets use outside in tracking through base stations which track both the headsets and the controllers. The major problem with this setup is that in crowded and often chaotic environments such as a career fair this could lead to occlusion. If objects or people get in the way of the sensors than the experience will be disrupted. In addition, the setup is more difficult and time consuming to put together in a temporary location (Langley, 2017).

The software used was Unity as it is a game engine with which the development team is most familiar with. It also allowed for development to the Universal Windows Platform, (UWP) which is the official program used for running any Windows based programs. For

custom 3d models of specific locations in Esbjerg the software Autodesk Recap was used to generate the model using a process called photogrammetry.

3.1.2. Explore

Information was gathered from a field test at the Aalborg University Esbjerg Open House. The information gathered was then used for the design of the application. Personas were also generated based on interviews conducted in both Esbjerg and Copenhagen. After these tests, a further design analysis was done in regards to movement, teleportation, selection and the general design of the interface.

The different personas express interest in different aspects that were later incorporated. For example, international students brought into question the size of the campus and the distances of the different accommodations available.

3.1.3. Test

After an initial prototype was constructed the focus was on improving its usability and functionality. Through qualitative feedback from test participants several design issues became apparent. Across all versions of the application features were added or removed based on the feedback received. For example, there was always a tutorial stage to introduce new users to the controls, but this was vastly changed from version 1 (Figure 3) to version 3 (Figure 4).

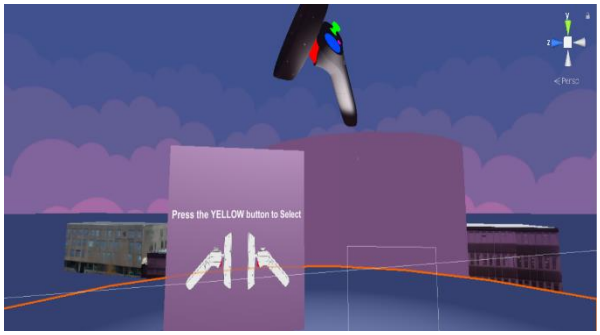


Fig. 3. Initial tutorial Scene

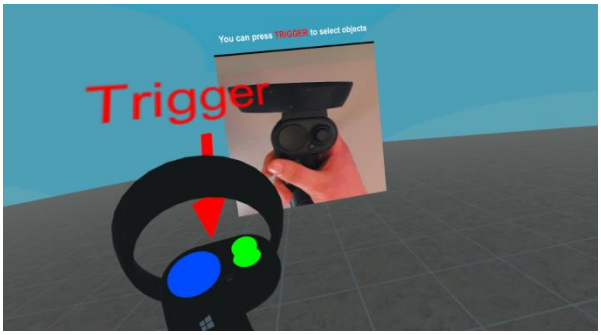


Fig. 4. Updated Tutorial

3.1.4. Listen

During the listening stage the results of all testing methods were analysed. These were then put into improving future iterations, and all the data collected was analysed and placed into comprehensive graphs.

3.2. Previous Prototype

In past projects the same team designed a virtual reality application with the same purpose as the current one. The past prototype was created using the Samsung Gear VR, a Samsung Galaxy S7 smartphone and an android tablet as hardware components. It also featured scenes shot with a 360 camera at a 7776 by 3888 resolution and were also featured within an environment built in Unity. The main difference was that the software was built for mobile applications and hence was restricted by these limitations. The resolution of both the images and videos had to be downscaled to fit within a two gigabytes storage limit. The application was controlled by a tablet connected through Bluetooth such that a person could control what the Gear VR would display.

Later the same project would be further iterated by adding audio components. This proved to be a decision with mixed results, as the virtual reality application would be used in scenarios where there needed to be a communication channel between the person using the headset and the person using the tablet.

3.3. First Prototype

3.3.1. Initial Design

The first prototype was created based on initial discussions between the stakeholders (represented by ambassadors of Aalborg University Esbjerg) and the team working on this study. However, this version was made with the main goal to be functional without much regard for intuitive controls or aesthetics. The main work went into creating the actual virtual environment using the mixed reality toolkit and building it as a universal window application (UWP).

The first version consisted of an Intro scene, a Map scene and a University scene. The user would start in the Intro scene and go through a tutorial to learn how to use the controller (Figure 3). After finishing they would advance through to a CGI map of Esbjerg. This was created using a Unity plug-in called Mapbox (2019) (Figure 5). In this map the user would

select between multiple building in order to view 360 footages from them. If they selected the university 3d model they would be transported to the University scene.

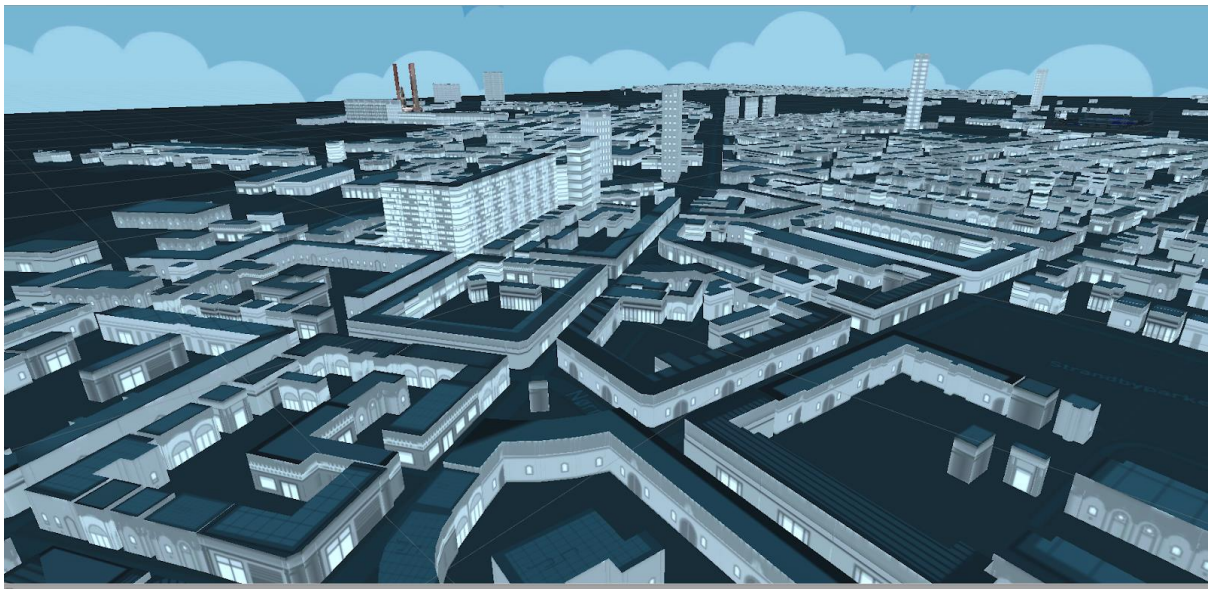


Fig 5. Big Map in Version 1

3.3.2. Further Iterations

Version 2 brought a large change to the architecture of the system. Due to negative feedback regarding the initial Esbjerg map design (Figure. 5) this initially separate scene was removed and replaced with a miniature map present accessible throughout the system (Figure 6). The negative feedback was directed towards the time consuming and un-intuitive design of the map. Initial tests with Version 1 showed users were confused by the large map and were having difficulties even getting to the university scene. Thus, version 2 used a miniature map system. This would allow users to get a fast overview of the city layout and its primary locations. On the map 3d models of significant city landmarks were added to act as shortcuts to those specific locations. In version 2 only the university and its facilities were available as that was one of the more important parts for the system to showcase and had to be worked on first. Some other small design changes were the remapping of certain buttons on the controller in order to be more intuitive for users to learn. As mentioned above the tutorial was also updated.

Version 3 saw the expansion of the PathVR application to include locations from around the city. While the initial plan since version 1 was to have each location have their separate scene this was abandoned by version 3 and they were all placed in one scene. These

locations include the downtown area, the stadium, the museum and the near island of Fanø. Interactable objects were also added to this version. These were objects in the virtual environment the user could interact with (Figure 6). Small changes were also added along the design cycle of the third version such as the improvement of the teleportation function.

Fig. 6 Interactive beer dispenser near the university brewery

Versions 2 and 3 focused on improving the level of user experience and the visuals. The main change from Version 1 is the compressing of 3 scenes into only one. The user interface was changed with more emphasis on a fast learning curve. According to Galitz (2007) a user interface should respect seven general principles: “accessibility”, “aesthetically pleasing”, “availability”, “clarity”, “compatibility” and “consistency”

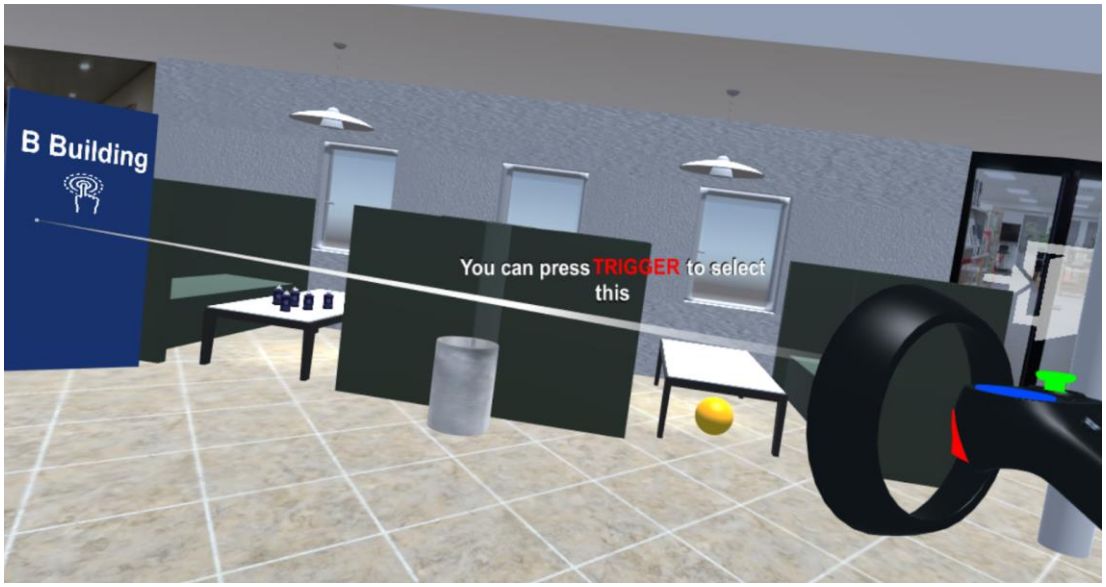


Fig.7. Red trigger for red button

Accessibility refers to the ability of multiple users from different backgrounds to be able to understand and interface with the system. Simplicity in design allows for the user to have a basic understanding without being crowded with unnecessary detail. Within the PathVR app the interface contains colour coded instructions that match the items referred to (Figure 7). Also the tutorial is accompanied by videos meant to aid the viewer in the understanding of the buttons and their functions. Forgiveness is also important within accessibility, where if the users commit an error of cause a glitch, they can always be returned to a previous stage and continue uninterrupted. This is possible in the PathVR application, by using the keyboard of the laptop which can also send input into the system. If the user is stuck within a certain area pressing backspace will return them to the previous stage.

Fig. 8. Map in Version 3

Aesthetically pleasing and consistent visuals were also used in order to attract people to continually use the application. The design guidelines provided by Aalborg University (2019) were followed in terms of colours, fonts and logos used. The computer generated elements were textured to fit within the scene as some of them are placed alongside a live action background.

Availability was ensured in the program through the use of a comprehensive layout. The application was constructed with the university entrance as the central hub and the starting location. From here users can travel to any location through the use of the map (Figure 8) and from any point can return back to the entrance instantly.

Clarity was used in the way the user interacted with the system. The interactive areas are highlighted by a white square around it with text indicating where they will be transported if they press in that specific place (Figure 9).

Fig 9. Objects indicating locations for transport

The **Compatibility** of the system depends mostly on the intuitive nature of the controllers. Over the iterative cycle the designers have noticed issues with certain button mappings and changed them to be more intuitive for the users. PathVR uses 3 buttons of the 5 available on the controller.

Configurability is assured by allowing both ambassadors and users to control the application. The application also allows multiple methods of travelling to a specific scene and maps also allow the users different alternative routes to take. So they have more than just one way of navigating through the application.

4. Methods

4.1. Design Theoretical Framework

This semester's project design engages in a user-centered approach in order to help improve the understanding of the end-users and the requirements of PathVR. This would match with the end use of the application for Aalborg University to attract potential students or other interested parties.

The end-users to benefit from this VR application are grouped within four user categories: Danish students living in Esbjerg, Danish students from outside the city and international students who have just been admitted to Aalborg University; they represent the people who will interact with the application. The fourth category is represented by the ambassadors/staff of Aalborg University Esbjerg, who will act as operators of the product, but will still have a degree of interaction with the system. Therefore, the design methodology which would best fit the purpose of this interactive and promotional tool is user-centered design. Various user-centered activities have been carried out throughout the entire development cycle of the virtual reality application (interviews, persona creation, audio/visual recordings, questionnaires, prototype testing, field testing and observations). These activities helped gain more insight into how the interactions between users and technologies emerge, and produce more engaging user experiences.

4.2. User-Centered Design

Following Miaskiewicz & Kozar (2011), various research shows that user-centered design (UCD) is often described as a "general philosophy towards design that brings the users or consumers into the design process" (p. 417). Further studies state that UCD revolves around the designers' constant implication in iterating and evaluating the products' level of usability and usefulness (Mao, Vredenburg, Smith and Carey, 2005). Hence, it can be argued that user-centered design nurtures the collaboration between creators and future end users, having as an important principle the continuous focus and involvement of end-users in the prototype's early development stages (Kujala, 2003).

In a study conducted by Mirri, Roccetti and Salomoni (2018), it is mentioned that users play an important role throughout the design and development stages of an interactive product, thus contributing to the base of various human-computer interaction methodologies. Mirri et al. (2018) argue that with the outgrowing development of such methodologies, users are

implicated in more design processes of common UCD techniques (for example, co-creation and open innovation). While co-creation involves an exchange of knowledge between a well-defined group of users and designers in order to "deliver a personalized experience", open innovation acts more as a collaboration tool among designers or "organizations" with the aim of "sharing intellectual property" (p. 1). On this note, Mirri et al. (2018) agree that some co-creation, HCI methodologies which can be applied in the context of software development, are UCD and Participatory Design (PD). Concerning the purpose of the current prototype which has been developed within the context of this study, the focus will be oriented towards the following design techniques: Participatory Design and Personas.

4.2.1. Participatory Design

Participatory Design (PD) has influenced the way users contribute to the design and contents of a product's development process (Mirri et al., 2018). Being an early Scandinavian contribution to the HCI research field, this design technique served as a great tool for workers to express their opinions and share concerns "in a period where computers were beginning to change what was going on at the workplace" as stated by Bødker and Kyng, (2018, p.2).

Nowadays, PD focuses on facilitating a straightforward collaboration between designers and end-users, by engaging them into joint design processes that aim to create successful interactive products which fulfil their respective requirements (Steen, Kuijt-Evers & Klok, 2007).

In the context of this project, this design technique brought ambassadors of Aalborg University Esbjerg much closer to the design process of the application, during which both parties have contributed input for further improving the quality of the existing prototype. The feedback from the ambassadors would come from either their verbal notes while trying the application or from the answers provided on a SUS questionnaire. This partnership has been maintained by keeping each other up-to-date and preserving a constant communication flow. This was achieved through organizing regular meetings or prototype test sessions where ambassadors would try the virtual reality application. The collected data would afterwards be analysed and translated into issues that needed to be addressed in the further iteration.

This cooperative experience has brought several benefits that proved to be of great help throughout the entire iterative process. As reported by Steen et al. (2007), Participatory Design offers a varied pallet of advantages, ranging from a political point of view to economical, and last but not least, practical. With regards to the political aspect, ambassadors were given a voice

in the prototype's design process by bringing their knowledge together with designers', to develop an interactive tool meant to fulfil its user requirements. From an economical perspective, their active implication has prevented researchers from spending additional time on design matters. Practicality is also of big significance, as this user-centered method supports designers discover more inventive way to create interactive products (Steen et al., 2007).

Despite its capability of engaging both researchers and users within a "long-term maximal effort" from which a mutual benefit arises (Bødker & Kyng, 2018), PD comes with downsides as well. It has been observed that the active participation of end-users in the design process may not necessarily result in a positive outcome, as users tend to "get too much of it while they also get too little out of the effort" (Bødker & Kyng, 2018, p.2). Therefore, maintaining the slightly distant yet close contact with the ambassadors of AAU has been done by resuming the meetings to prototype testing and feedback sessions.

4.2.2. Personas and Thematic Analysis

In order to create a product whose design requirements should satisfy the needs of a wide range of individuals, designers must first understand their users, as this is considered an important obstacle to overcome throughout development stages (Marsden et al., 2017). In this sense, the HCI industry has developed a variety of qualitative design methods which aim to collect as much user insight as possible. Such techniques center around the use of personas, identity models, role plays and many others (Marsden et al., 2017). Within the context of this project personas were adopted as the main user-centered, qualitative technique.

According to Nielsen (2012b) personas were first used in the development of IT systems, but has since been expanded into other areas of research. Despite personas being used in all facets of design there has not been a lot of work put into discovering what makes the method work or how it functions from an ethnographic standpoint (Nielsen and Hansen, 2014).

In their "*Study on the Use of Personas in Denmark*", Nielsen and Hansen (2014) distinguish and compare different aspects of each other's' writing on the subject of personas. The study's main focus was achieving a better understanding of how Danish practitioners implement personas in their companies by reflecting on improvements, benefits and confrontations which occur when working with such design techniques (Nielsen & Hansen, 2014). Despite existent research arguing that designers abide personas due to its fictional component, which may "lead to a false sense of understanding" (Friess, 2012, p. 1210), findings collected by the Scandinavian study prove the contrary. Nordic researchers learned

that personas used in practice had attained great success, by positively contributing to design development and decisions-making (Nielsen & Hansen, 2014).

While Participatory Design reflected the collaboration between the study team and stakeholders represented by ambassadors of AAU, the following paragraphs detail the persona creation process for the other three user categories: Danish students coming from Esbjerg, Danish students living outside the city and international students from Aalborg University Esbjerg. Moreover, a clear distinction needs to be made with regards to who are the intended end-users of the virtual reality application and for whom is the application designed.

Within the context of this project, these experiences are designed in accordance to each of the three categories that bring their own user requirements. Therefore, the overall design of the product has started by creating, for each user category, a persona that comprises the actual needs and expectations of users in regards to the system's performance. Known for "keeping the needs of the intended user population at the forefront of the process" (Friess, 2012, p. 1209), the personas developed in the current study follow a set of stages during which researchers maintained constant prototype iterations based on up-to-date feedback.

The persona development process followed Chang, Lim, & Stolterma's (2008) charts of design stages, based on which researchers selected the most optimal start for the design procedure. Chang et al. (2008) found that a persona "is ideally created after user studies, launched and communicated in the following design steps" (p. 3) until a final design idea is achieved (Chart A). Based on their own later findings, they argue that a persona is only completed when the design process has ended, as it's being constantly under development during design procedure (Chart B). While other situations imply that persona creation follows the design idea generation stage (Chart C), some consider that personas can "exist undocumented" whilst contributing to the overall design (Chart D) (Figure 10) (Chang et al., 2008).

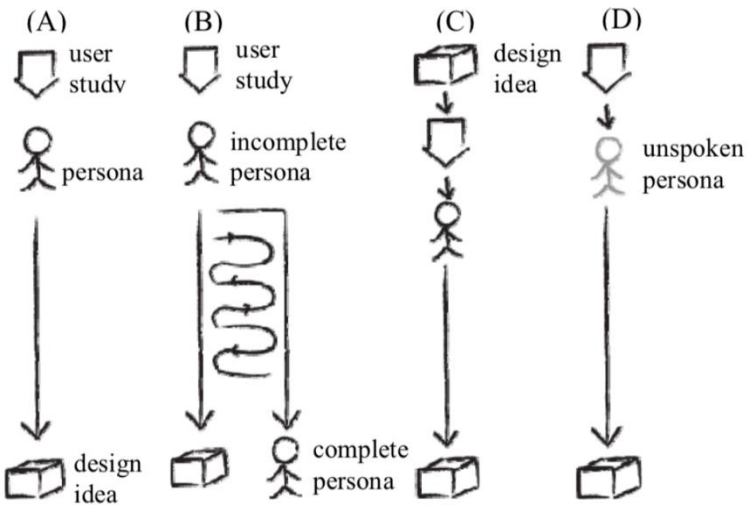


Figure 10. Various stages for persona development (from Chang et al., 2008)

The persona creation process first began by conducting interviews with participants from each of the user categories (Danish students living in Esbjerg (7), Danish students living outside of Esbjerg (9) and International students (4)). The questions were related to current occupation, educational preferences and needs, daily routines, and personal inclinations with respect to virtual reality, as well as opinions in regards to what it can offer to the public. The interviews (found in section **9. Appendix**) were held at Rybners Gymnasium in Esbjerg, Next Sukkertoppen in Copenhagen and at Aalborg University in Esbjerg.

The thematic analysis started once the interviews were brought in for transcription. Codes were generated regarding various thematic aspects (Information retrieval, universities in general, Aalborg University Esbjerg, and virtual reality) and were furthermore placed in three distinctive thematic maps which corresponded to the three user categories present in the analysis: Danish students studying at Rybners Gymnasium, Esbjerg (Figure 11), Danish students from outside the city (Figure 12) and students coming from outside the country (Figure 13).

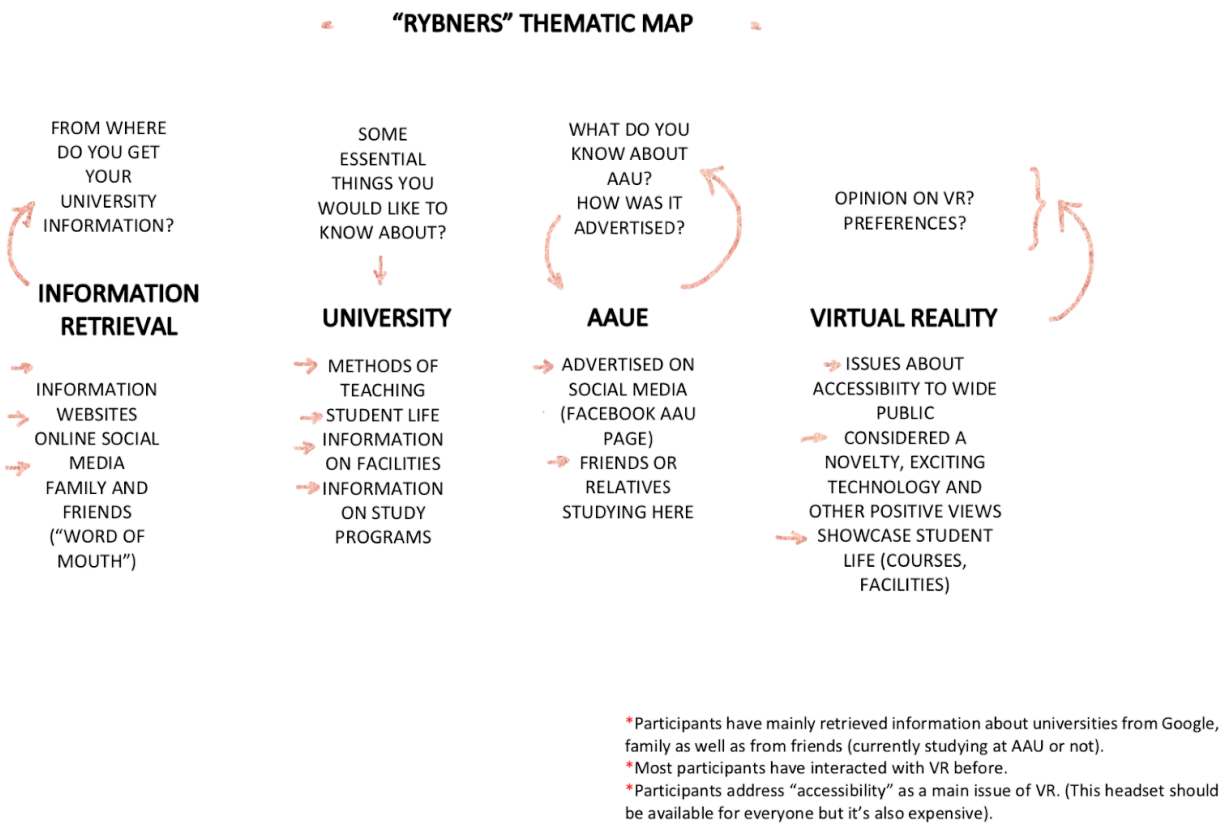


Fig. 11. Thematic map - Danish students inside Esbjerg

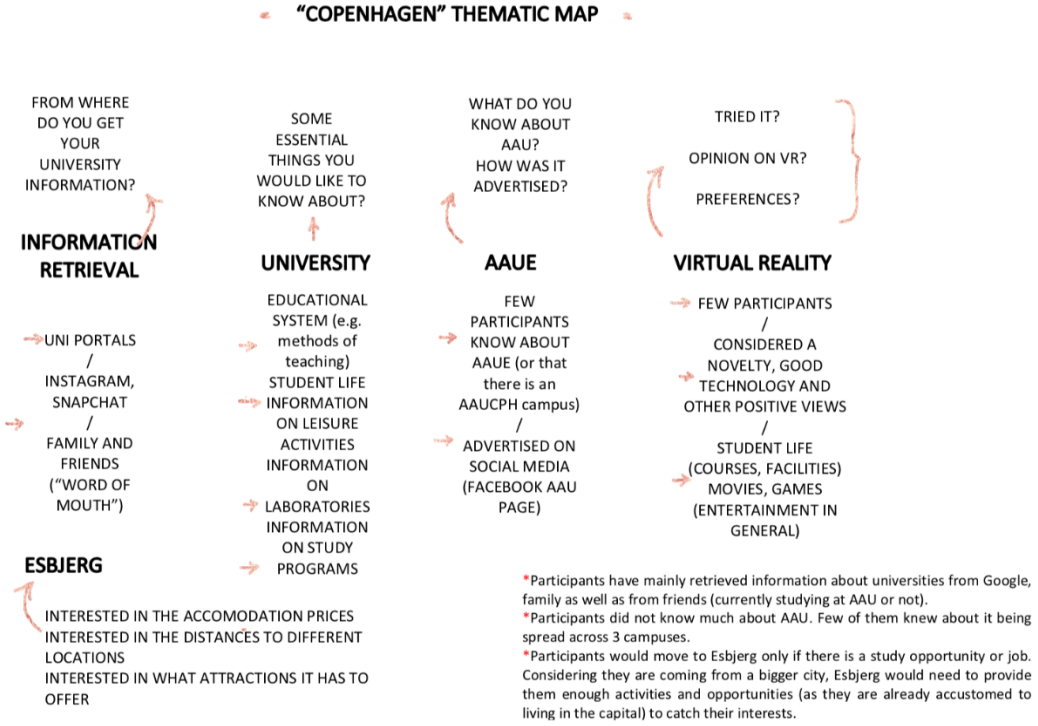
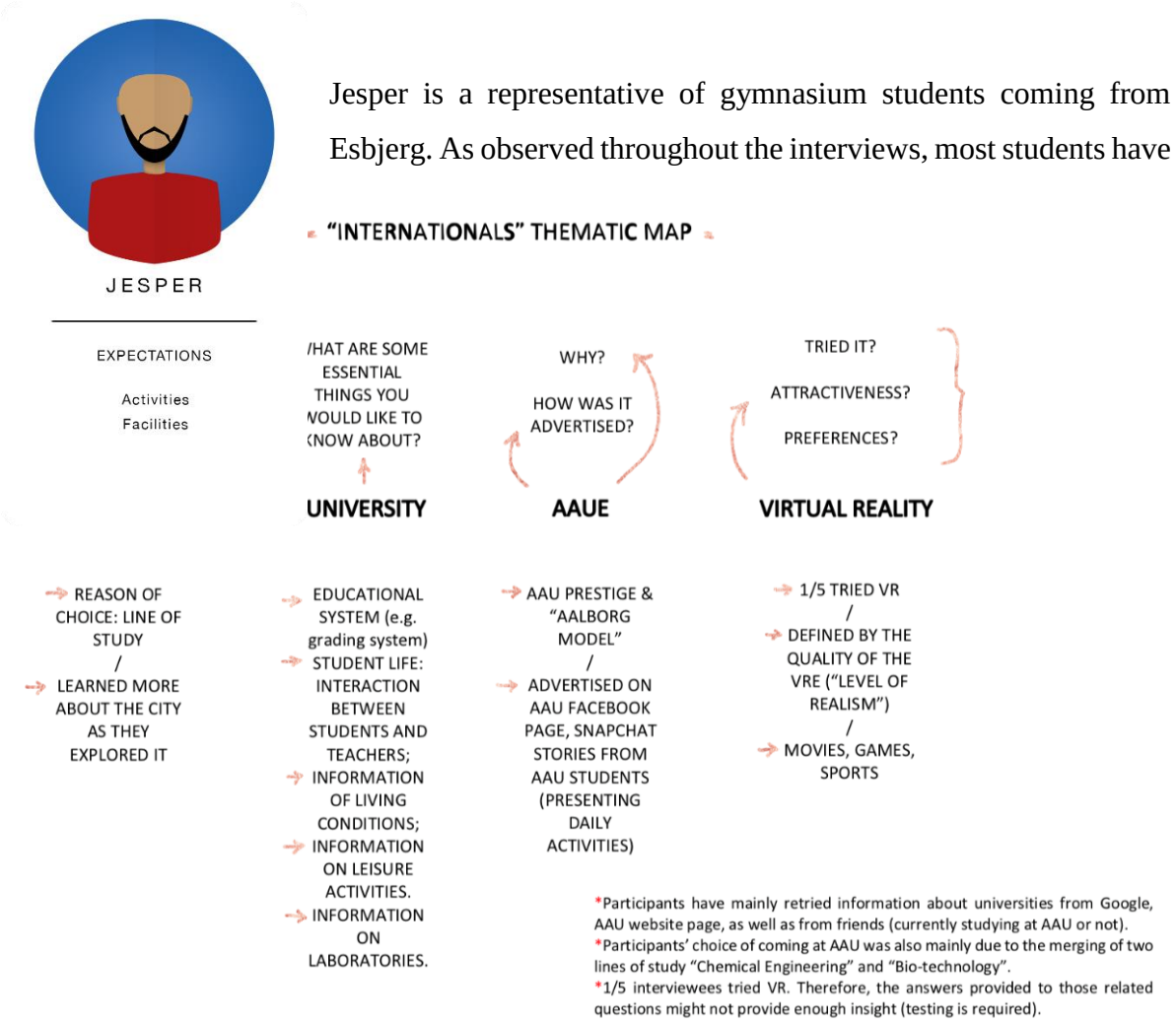


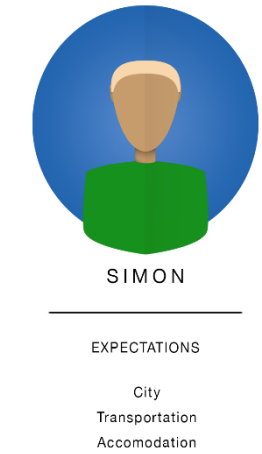
Figure 12. Thematic map - Danish students outside Esbjerg

Fig. 13. Thematic map - International students

Based on the information retrieved from the above thematic maps, a first set of personas was created, each one being provided a name and goals/expectations from the product that represent real user requests with respect to the functionality and design of the VR application.



Jesper is a representative of gymnasium students coming from Esbjerg. As observed throughout the interviews, most students have already been informed about Aalborg University Esbjerg (either by their friends, family, or "word of mouth") but shared a particular interest in what the university actually has to offer: laboratories, facilities, study programs, as well as leisure time activities organized amongst students.



Simon speaks for gymnasium students living outside Esbjerg city (in this situation, coming from Copenhagen). Individuals belonging to this category are particularly interested in the main attractions of Esbjerg, and seek to find out what exactly could determine them to move outside their hometown and come study at Aalborg University Esbjerg. In addition to this, they also express concerns regarding the methods of transportation to/from Esbjerg and within the city, as well as prices with regards to accommodations.

Maria represents international students coming from outside Denmark. Her main expectations from PathVR application consists in its possibility of covering a wide range of matters directly related to: the university (facilities, laboratories, methods of teaching, grading system, certified courses), the city (attractions and leisure time facilities) and financial aspects (price for accommodation, food expenses and others).

Taking this into consideration, PathVR aims to fulfil the above mentioned expectations by comprising them into a virtual reality application designed for a diverse user spectrum.

4.3. Designing and Conducting Experiments

One important focus of this project was developing a virtual reality promotional tool for the PR Department of Aalborg University Esbjerg, that would act as an asset in attracting prospective students while attending educational fairs and other promotional events. In addition to this, the study's main objective was to analyse how can a virtual reality promotional tool be created when adopting user-centered design as the main design methodology, and how can one measure the quality of the experiences that it provides, considering the purpose for which it was designed. Therefore, researchers of this study have conducted multiple tests that rely heavily on analysing the level of presence and user-experience felt by participants when interacting with a virtual reality application designed to fulfil the requirements of their corresponding personas.

4.3.1. Ethical Concerns

According to Yip, Han and Sng (2016), there are numerous ethical and legal concerns which must be taken into account when conducting research on human subjects, due to the participants' role of "serving as sources of data". The Belmont Report (1979) also expands discussion on such issues and offers researchers an analytical methodology for conducting experiments, based on three important ethical concerns:

- "Respect for Persons" - requires to "acknowledge autonomy" and "protect those with diminished autonomy" (p.3)
- "Beneficence" - requires to "do not harm" and "maximize possible benefits and minimize possible harms" (p.4)
- "Justice" - interpreted from an individual to societal perspective (p.4)

With regards to this matter, all individuals who granted permission of participating in this study have been treated with respect and were fully informed of how the experimental procedures will take place. Hence, confidentiality was ensured for collected data that consisted of both written and recorded information (with exception for interviews, questionnaires and SUS test scores). It is important to mention that during the experimental sessions, participants had the right to stop their interaction with the system at any given time. Regarding informed consent, verbal and written agreements have been settled between researchers and the educational institutions where the testing sessions occurred.

4.3.2. Presence Experiment

The user-centered design methodology on which this project is built on consisted of creating a persona for each of its three target user groups representing. In relation to this, the PathVR was developed with the main goal of creating tailored experiences, that would fulfil each group of user requirements and needs. Therefore, one focus of this study was to analyse how can a virtual reality promotional tool be created through a user-centered approach. The experimental procedure consisted in assessing the level of presence for each of the three end-user groups (personas) at two different design iteration stages of the virtual reality application. A total of seventy-five gymnasium students and internationals participated in this study. The participants were attributed to three different groups, represented by their own persona, and interacted with two consecutive prototype iterations: version 2 (updated based on data gathered from initial

field testing) and version 3 (updated virtual reality application based on information collected in version 2). The first prototype iteration (version 1) was constructed with a focus on functionality. This first iteration was built by including a map of Esbjerg city right at the very beginning of the application. Users could navigate through the virtual reality environment by flying a helicopter that would later on bring them at Aalborg University Esbjerg. The design of all 3 versions is covered in detail in the **3. Design and Implementation** section.
The average duration for testing each of the prototype's iterations was approximated to twenty minutes, during which participants have navigated through the virtual environment and also participated in a questionnaire. The questionnaire used throughout experimental procedures focused on analysing the level of presence generated by the application. Derived from its original version created by Witmer and Singer (1998), the questionnaire measures the amount of presence that participants feel during test sessions, and its answer consists in ratings from one ("Not at all") to six ("Completely") regarding various aspects of the virtual reality environment (see **9. Appendix**).

4.3.3. Assessment of User-Experience (UX)

Along with presence analysis, researchers of this study have also focused on evaluating the level of user experience, which aimed to observe the overall quality of the user-prototype interaction across the two prototype iterations (version 2 and 3). In order to gather and analyse relevant data, researchers have used the User Experience Questionnaire (UEQ) which allowed for an immediate measurement of distinct quality aspects.

According to Schrepp, Hinderks and Thomaschewski (2011), the questionnaire was originally developed in 2005 "by a data analytical approach", and it consists of six UEQ scales which focus on: *attractiveness*, *perspicuity*, *efficiency*, *dependability*, *stimulation* and *novelty*. Overall, the questionnaire is designed to take into consideration aspects regarding both pragmatic and hedonic qualities that contribute in achieving a richer interpretation of the user-experience level (Schrepp et al., 2011). For a better visualization and understanding of scales, Schrepp (2018) outlines a schematic approach of the UEQ structure (Figure 14).

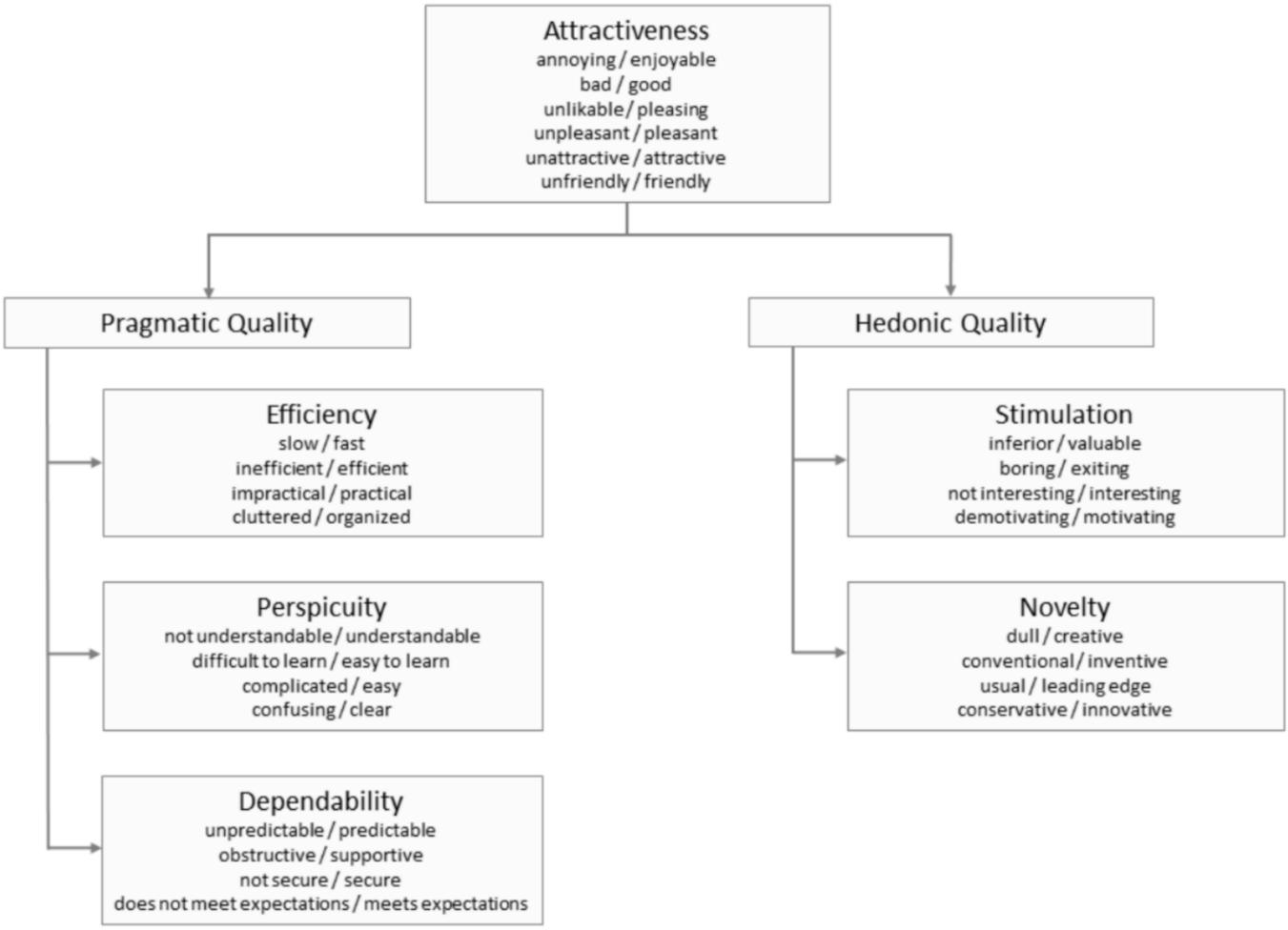


Fig. 14. Assumed scale structure of the UEQ (from Schrepp, 2018)

In line with Schrepp (2018), "attractiveness" is considered "a pure valence dimension", while the remaining five scales reflect on two other distinct dimensions categorized as pragmatic ("goal-oriented") and hedonic ("not goal-oriented") (p.2). As it can be observed, pragmatic qualities focus on aspects that analyse *efficiency* (performing task effortlessly), *perspicuity* (adjusting with the product) and *dependability* (having control over the interaction). On the other hand, *stimulation* and *novelty* are classified as hedonic qualities, designed to reflect upon how the product is perceived by its intended users (Schrepp, 2018).

The User Experience Questionnaire was developed as 7-point Likert Scale with items ranging from -3 (most negative answer) to +3 (most positive), 0 being considered as neutral point. The items are presented in randomized order and are grouped as pairs of terms of opposite meaning (e.g. "annoying/enjoyable", "cluttered/organized", "obstructive/supportive" etc.)

Within the context of this project, the User Experience Questionnaire was used by researchers to compare an established prototype (version 2) with an updated iteration (version 3) in order to determine which of the two provides a higher level of UX. Therefore, at the end of each testing session, all participants were asked to fill out the UEQ (can be found in section **9. Appendix**) and if possible, to provide additional feedback concerning either functionality or design matters.

The duration of each experimental session covered two consecutive days for the two experimental tests in Esbjerg and Copenhagen, each testing session lasting between ten to twenty minutes. In Esbjerg there were 12 participants on the first day and 12 participants on the second day, while for Copenhagen there were 12 participants on the first day and 9 on the second day. The tests in both Esbjerg and Copenhagen were conducted at two separate gymnasiums over the course of the two days. A third experimental test was conducted on internationals at AAUE which lasted a single day with 12 participants. A fourth test was conducted again in Esbjerg lasting two consecutive days, with 10 participants the first day and 8 on the second day with the test being conducted at two different gymnasiums.

4.3.4. UX Benchmarks

In line with Schrepp (2018), UX benchmarks are considered to analyse whether a product "fulfils the general expectations concerning user experience" (p.5). According to Schrepp (2008), the general interpretation of each of the six scales suggests that scores ranged between -0.8 and 0.8 represent "a neutral evaluation" (p.5), scores higher than 0.8 indicate "a positive evaluation" (p.5) and values less than -0.8 imply "a negative evaluation" (p.5).
In the context of this study, the UX level was measured individually for Persona I, Persona II and Persona III and compared to the UEQ benchmark which distributes a product to five categories per scale (Schrepp, 2018). These categories are:

- *"Excellent: In the range of the 10% best results.*
- *Good: 10% of the results in the benchmark data set are better and 75% of the results are worse.*
- *Above average: 25% of the results in the benchmark are better than the result for the evaluated product, 50% of the results are worse.*
- *Below average: 50% of the results in the benchmark are better than the result for the evaluated product, 25% of the results are worse*

- *Bad: In the range of the 25% worst results"* (Schrepp, 2018, p.6)

In the light of the above stated facts, three UX benchmarks have been constructed with the objective of studying how is PathVR perceived by the three different personas.

4.3.5. Participation in the study

Gold's (1958) *Typology of Participant Observer Roles* describes four particular types of observer roles that researchers should take into account when conducting studies. These roles are declared to range from "complete participant at one extreme to complete observer at the other" (p.217).

The *complete participant* acts as an insider and its identity and purpose "are not known to those whom he observes" (Gold, 1958, p. 219). His role grants full access to information regarding both experimental settings and participants who are under observation during a particular study. The *participant as observer* role argues that both researchers and informants are fully aware of the context that brought them together. In this situation, researchers act as observers who actively partake in the setting that is being analysed. The *observer-as-participant* role employs a minimal degree of implication in what concerns researchers and their position in the study. This role is applied in "studies involving one-visit interviews" where researchers reduce their analysis "only to formal observations" (Gold, 1958, p. 221). The *complete observer* role suppresses any type of researcher-informant interaction. In this context, users participating in this study are not aware that they are being studied, hence their role serves as informants for the ones conducting the analysis.

In this particular project, two out of four researchers partook in the direct assessment of the performance of the virtual reality application. One test moderator acted as a *complete observer* (not engaging with participants) but also as test facilitator (inform participants about testing procedure and indirectly observe their interaction through video recordings). The other researcher employed the role of *participant as observer*, active in the experimental setting, with the purpose of assuring that the user-prototype interaction is safely and constantly maintained and that all technological assets function properly.

4.3.6. Conducting Usability Tests

Researchers benefit from usability testing due to its self-explanatory objective of testing a product's usability level, as well as its implications in improving the design process that lays

behind its development (Dumas & Redish, 1999). Designing a proper usability test requires researchers to take into account a list of steps with thorough instructions regarding participants, equipment, tasks, test scenario and environment, measurement, and end-goal. By considering this pair of goals, researchers are assured to be in the process of conducting a usability test, and not a quality test. Moreover, multiple focus points have been selected to narrow down the variety of tasks towards which designers should pay particular attention. As observed by Dumas and Redish (1999), these tasks are directly settled by researcher for their users and reflect the level of difficulty with which they are performed. In addition to this, designers might also wish to analyse the occurring interactions between the prototype's graphical user interface (GUI) with both novice and experienced users.

With these aspects kept in mind, designers can better visualize the most appropriate user groups to test their product on. On this note, it is always important to consider that users participating in such testing procedures should represent the real end-user group of the product still under development. During usability testing, participants are asked to perform typical tasks while being observed by study researchers who often act as observers of the interaction and gather data in order to analyse the "participant's satisfaction with the product" (U.S. Department of Health & Human Services, 2019).

In this current study, usability testing sessions have been conducted with the three ambassadors of Aalborg University Esbjerg, due to them representing one of the intended future user groups of the interactive application. Hence, they are required technical knowledge of product operation. In addition to this, researchers have also showed significant interest in analysing whether or not the product fits the ambassador's requirements and preferences.

During usability tests, each ambassador was asked to put on the virtual reality head-mount and pretend to act as a prospective student of Aalborg University Esbjerg, while one of the test moderators played the role of a virtual reality guide who transported the "student" through different virtual locations. While taking turns in testing the product, ambassadors were told to think out-loud and explain any current concerns or potential functionality issued that came across. Once the usability experimental procedures have ended, participants were required to fill out the SUS questionnaire (developed by Brooke, 1996) and to provide any additional feedback with regards to the prototype. The SUS is developed as a Likert scale with answers ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"), SUS consists of ten different questions designed with a heavy focus of analysing various usability matters of the prototype.

These testing procedures have been settled to take place on university grounds (e.g. lecture room) and to last on average half an hour, during which ambassadors were also given a

technical introduction with respect to operating the virtual reality system. Participating in this study were also researchers who provided users with the necessary technical equipment (Dell VR head-mount and its corresponding controllers).

4.3.7. Conducting User-Centred Interviews

From the beginning stages of this project, a series of interviews were arranged with participants who were later considered to represent the three distinct end-user groups (or personas). The interviews were designed to gather as much qualitative input as possible, in order to develop a final product that would fulfil all user requirements reported by the three different user categories. In addition to this, the interviews have played an important role in establishing a much closer relation between designers and future end-users, allowing them to collect vital information that would later be transposed as main design guidelines for building a successful interactive tool.

The interviews took place in three separate locations, and participants were selected in accordance with the user category that they were part of: Copenhagen Next Sukkertoppen Gymnasium (students outside Esbjerg), Rybners Gymnasium (students from Esbjerg) and Aalborg University Esbjerg (internationals who have just started their study program). All interviews were conducted within the presence of a member of the study team and the future users of the product, and were organized with just one user at the time in order to avoid overlapping discussion between participants. Each interview session respected the following protocol: when entering the room, participants would be greeted and asked to have a sit, while they are being offered a short moderator speech describing the process they were about to undergo. The interview would afterwards begin once participants have been fully informed.

Three different interviews were designed with usage corresponding to their representative user category. Each interview would accommodate questions regarding users' current educational situations, educational preferences, different types of leisure activities and last, but not least, their experience with virtual reality (questions can be found in section **9. Appendix**). These interviews were later on transcribed and used as main persona creation material, in order to obtain an accurate profile of the users' needs and expectations from the product.

4.3.8. Field Testing - Open House (23rd February, 2019)

In the early stages of prototype development, the virtual reality application has been submitted to an initial field test which occurred during the Open House event organized by Aalborg University Esbjerg, and held on campus premises. Although a total of 20 participants interacted with the virtual reality application, of them data was only collected from 14 users, due to them representing actual prospective users of AAU. The virtual reality application developed within that particular time frame represented the first prototype iteration of PathVR. This version consisted of three main parts: the loading scene (feature which allows for a safe application load-up), the map of Esbjerg city (with its particular attractions) and some specialized scenes in which users are presented with the street view option of the virtual locations that they have visited.

During this field testing session, researchers have targeted presence and user-experience as main factors of analysis in the user's interaction with the virtual reality application. The testing protocol implemented within the experimental procedure involved a "Think-Aloud" approach, where participants were asked to orally describe their actions and express their opinions/concerns with regards to any functionality/design aspect of the application. Participating in this analysis were researchers of this study, pupils in their final year of gymnasium (prospective AAUE students) and other bystanders at the event (usually accompanying said pupils) as can be seen in Figure 15.

The testing procedure occurred as follow: firstly, participants were greeted and invited over to try out the application. Before being handed over the HMD, participants were asked for audio/video consent, as researchers wished to record the interaction for use in further analysis. Important to be mentioned is the researcher's limited level of implication during the actual interaction, as they were required not to intervene while participants are talking, unless a technical problem occurred. After they have completed the virtual reality tour, users were kindly asked to fill out two questionnaires, the Presence and User-Experience Questionnaire. Taking into consideration the participants' limited time, the short version of the UEQ was used (S-UEQ) which allowed for a quick and easy assessment of the user-experience level generated by the PathVR application.

Fig. 15. Field testing at AAU Open House

4.3.9. Field Testing - Flensburg Educational Fair (9th - 10th, May)

PathVR was designed as a tool for promoting Aalborg University Esbjerg and the city in general, in order to attract new prospective students. Therefore, collaborations were settled between both PR Department of AAUE (Aalborg University Esbjerg) and international ambassadors designated to promote the educational institutions at foreign educational fairs.

Aspects regarding the functionality of the prototype have been evaluated at an international fair located in Flensburg (Germany), where students coming from Germany and other countries come to observe career offerings from different institutions. The promotional tool was mainly operated by ambassadors of AAUE throughout the two days with assistance from two of the researchers on the first.

Considered an ideal occasion for achieving a better promotion, Aalborg University Esbjerg has prepared a special arrangement that consisted in dedicating the virtual reality system its own section (Figure 16), where students would try out the application and experience the university's facilities and attractions, as well as the city of Esbjerg. Participants were guided by the ambassadors throughout a multitude of virtual locations, while being offered detailed oral descriptions about what they were experiencing. At this test the users did not have time for any quantitative data gathering method so the researchers had to rely on observations of

how the users interacted with the system. Based on these notes the researches had begun working on version 4 of the application which would see to fix small issues with the product.

Fig. 16. Field Testing at International Fair (Flensburg)

5. Results

5.1. Experimental Procedure: Outline

The current study aims to observe how a virtual reality promotional tool can be created when adopting UCD as the main design methodology, and how one can measure the quality of the experiences it provides for the users. Therefore, two experimental procedures were conducted with one focusing on presence and another focusing on user-experience (UX). The two experimental procedures were applied across two iterations of PathVR (version 2 and 3).

As mentioned in section **4. Methods**, a total of 75 users participated in this study. They were attributed to three different groups, dedicated to represent the three different personas: persona I (consisting of 24 gymnasium students from Esbjerg), persona II (21 gymnasium students outside Esbjerg) and persona III (12 international students). Each persona (with exception being persona III) interacted with two consecutive versions of PathVR: version 2 (developed based on early prototype analysis) and version 3 (updated application based on data gathered in version 2). An initial prototype iteration (version 1) was originally constructed with focus mainly on functionality.

5.2. Presence Experiment (Version 2)

During this experimental procedure, the level of presence felt by the three distinct personas were studied from their interaction with PathVR (version 2). The focus of this analysis was to measure the quality of the VR application developed within a UCD to fulfil each persona's requirements and preferences.

5.2.1. Test for Normal Distributions

Before applying any statistical test, the collected data was first averaged for each individual persona. The scores for each question were summed up and divided by the number of questions (13).

Table 1. *Mean Persona I*

	Persona I	Std. div.
Q1	4.38	1.37
Q2	4.46	1.38
Q3	4.13	1.19
Q4	4.71	0.90
Q5	4.38	1.05
Q6	4.83	0.91
Q7	4.63	1.17
Q8	5.21	0.77
Q9	4.04	1.51
Q10	3.25	1.45
Q11	4.29	1.68
Q12	4.21	0.83
Q13	4.46	1.20
Avrg	4.382	

Table 2. *Mean Persona II*

	Persona II	Std. div.
Q1	4.52	1.25
Q2	4.24	1.13
Q3	3.86	1.01
Q4	4.86	0.91
Q5	4.14	1.27
Q6	4.38	0.86
Q7	4.76	0.76
Q8	5.10	0.83
Q9	4.14	1.37
Q10	4.19	1.43
Q11	4.86	1.15
Q12	4.19	0.92
Q13	4.57	1.45
Avrg	4.447	

Table 3. *Mean Persona III*

	Persona III	Std. div.
Q1	4.27	1.27
Q2	5.36	1.12
Q3	4.36	1.28
Q4	4.73	1.00
Q5	4.73	1.42
Q6	4.55	1.29
Q7	5.36	0.80
Q8	5.18	0.87
Q9	5	1.41
Q10	4.58	1.21
Q11	4.83	1.25
Q12	4.82	1.25
Q13	4.36	1.12
Avrg	4.779	

In order to observe whether the data was normally distributed, a Shapiro-Wilk test had been applied on each individual sets of data (Table 1, Table 2, Table 3). This test concluded that the data gathered from each persona is normally distributed, as it can be seen in the table 4 below.

Table 4 *Shapiro-Wilk Test for Normality*

Sharpiro-Wilk	Version 2	Statistic	df	Sig.
Mean	Persona I	0.969	24	0.640
	Persona II	0.988	21	0.995
	Persona III	0.912	12	0.228

Before performing the One-way ANOVA statistical analysis, one must also study the homogeneity of variance among the three different independent groups. Considered an assumption of ANOVA, the homogeneity of variance states that all comparison groups have similar population variances (Statistics Solutions, 2019). Within the context of this study, the Levene's test was used as the main assessment tool for analysing the homogeneity of variance.

When performing this test, one should obtain a *p-value* higher than .05 in order to avoid any violations of the above mentioned assumption.

Table 5. *Homogeneity of Variances for Personas*

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Mean	Based on Mean	1.065	2	54	0.352
	Based on Median	0.889	2	54	0.417
	Based on Median and with adjusted df	0.889	2	45.372	0.418
	Based on trimmed mean	1.024	2	54	0.366

As seen in Table 5, the Levene's test resulted in a similarity of variances for the mean of three different persona groups, with F (2,54) = 1.065 and p = 0.352.

5.2.2. One-way ANOVA Test

Due to the data being normally distributed, the statistical analysis was expanded by conducting a One-way ANOVA test, that when applied in the context of this study, aims to observe the effect of personas (as UCD methodology) on the level of presence generated by the VR application. More specifically the test analysed the differences between the levels of presence gathered from each persona. This is done by studying whether or not there is any statistically significant difference between the means of the data registered by the three personas. The One-way ANOVA test provides a null hypothesis (H0) - which assumes that there is no difference in the means of the groups, and an alternative hypothesis (H1) - which argues the presence of at least two group means that are assumed to be statistically significantly different from one another. Taking into consideration this study's objective, the following hypotheses have been formulated:

- H0 = Personas (as UCD methodology) do not impact the level of presence
- H1 = Personas (as UCD methodology) do impact the level of presence

Table 6. *One-way ANOVA Test on Means of Presence/Personas*

ANOVA

Mean

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.751	2	0.376	1.096	0.342
Within Groups	18.508	54	0.343		
Total	19.260	56			

The analysis suggests that the effect of personas (as UCD methodology) on the level of presence generated by the application was not statistically significant, F (2, 54) = 1.096, p = 0.342, hence the null hypothesis was not rejected (Table 6).

5.2.3 Independent measures t-test

This study expected a variation in the level of presence experienced by the three different user groups (personas). However, taking into account the statistical results obtained in the One-way ANOVA test, additional studies have been conducted, in order to analyse the differences in the level of presence among pairs of personas. Therefore, three independent t-tests were performed on the following pairs: Persona I vs Persona II (Table 7), Persona I vs Persona III (Table 9), and Persona II vs Persona III (Table 10). The independent t-test aims to compare the means between two unrelated groups, on the same independent variable (Laerd Statistics, 2019)

Table 7. *Independent t-test (Persona I vs Persona II)*

Group Statistics

Version 2		N	Mean	Std. Deviation	Std. Error Mean
Means	1	24	4.38141	0.629225	0.128440
	2	21	4.49451	0.472042	0.103008

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Means	Equal variances assumed	2.144	0.150	-0.674	43	0.504	-0.113095	0.167815	-0.451526	0.225336
	Equal variances not assumed			-0.687	42.082	0.496	-0.113095	0.164644	-0.445340	0.219150

When comparing the means between the two personas, the results showed no statistically significant difference in the scores regarding the level of presence rated by Persona I (M=4.38, SD=0.62) and Persona II (M=4.49, SD=0.47); t (43) = -0.67, $p = 0.504 > 0.05$.

Table 8. *Comparison between Persona I and Persona II*

	Persona I	Std. div.	Persona II	Std. div.	Difference
Q1	4,38	1,37	4,52	1,25	-0,14
Q2	4,46	1,38	4,24	1,13	0,22
Q3	4,13	1,19	3,86	1,01	0,27
Q4	4,71	0,90	4,86	0,91	-0,15
Q5	4,38	1,05	4,14	1,27	0,23
Q6	4,83	0,91	4,38	0,86	0,45
Q7	4,63	1,17	4,76	0,76	-0,14
Q8	5,21	0,77	5,10	0,83	0,11
Q9	4,04	1,51	4,14	1,37	-0,10
Q10	3,25	1,45	4,19	1,43	-0,94
Q11	4,29	1,68	4,86	1,15	-0,57
Q12	4,21	0,83	4,19	0,92	0,02
Q13	4,46	1,20	4,57	1,45	-0,11
Avrg	4,381923		4,446557		-0,06

Table 8. presents the two experimental conditions, for which each of the thirteen questions had its mean calculated and compared.

Observations based on the results registered in Q.6. ("*How compelling was your sense of moving around inside the virtual environment tour?*") showed that the Danish students from Esbjerg (Persona I) have scored higher than the students living outside the city (Persona II), even though both groups have interacted with the same VR application while navigating through the virtual environment. This may be due to the fact that users representing Persona I are already familiar with the city and its attractions whereas the others may have probably seen the city for the first time.

On an additional note, Q.10 ("*How much did the visual display quality interfere or distract you from performing the virtual tour?*") has also recorded a slight difference (0.94) between the means of the two personas: Persona I: 3.25, Persona II: 4.19. This difference argues that, during their interaction with PathVR (version 2), students from outside Esbjerg have been distracted by the visual quality of the application more than the others.

Table 9. *Independent t-test (Persona I vs Persona III)*

Group Statistics

Version 2		N	Mean	Std. Deviation	Std. Error Mean
Means	1	24	4.38141	0.629225	0.128440
	3	12	4.69231	0.670600	0.193585

Independent Samples Test

		Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Interval of the Lower	Interval of the Upper
Means	Equal variances assumed	0.005	0.943	-1.368	34	0.180	-0.310897	0.227300	-0.772827	0.151033
	Equal variances not assumed			-1.338	20.881	0.195	-0.310897	0.232319	-0.794199	0.172405

The results obtained within this analysis show that there is no statistically significant difference in the scores for Persona I (M=4.38, SD=0.62) and Persona III (M=4.69, SD=0.67); t (34) = -1,36, $p = 0.18 > 0.05$.

Table 10. *Independent t-test (Persona II vs Persona III)*

Group Statistics

Version 2		N	Mean	Std. Deviation	Std. Error Mean
Means	2	21	4.49451	0.472042	0.103008
	3	12	4.69231	0.670600	0.193585

Independent Samples Test

		Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Interval of the Lower	Interval of the Upper
Means	Equal variances assumed	1.154	0.291	-0.992	31	0.329	-0.197802	0.199303	-0.604283	0.208679
	Equal variances not assumed			-0.902	17.346	0.379	-0.197802	0.219285	-0.659751	0.264147

Lastly, the final t-test showed no statistically significant difference in the scores recorded for Persona II (M= 4.49, SD=0.47) and Persona III (M=4.69, SD=0.67), with regard to the level of presence felt by the users belonging to their respective persona; t (31) = -0.99.

When analysing the means of each individual question, a difference in the average of the scores collected from Q10 ("*How much did the visual quality interfere or distract*" participants from performing the virtual tour) and Q2 ("*How responsive was the virtual environment to activities*" initiated by participants) was noticed between Persona III vs Persona I, respectively Persona III vs Persona II.

Table 11. *Persona III compared to Persona I and Persona II*

	Persona III	Persona I	Difference	Persona III	Persona II	Difference
Q1	4,27	4,38	-0,11	4,27	4,52	-0,25
Q2	5,36	4,46	0,90	5,36	4,24	1,12
Q3	4,36	4,13	0,24	4,36	3,86	0,50
Q4	4,73	4,71	0,02	4,73	4,86	-0,13
Q5	4,73	4,38	0,36	4,73	4,14	0,59
Q6	4,55	4,83	-0,28	4,55	4,38	0,17
Q7	5,36	4,63	0,74	5,36	4,76	0,60
Q8	5,18	5,21	-0,03	5,18	5,10	0,08
Q9	5	4,04	0,96	5	4,14	0,86
Q10	4,58	3,25	1,33	4,58	4,19	0,39
Q11	4,83	4,29	0,54	4,83	4,86	-0,03
Q12	4,82	4,21	0,61	4,82	4,19	0,63
Q13	4,36	4,46	-0,10	4,36	4,57	-0,21
Avrg	4,779231	4,381923	0,40	4,779231	4,446557	0,33

From the above Table 11, it can be seen that during their interaction with PathVR, international students (Persona III) seem to have been distracted by the application's visual quality more than the gymnasium students from Esbjerg (Persona I) with the difference between means being 1.33. Despite this, internationals have considered the VR application to be more responsive to their actions than what gymnasium students living outside this city (Persona II) believed, with the difference between means being 1.12.

In addition to this, it can also be observed that the users coming from abroad felt slightly less in control of the virtual events than the students who either live in Esbjerg or outside the city. This is reflected within the differences in means obtained from Q1. "*How much were you able to control events?*" between Persona III (M=4,27) - Persona I (M=4.38) and Persona III (M=4,27) and Persona II (M=4,52).

5.3. UX Experiment (Version 2)

Together with presence analysis, this study has evaluated the UX level generated by the different user interactions with the two design iterations (version 2 and 3) of PathVR.

In order to perform an immediate assessment of the distinct UX quality aspects, the UEQ was used as the main analysis tool (more details are presented in section **4. Methods**). Important to be mentioned from the very beginning is that although UEQ consists of six different scales, only five have been taken into consideration within the context of this analysis. The one excluded scale reflects one pragmatic UX quality ("Dependability") whose objective is to observe whether or not users feel in control of the interaction. This aspect was thoroughly analysed in the previous experimental procedure through the presence questionnaire which analyses aspects regarding user control (see **5.2.1 Assessment of Presence (Version 2)**). The overall focus of this analysis was to study how would a UCD approach impact the level of user experience, in a virtual reality environment.

5.3.1. Test for Normal Distributions

Before conducting any statistical analysis, the data was first averaged for each individual persona (*PI, PII, PIII*): the scores for all the answers were summed up and divided by the number of questions (22) (Table 12, Table 13, Table 14). In addition to this, the mean of each scale is also calculated and divided for each persona, in order to better distinguish the differences among the five UX qualities.

Table 12. *UX Mean PI*

	Persona I	Std. div.
Q1	5.83	0.816
Q2	6.38	0.875
Q3	5.25	1.032
Q4	6.38	0.875
Q5	5.17	1.404
Q6	5.42	1.100
Q7	5.54	1.103
Q8	5.50	0.978
Q9	4.96	1.334
Q10	6.17	0.816
Q11	5.38	1.715
Q12	5.67	0.868
Q13	4.38	1.498
Q14	5.63	0.824
Q15	5.63	1.096
Q16	5.25	1.294
Q17	6.08	1.018
Q18	5.79	1.021
Q19	5.54	1.414
Q20	5.46	1.141
Q21	6.29	0.806
Q22	4.83	1.880
Avrg	5.35	

Table 13. *UX Mean PII*

	Persona II	Std. div.
Q1	5.76	0.790
Q2	5.71	1.189
Q3	5.57	1.200
Q4	6.33	1.065
Q5	5.33	1.197
Q6	5.48	1.209
Q7	6.10	0.768
Q8	5.10	1.091
Q9	5.29	1.419
Q10	6.19	0.928
Q11	6.05	0.973
Q12	5.52	0.873
Q13	4.71	1.102
Q14	5.57	1.028
Q15	5.38	1.117
Q16	5.14	1.108
Q17	5.52	1.289
Q18	5.38	1.203
Q19	5.90	0.831
Q20	5.48	1.167
Q21	6.38	0.865
Q22	5.52	1.250
Avrg	5.36	

Table 14. *UX Me*

	Persona III	Std. div.
Q1	6.42	0.793
Q2	6.25	0.866
Q3	5.83	1.749
Q4	6.00	1.414
Q5	5.75	1.765
Q6	5.92	1.505
Q7	6.67	0.492
Q8	5.33	1.371
Q9	5.92	1.165
Q10	6.67	0.492
Q11	5.33	1.557
Q12	6.33	0.651
Q13	5.25	0.965
Q14	6.33	0.651
Q15	6.33	0.492
Q16	6.25	0.866
Q17	6.17	0.937
Q18	6.25	0.754
Q19	6.42	0.669
Q20	6.42	0.669
Q21	6.50	0.674
Q22	6.17	0.937
Avrg	5.83	

Table 15. *UX Mean for Individual Persona/Scale*

Category	Persona I	Persona II	Persona III
Attractiveness	5.736	5.696	6.395
Perspicuity	5.543	5.670	5.938
Efficiency	5.263	5.463	6.063
Stimulation	5.688	5.356	6.168
Novelty	5.531	5.821	5.793

A Shapiro-Wilk test was conducted on each individual set of data (recorded by the three personas) in order to check for normal distribution across scores (Table 15). This test concluded that the data gathered from each persona is normally distributed, and results are presented in the Table 16 below.

Table 16. *Shapiro-Wilk Test for Normality*

Sharpiro-Wilk	UEQ	Statistic	df	Sig.
	Persona I	0.965	24	0.540
	Persona II	0.950	21	0.345
	Persona III	0.941	12	0.509

5.3.2. One-way ANOVA Test

Before conducting the parametric test, the homogeneity of variance was also analysed by performing a Levene's test among the data collected by Persona I, II and III. As described in previous report sections, this statistical procedure assumes that all comparison groups have similar population variances (Statistics Solutions, 2019). In order to avoid any violations of assumption, the *p-value* should be higher than .05. As can be seen in Table 17 below, the Levene's test satisfied the assumption of homogeneity of variances, with F (2,54) = 0.50 and *p* = 0.60.

Table 17. *Homogeneity of Variances for Personas*

		Levene Statistic	df1	df2	Sig.
Mean	Based on Mean	0.509	2	54	0.604
	Based on	0.435	2	54	0.649
	Based on Median and	0.435	2	47.171	0.650
	Based on trimmed mean	0.467	2	54	0.630

Due to the data being normally distributed and the homogeneity of variance not being violated, the same statistical procedure was applied (One-way ANOVA test) which, within the context of this analysis, aims to evaluate if there is any statistically significant difference between the UX means of each individual persona. As described in the previous analysis, the One-way ANOVA test checks if the null hypothesis (H0) is rejected and if it is, provides an alternative (H1). In accordance with the aim of this study, the following hypothesis have been formulated:

- H0 = Personas (as UCD methodology) do not impact the level of UX
- H1 = Personas (as UCD methodology) do impact the level of UX

Table 18. *One-way ANOVA Test on Means of UX/Personas*

ANOVA

Mean

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.182	2	1.091	3.963	0.025
Within Groups	14.867	54	0.275		
Total	17.050	56			

The One-way ANOVA analysis concluded in a significant effect of personas (as UCD methodology) on the level UX, analysed for the three distinctive user categories, F (2, 54) = 3.96, p = 0.025. Thus, the null hypothesis was rejected (Table 18).

As earlier observations (One-way ANOVA) show an overall significant difference between the three different groups (personas), the test does not specify which exact groups differ, whereas a post hoc tests does. Therefore, in order to see between which personas there is a significant difference, the Hochbergs GT2 Test was used, due to the similarity of variances resulted from Table 17. *Homogeneity of Variances for Personas* and the difference between sample sizes: Persona I (24 participants), Persona II (21 participants) and Persona III (12 participants). In the light of above mentioned criteria, the following Table 19 will outline the results obtained from performing the Hochbergs GT2 test.

Table 19. *Hochbergs GT2 Test for significant difference across comparisons*

Multiple Comparisons

Dependent Variable:

	(I) Version 2	(J) Version 2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Hochberg	1	2	-0.01082	0.15679	1.000	-0.3967	0.3750
		3	-.48485*	0.18551	0.034	-0.9414	-0.0283
	2	1	0.01082	0.15679	1.000	-0.3750	0.3967
		3	-.47403*	0.18988	0.046	-0.9413	-0.0067
	3	1	.48485*	0.18551	0.034	0.0283	0.9414
		2	.47403*	0.18988	0.046	0.0067	0.9413

*. The mean difference is significant at the 0.05 level.

The Hochbergs GT2 Test aims to determine which of the three persona "means differ from one another in an analysis of variance" (Cramer & Howitt, 2004). Within the context of

this study, the Hochbergs GT2 test performs multiple comparisons between the different pairs of personas in order to find the most statistically significant difference. Therefore, the following sets of comparisons have been constructed: [Persona I & Persona II; Persona I & Persona III], [Persona II & Persona I; Persona II & Persona III], and [Persona III & Persona I; Persona III & Persona II].

By taking a look at the results obtained within the very first set, one can observe the lack of statistically significant difference between Persona I and Persona II, with $p = 1.000$. This absence of significance is also observed within the averages calculated per question (for each individual persona) and subsequently, within the averages calculated per UX category (again, for each one of them). These observations can be found in Table 20 below. Despite the lack of any statistically significant difference between the means of Persona I and Persona II ($p > 0.05$), two scores were found to be worth discussing. The data gathered within scale 2 which goes from *not understandable* to *understandable* (see section **C** in **9. Appendix**) reflects the *perspicuity* quality of UX. It has been noticed that students who live in Esbjerg have rated the pragmatic quality slightly higher than the gymnasium students living outside the city, by a difference of 0.66. When comparing the means of scores that analyse the *efficiency* quality of UX which goes from *impractical* to *practical*, results show a slightly higher rating originating from Persona II, by a difference of 0.69. Moreover, Table 21. *Persona I vs Persona II (Avrg/UX Category)* indicates little difference between the means of the five distinct UX qualities, calculated for the individual personas.

Table 20 *Persona I vs Persona II (Avrg/Question)*

	Persona I	Persona II	Difference
Q1	5.830	5.760	0.070
Q2	6.375	5.710	0.665
Q3	5.250	5.570	-0.320
Q4	6.380	6.330	0.050
Q5	5.170	5.330	-0.160
Q6	5.417	5.476	-0.060
Q7	5.540	6.100	-0.560
Q8	5.500	5.100	0.400
Q9	4.960	5.290	-0.330
Q10	6.170	6.190	-0.020
Q11	5.380	6.050	-0.670
Q12	5.667	5.520	0.147
Q13	4.380	4.710	-0.330
Q14	5.625	5.571	0.054
Q15	5.630	5.380	0.250
Q16	5.250	5.143	0.107
Q17	6.080	5.520	0.560
Q18	5.792	5.380	0.412
Q19	5.540	5.900	-0.360
Q20	5.460	5.480	-0.020
Q21	6.290	6.380	-0.090
Q22	4.833	5.524	-0.690
Avrg	5.349	5.359	-0.041

Table 21. *Persona I vs Persona II (Avrg/UX Category)*

Category	Persona I	Persona II	Difference
Attractiveness	5.736	5.696	0.040
Perspicuity	5.543	5.670	−0.127
Efficiency	5.263	5.463	−0.199
Stimulation	5.688	5.356	0.332
Novelty	5.531	5.821	−0.290

Considering that the reported results from both presence and UX analysis did not present any statistical differences between Persona I and Persona II, a merging of the two user categories has been performed, which resulted in a new persona with combined expectations. The new Persona I is now a representative of Danish gymnasium students who live both inside and outside Esbjerg city, and its requirements illustrate the mixture of the two initial sets of demands.

Therefore, the updated Persona I requires the virtual reality application to cover the following expectations: activities, facilities, city, transportation and accommodation. The updated Persona I will be referred from this point forward as Revised Persona I to avoid confusion. The Revised Persona I will only be taken into consideration when performing statistical analysis on version 3 of PathVR.

The comparison between means of Persona I & Persona III showed a statistically significant difference, with p = 0.034 (very close to the threshold = 0.05). The most visible scores that sustain the significant difference are recorded within scale 7, 16 and 22 (see section **C** in **9. Appendix**). The UX qualities represented by the different scales are, in order, *stimulation*, *efficiency* and *novelty*.

When comparing the means of the scores that study *stimulation* as a quality of UX, Table 22. *Persona I vs Persona III (Avrg/Question)* shows that international students have considered the VR application to be more *interesting* (M=6.670) and *more efficient* (M=6.250) than what Danish students from Esbjerg believed (M=5.540, respectively, M=5.250), by differences of 1.130, and 1.000 respectively. *Novelty*, considered a hedonic quality of UX (Schrepp, 2018) has also seen a substantial difference in ratings. According to Table 22. which compares the means of each question for each persona, international students believed the VR application to be more *innovative* (M=6.170), in contrast with the gymnasium students from Esbjerg (M=4.833); with difference in means equal to 1.337.

Table 22. *Persona I vs Persona III (Avrg/Question)*

	Persona I	Persona III	Difference
Q1	5.830	6.420	-0.590
Q2	6.375	6.250	0.125
Q3	5.250	5.830	-0.580
Q4	6.380	6.000	0.380
Q5	5.170	5.750	-0.580
Q6	5.417	5.920	-0.503
Q7	5.540	6.670	-1.130
Q8	5.500	5.330	0.170
Q9	4.960	5.920	-0.960
Q10	6.170	6.670	-0.500
Q11	5.380	5.330	0.050
Q12	5.667	6.330	-0.663
Q13	4.380	5.250	-0.870
Q14	5.625	6.330	-0.705
Q15	5.630	6.330	-0.700
Q16	5.250	6.250	-1.000
Q17	6.080	6.170	-0.090
Q18	5.792	6.250	-0.458
Q19	5.540	6.420	-0.880
Q20	5.460	6.420	-0.960
Q21	6.290	6.500	-0.210
Q22	4.833	6.170	-1.337
Avrg	5.349	5.834	-0.545

Table 23. *Persona I vs Persona III (Avrg/UX Category)*

Category	Persona I	Persona III	Difference
Attractiveness	5.736	6.395	−0.658
Perspicuity	5.543	5.938	−0.395
Efficiency	5.263	6.063	−0.800
Stimulation	5.688	6.168	−0.480
Novelty	5.531	5.793	−0.262

The comparison between means of Persona II and Persona III has resulted in a *p-value* = 0.046 (extremely close to the threshold = 0.05), which concluded that there is a statistically significant difference between the two personas. The most visible scores that sustain the significant difference are recorded within scale 15, 16 and 20 (see section **C** in **9. Appendix**). The UX qualities represented by the different scales are, *stimulation*, *efficiency* and *attractiveness* respectively.

When comparing the means of the scores that study *stimulation* as quality of UX, Table 22. *Persona I vs Persona III (Avrg/Question)* shows that international students have considered the VR application to be more *motivating* (M=6.330) and more *efficient* (M=6.250) than what Danish students from outside Esbjerg believed (M=5.380, respectively, M=5.1430), with a

score difference of 0.95, and 1.107. *Attractiveness* has also differed in level: international students believed the VR application to be more *attractive* (M=6.170), in contrast with what gymnasium students living outside the city considered (M=5.524); with a difference in means of 0.64.

Table 24. *Persona II vs Persona III (Avrg/Question)*

	Persona II	Persona III	Difference
Q1	5.760	6.420	-0.660
Q2	5.710	6.250	-0.540
Q3	5.570	5.830	-0.260
Q4	6.330	6.000	0.330
Q5	5.330	5.750	-0.420
Q6	5.476	5.920	-0.444
Q7	6.100	6.670	-0.570
Q8	5.100	5.330	-0.230
Q9	5.290	5.920	-0.630
Q10	6.190	6.670	-0.480
Q11	6.050	5.330	0.720
Q12	5.520	6.330	-0.810
Q13	4.710	5.250	-0.540
Q14	5.571	6.330	-0.759
Q15	5.380	6.330	-0.950
Q16	5.143	6.250	-1.107
Q17	5.520	6.170	-0.650
Q18	5.380	6.250	-0.870
Q19	5.900	6.420	-0.520
Q20	5.480	6.420	-0.940
Q21	6.380	6.500	-0.120
Q22	5.524	6.170	-0.646
Avrg	5.359	5.834	-0.504

Table 25. *Persona II vs Persona III (Avrg/UX Category)*

Category	Persona II	Persona III	Difference
Attractiveness	5.696	6.395	−0.699
Perspicuity	5.670	5.938	−0.268
Efficiency	5.463	6.063	−0.600
Stimulation	5.356	6.168	−0.812
Novelty	5.821	5.793	0.028

5.4. UX Benchmarks for PathVR (version 2)

5.4.1. UX Persona I

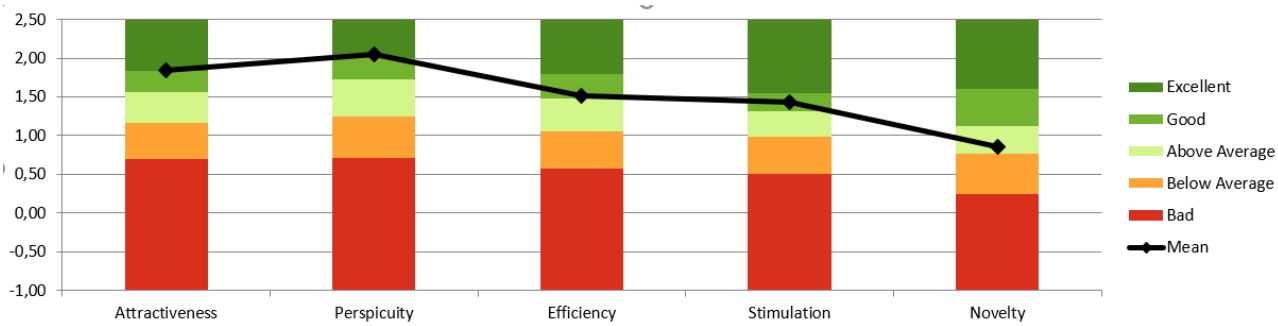


Fig 17. *UX Benchmark Persona I*

Figure 17 describes how the five UX qualities were perceived by Danish gymnasium students who inhabit Esbjerg city. As one can observe, the highest place in the ranks is occupied by *perspicuity* and *attractiveness* which analyse how understandable/easy to learn yet unpleasant/pleasant the VR application is for its intended users. Therefore, *perspicuity* (2.05) and *attractiveness* (1.84) has been considered to place PathVR just at the border between "Good" and "Excellent". In addition to this, the VR application has also provided a "Good" *stimulation* (1.44) and an "Above Average" *efficiency* (1.52). Located at opposite poles is *novelty* (0.85) whose ranking suggests that, in terms of innovation and creativity, PathVR is situated "Above Average".

5.4.2. UX Persona II

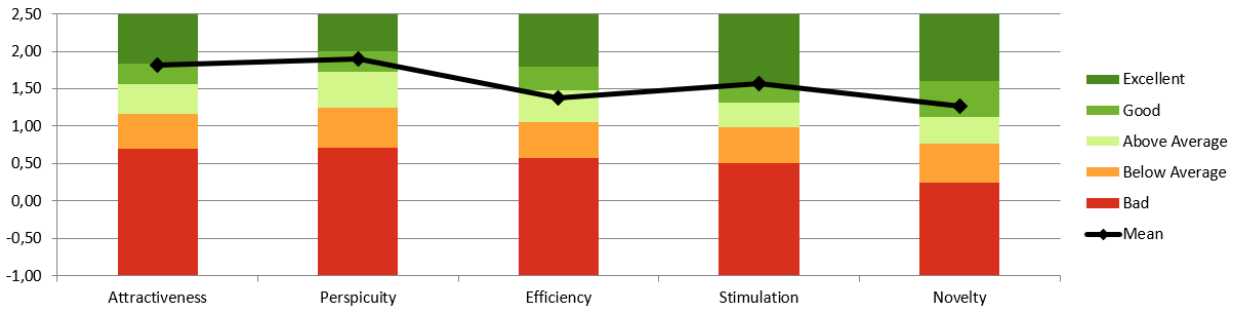


Fig.18. *UX Benchmark Persona II*

As it can be observed in Figure 18 the highest score is registered by *perspicuity* (1.90), followed by *attractiveness* (1.82) and *stimulation* (1.57). Considered one of the two hedonic qualities of UX, *stimulation* argues that users representing Persona II have found their interaction with

PathVR very exciting and motivating, therefore placing it within the "Excellent" category. *Novelty* (1.27) and *efficiency* (1.38), on the other hand, set the VR application within the "Good" - "Above Average" categories.

5.4.3. UX Persona III

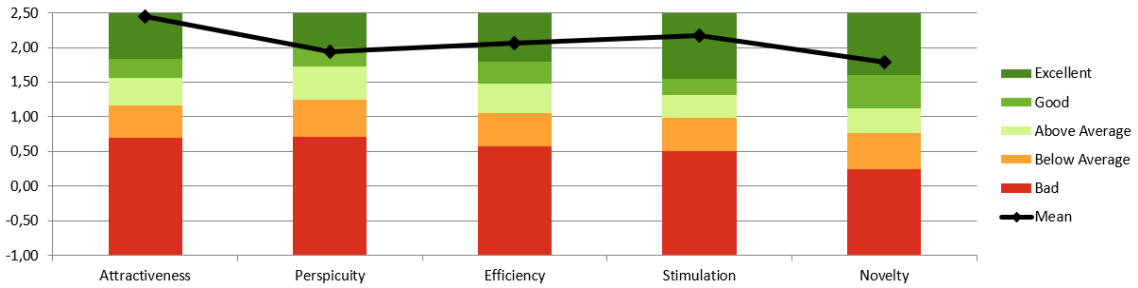


Fig. 19. UX Benchmark Persona III

The analysis presented in Figure 19, shows that every one of the five UX qualities has placed PathVR within the "Excellent" UX benchmark: *attractiveness* occupies the highest score position (2.44), being followed by *stimulation* (2.17) and *efficiency* (2.06). Slightly different from others are *novelty* (1.79) and *perspicuity* (1.94), which have also considered PathVR to belong within the "Excellent" category.

5.5. Presence Experiment (Version 3)

The main purpose of conducting a secondary experimental procedure was to analyse whether or not there is a significant difference between the level of presence generated by PathVR (version 2) in comparison with the updated VR application (PathVR, version 3). The participants involved in this statistical analysis were represented by the Revised Persona I, whose design was the result of merging the original Persona I and Persona II together (as previously described in section **5.3.2. One-way ANOVA Test**). Thus, the Revised Persona I is the representative for Danish gymnasium students living both inside/outside Esbjerg.

5.5.1. Test for Normal Distributions

Before conducting any statistical analysis, the data collected throughout testing procedures was first averaged for each version of PathVR. The scores for each question were added together and afterwards divided by the number of questions (13).

Table 26. *Presence Mean (Version 2)*

	Version 2	Std. div.
Q1	4.440	1.307
Q2	4.360	1.264
Q3	4.000	1.108
Q4	4.780	0.902
Q5	4.270	1.156
Q6	4.620	0.912
Q7	4.690	0.996
Q8	5.160	0.796
Q9	4.380	1.482
Q10	3.690	1.505
Q11	4.560	1.470
Q12	4.200	0.869
Q13	4.510	1.218
Avrg	4.435	

Table 27. *Presence Mean (Version 3)*

	Version 3	Std. div.
Q1	4.390	1.335
Q2	4.170	1.098
Q3	4.390	1.145
Q4	4.500	1.505
Q5	4.060	1.392
Q6	4.330	1.188
Q7	5.110	1.079
Q8	5.280	0.826
Q9	3.940	1.862
Q10	3.500	1.295
Q11	4.170	1.383
Q12	4.610	0.979
Q13	4.220	1.114
Avrg	4.359	

The analysis of checking for normal distribution was performed through the Shapiro-Wilk test, which resulted in data being normally distributed, across each of the two iterative versions of PathVR (as presented in Table 28. below).

Table 28. *Shapiro-Wilk Test for Normality*

		Shapiro-Wilk		
Version 3		Statistic	df	Sig.
Means	2	0.980	45	0.640
	3	0.950	18	0.418

5.5.2. Independent measures t-test

In order to assess the differences in the level of presence felt by participants when interacting with each of the two PathVR versions, the independent measures t-test was put into practice and its design was adapted to fit the purpose of this analysis.

For previous t-tests, the independent variable was represented by the single version of the VR application and the independent measures consisted in the three distinct personas. In the context of this current analysis, the independent variable is represented by the Revised Persona I, and the two independent measurements consist of PathVR (version 2), and PathVR (version 3) respectively.

Table 29. *Independent t-test for Presence (version 2 vs version 3)*

Group Statistics

Version 3		N	Mean	Std. Deviation	Std. Error Mean
Means	2	45	4.43419	0.558122	0.083200
	3	18	4.35897	0.582253	0.137238

Independent Samples Test

		Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Difference Lower	Difference Upper
Means	Equal variances assumed	0.018	0.895	0.477	61	0.635	0.075214	0.157557	-0.239841	0.390269
	Equal variances not assumed			0.469	30.215	0.643	0.075214	0.160489	-0.252450	0.402877

When comparing the means between version 2 (M=4.43, SD=0.55) and version 3(M=4.35, SD=0.58) of the VR application, results show no statistically significant difference in how presence was ranked by the Revised Persona I; t (61) = 0.47, $p = 0.635 > 0.05$.

Table 30. Comparison between Version 2 and Version 3

	Version 2	Std. div.	Version 3	Std. div.	Difference
Q1	4.440	1.307	4.390	1.335	0.050
Q2	4.360	1.264	4.170	1.098	0.190
Q3	4.000	1.108	4.390	1.145	-0.390
Q4	4.780	0.902	4.500	1.505	0.280
Q5	4.270	1.156	4.060	1.392	0.210
Q6	4.620	0.912	4.330	1.188	0.290
Q7	4.690	0.996	5.110	1.079	-0.420
Q8	5.160	0.796	5.280	0.826	-0.120
Q9	4.380	1.482	3.940	1.862	0.440
Q10	3.690	1.505	3.500	1.295	0.190
Q11	4.560	1.470	4.170	1.383	0.390
Q12	4.200	0.869	4.610	0.979	-0.410
Q13	4.510	1.218	4.220	1.114	0.290
Avrg	4.435		4.359		0.076

5.6. UX Experiment (Version 3)

Along with the presence evaluation performed in previous experimental stages, this study has also focused on analysing whether or not the UX level displays any significant differences between how the Revised Persona I is perceiving the interaction with PathVR (version 2), in comparison to PathVR (version 3).

5.6.1. Test for Normal Distributions

The statistical analysis has first begun by collecting the scores of each participant for each of the questions. The scores of each question were summed up and divided by the total number of questions (22). The next statistical procedure consisted in the evaluation of normal distribution among data by conducting a Shapiro-Wilk test. The resulting data (Table X below) has proved to be normally distributed for each PathVR (version 2) and PathVR (version 3).

Table 31. *Shapiro-Wilk Test for Normality*

Tests of Normality

		Shapiro-Wilk		
Version 3		Statistic	df	Sig.
Mean	2	0.978	45	0.557
	3	0.926	18	0.163

5.6.2. Independent measures t-test

This experimental test has particularly focused on identifying how different the level of user experience is, when the Revised Persona I interacts with the two virtual reality app iterations. The analysis tool used to perform this statistical procedure is represented by the independent measures t-tests whose design resembles the one described in section **5.5.2. Independent measures t-test**, with exception being the purpose of analysis.

Table 32. *Independent t-test for UX (version 2 vs version 3)*

Group Statistics

Version 3		N	Mean	Std. Deviation	Std. Error Mean
Mean	2	45	5.3535	0.48888	0.07288
	3	18	5.4495	0.66839	0.15754

Independent Samples Test

		Equality of Variances		t-test for Equality of Means						
									Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Mean	Equal variances assumed	1.211	0.275	-0.631	61	0.530	-0.09596	0.15196	-0.39982	0.20790
	Equal variances not assumed			-0.553	24.619	0.585	-0.09596	0.17358	-0.45374	0.26182

The comparison between the two individual means obtained for PathVR (version 2) and the updated VR application (version 3), (M=5.35, SD=0.48; M=5.44, SD=0.66). Results show no statistically significant difference in how the level of UX was perceived by the Revised Persona I when interacting with the application.

5.7. Additional Evaluations

Along with the two experimental procedures presented above, additional evaluations were performed with focus on gathering data regarding level of usability and user-experience of PathVR. One of the evaluations consisted in assessing the level of usability for PathVR and the other focused on analysing the level of both usability and user-experience for the first VR prototype iteration.

5.7.1. Usability Test Scores

5.7.1.1. Ambassadors' ratings on SUS

As previously mentioned in this study, two usability tests sessions were conducted with the three ambassadors of Aalborg University Esbjerg, due to them being the stakeholders of this study. Considering that PathVR has been iterated twice throughout its development cycle, the SUS was used in order to assess the application's level of usability, for each of the two versions.

The SUS consisted of ten questions, with answers ranking between 0 (low usability) and 100 (high usability). Each question was ranked between 0 and 4, depending on what participants thought in regards to the system's performance. The final SUS score for every participant was obtained by summing the rank of each question and multiplying it with 2.5. Questions of the SUS can be found in section **9. Appendix.**

Table 33. *System Usability Test Scores (version 1)*

System Usability Scale	Participant 1	Participant 2	Participant 3
Q. 1	3	3	4
Q. 2	4	3	4
Q. 3	3	3	4
Q. 4	4	4	2
Q. 5	4	3	3
Q. 6	4	3	4
Q. 7	4	3	3
Q. 8	4	4	4
Q. 9	3	4	4
Q. 10	3	2	4
Summed Score	36	32	36
Final Score	90	75	90

From what can be observed in the table above (Table X), the final SUS scores differ from one ambassador to another, with the total average being 85 (indicating that the system was found very usable). Despite the positive responses, it could be argued that the scores could change (might improve) if the application was to be tested with a bigger sample of participants.

When asked for additional feedback, the three ambassadors stated that the application functioned well, its content is consistent and the quality was considered to have been improved. Moreover, participants expressed concerns in regards to operating the controllers within the

virtual environment. They stated that they needed time in order to get a proper hold of their functionality and adjust to this particular type of interaction. Furthermore, ambassadors mentioned the smoothness of the content being displayed, as well as the application's design which allowed them to feel more in control of the interaction. In addition to this, ambassadors have also provided designers with ideas for possible features that could be implemented within the virtual environment: one big map containing only the university, shortcuts to different locations, as well as a better integration and increased visibility of the buttons.

Table 34 *System Usability Scale Scores (version 2)*

System Usability Scale	Participant 1	Participant 2	Participant 3
Q. 1	3	4	3
Q. 2	4	2	4
Q. 3	3	3	3
Q. 4	4	2	4
Q. 5	3	3	4
Q. 6	2	3	4
Q. 7	3	3	3
Q. 8	4	2	3
Q. 9	3	2	4
Q. 10	4	4	4
Summed Score	33	28	36
Final Score	82.5	70	90

The second iteration of the application (version 2) brought changes within the usability level which this time around, ranked lower scores in comparison to the previous analysis. While version 1 achieved an average of 85 points, version 2 scored an average of 80.83. This difference is observed within the answers provided at "Q. 8. I found the system very cumbersome (difficult) to use" and "Q. 10. I need to learn a lot of things before I could get going with this system.".

In contrast to what has been observed while testing version 1, ambassadors seem to have encountered more difficulties in learning how to operate this prototype iteration, even though they found the system less difficult to use.

5.7.2. Field Testing ("AAU Open House")

5.7.2.1. SUS and "Think-Aloud"

The application's level of usability was first analysed within a field test conducted at the Aalborg University Esbjerg, during the "Open House Event". Participating in this session were researchers of this study, along with prospective AAU students who visited the facility together with family and friends.

The testing procedure involved users interacting with prototype version 1, for which participants were asked to assess usability matters, as well as their overall user experience generated by the application's current design. The analysis tools used consisted of a SUS questionnaire (both in Danish and English) and a UEQ (short version). The following results will mainly focus on the usability scores, as results from the UEQ will be presented later in the analysis.

Table 35 *SUS Scores*

SUS Score	Score	Max
	57.5	100
	50	100
	67.5	100
	75	100
	67.5	100
	87.5	100
	85	100
	62.5	100
	65	100
	97.5	100
	72.5	100
	87.5	100
	72.5	100
	95	100
	81.4	100

The lowest score in the table presented above (Table 35), shows that the lowest score registered within the field-testing results was 50 with the highest being 97.5. The average for the overall usability score was 81.4. Despite achieving a total score of 81.4 out of 100, the SUS results obtained during field testing seemed to indicate that participants had a very positive experience when interacting with the VR application, for the first time

5.7.2.2. Early UX observations

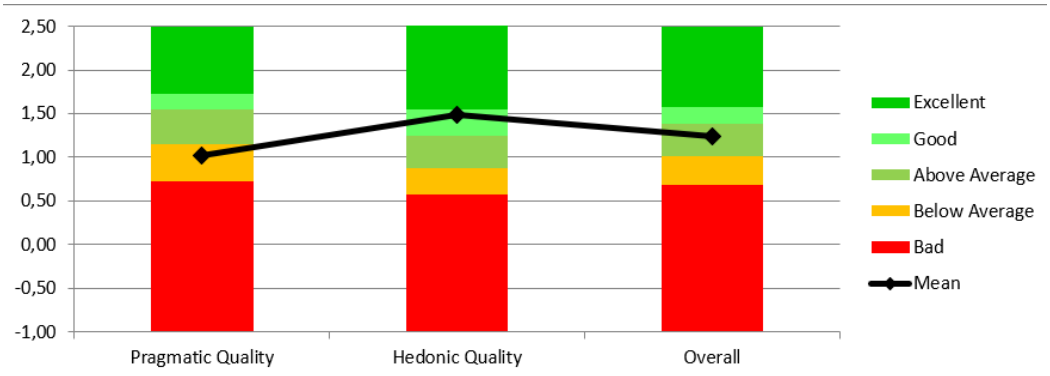
In addition to analysing the system's level of usability, users participating throughout the field testing procedure were also asked to rate their level of user experience, generated by their interaction with initial version of PathVR. This analysis is based on answers recorded by a total of 14 participants, and is furthermore compared to the UX benchmark (Fig 20) provided by Schrepp (2018). The analysis tool used in order to collect data regarding the different qualities of UX is the User Experience Questionnaire Scale (for short, the UEQ Scale) which has been described in detail within section **4.3.3. Assessment of User Experience**.

The Short-UEQ analyses only eight UX qualities from a total of twenty-six. These qualities are equally divided into two groups: one reflecting four *pragmatic* UX characteristics (represented by scales 11, 13, 20 and 21) and the other focusing on the *hedonic* quality (scales 6, 7, 10 and 15), as it can be observed in the table below.

Table 36. *Structure of Short-UEQ* (from Schrepp, 2018)

obstructive	o o o o o o o	supportive
complicated	o o o o o o o	easy
inefficient	o o o o o o o	efficient
confusing	o o o o o o o	clear
boring	o o o o o o o	exiting
not interesting	o o o o o o o	interesting
conventional	o o o o o o o	inventive
usual	o o o o o o o	leading edge

Fig. 20. *UX Benchmark (Field Testing)*



Participants at the Open House tested version of the PathVR prototype and they found it to be overall Above Average benchmark, the overall rating was due to Participants finding the Pragmatic Qualities to be Below Average benchmark which had a mean of 1.01, but the Hedonic Qualities were Above Average benchmark with a mean of 1.48.

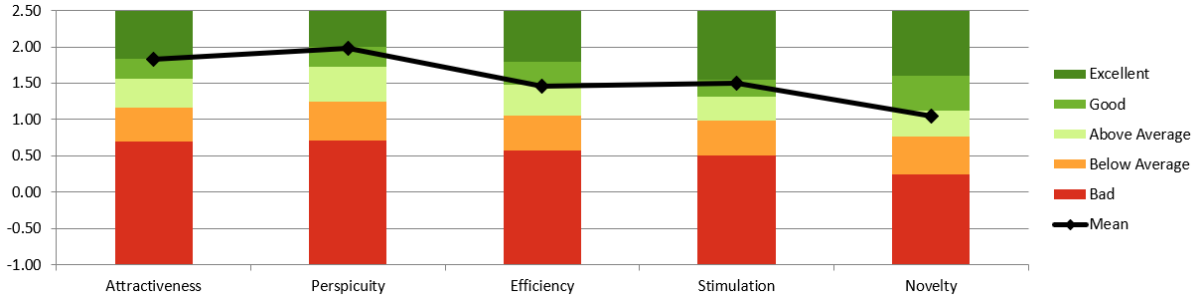
6. Discussion

This study has been the culmination of an almost two-year collaboration with the PR Department of Aalborg University Esbjerg. Hence, results of this particular study do not just reflect on the work during this previous year but on the previous two years. The focus of this study was on creating a virtual reality application through a user-centered approach. In order to tackle this, the level of user experience generated by such an approach had to be analysed. In addition, the overall quality of the system created through this methodology had to be assessed.

The user-centered methodology implemented within the design of the VR application consisted in the creation of personas. In order to analyse whether or not personas, as UCD methodology, affect the level of user experience, different experimental procedures have been conducted among distinctive pairs of end-users. Results have shown that personas (as design methodology) do have an impact on the level of UX. Based on the finding the two personas represented by danish students both inside and outside Esbjerg did not have any difference in UX between the two. Hence they were merged into one (Revised Persona I) in a later test. This second test was between version 2 and 3 but was only performed on Revised Persona I with no statistically significant difference in UX. However, during the first test there was a significant difference in UX between Persona I and Persona III and between Persona II and Persona III. Thus, it can be argued that this UCD approach does impact the level of user experience. Although, it would also seem that if the personas are too similar then the UX between them will not differ. In this case Persona I and Persona II were described in very similar fashion with the only major difference being where they study.

Using the UX benchmarks it can be observed that the application appears to be skewed in favor of one of the final two personas (Revised Pesona I and Persona III). Based on the comparison of the UX Benchmark for Persona III (Figure 19) with the Benchmark for Revised

Persona I (see Fig. 21), there is a tendency of the PathVR application to skew towards international students.



They placed the application within the ‘Excellent’ benchmark for all 5 scales of user experience. By comparison, the danish students placed the application lower in the ‘Good’ benchmark for the perspicuity, efficiency and novelty scales with the later being in the lower end. This brings into question what was done inside the application to bring it down for danish students. Based on the data which generated the benchmarks there were several particular answers that reflected this opinion. Even though the answers range from neutral to positive they are average and above average. The app was overall rated more usual, slow and conventional by the danish student.

The quality of the VR application should also be further analysed based on established criteria. The level of presence was chosen to gage the quality of the overall system throughout each iteration and across all three personas. The main issue was to analyse how the user-centered methodology (personas) affected the level of presence felt by the users during the VR experience. Both across version 2 and version 3 there is no statistically significant difference in the level of presence between all personas.

Even though there was no statistically significant difference in their presence levels between Persona I and Persona III there were UX differences as stated above. The same can be said about Persona II and Persona III. It could be argued that version 2 and version 3 are relatively similar in terms of appearance and navigation. Therefore, one can argue that two different personas could find the experiences similar in terms of presence.

6.1. Reliability of the results

Most of the test sessions were conducted at gymnasiums. Unfortunately, one of the sessions at Rybners Gymnasium had to be held in an open space rather than the usual more controlled environment. The fact that the test was held in a canteen might have affected the results in comparison to the other data gathered. It is important to mention that the respective test was conducted over two days with only the first in the canteen. When comparing the results of the two days, both in terms of presence scores and UEQ scores, the largest difference was of 0.4. This was registered for *efficiency* (on the UEQ).

Throughout testing glitches would become visible within the program. These would ultimately pull the user out of the experience with the worst cases being when the program had to be restarted. Due to the fact that the controllers ran on non-rechargeable batteries, on some occasions the controller would interrupt its Bluetooth connection causing problems with the

tracking. Since some of the questions pertained to how distracted they were during their experience, this could contribute to a lower score.

Another issue was the fact the headset itself lost tracking by losing the anchor points it was tracking in the physical room with its two cameras. This caused errors in the spatial placement of the in-game camera. This meant that the application would have to be restarted, or everything had to be moved back to its original position, in order for the headset to continue from its previous position.

The questions also proved to be quite challenging for some of the participants. Some asked for clarifications upon completing the questionnaire and so they could have misinterpreted the questions. For example, a few test participants had trouble understanding what presence is or how it applied to the questions.

During the Open House event it was planned to use the think aloud method as a passive data gathering method. This was an extremely open environment with a lot of people moving from stand to stand with little time to spare. Even though this gave a good opportunity for the VR application to be tried out by as many people as possible the think aloud method could not be applied. Since this was tried in version 1 of the prototype the program often proved to be too unintuitive for the people trying it so they would often ask questions and guidance, forcing the facilitators to engage in a dialogue.

This negated the principle laid out by Nielsen (2012a) of letting the user talk while the facilitators mostly listen. As stated above there were also scenarios where the headset had to be removed due to glitches and this further hindered the think aloud process. While the data gathered using the think aloud method proved to be unusable due to lack of any consistency during the approach, the verbal feedback was still extracted as design notes for version 2.

General observations were written down during all testing sessions. Most observations during user interactions concerned the notice of struggle. If the user would appear lost or confused at any point during the experience observations would be noted down speculating on possible causes and fixes. Since the notes were taken from the subjective perspective of the observer, certain events might have been overlooked (Harboe, 2013). A potential problem is the Rosenthaler effect where observers influence the outcome of the test intentionally or unintentionally. The current study could have been stronger if a clearer and possibly strict structure was followed by the research team.

6.2. Other Implementation choices

Inside-out tracking was one of the features that convinced this study that a Windows Mixed Reality headset would be a good choice of hardware. However, since the start of this study new headsets were discovered using similar technology such as the Oculus Rift S (Oculus, 2019). A key advantage of the Rift S is that applications for it do not have to be built using the robust windows framework (Universal Windows Application). There is also work done by other companies to minimize the use of external trackers. A special inside-out tracker can be attached to the HTC Vive to give it the possibility to function without its base stations (Langley, 2017).

6.3. Future work

For a future project as discussed in the end of Introduction, the PathVR can be adapted to fit several other purposes. One of these purposes that have been made is the promotion of the Fiskeri- og Søfartsmuseet, where a promotion of the local museum was a part of a larger project taking place in the Esbjerg municipal. This design methodology can therefore be introduced into several other scenarios. The effectiveness of adapting this to other scenarios still has to be proven though.

Based on consultations with start-up advisors any product worth investing into should consider the issue of scalability. While this can be considered not directly connected to the study it is nonetheless an aspect worth considering within the current prototype. The robust windows framework mentioned above hinders the possibility of allowing the app to be used with any headset or just be available online. As observed in **2.7. Related Works** virtual reality application which are web-based benefit from ease of access with the hardware choice left to the user. Having a server based system allows for easy content updates which is a valid concern for the current PathVR application. The fact that new content cannot be introduced easily and requires for the application to be built again in unity presents a problem for the scalability of the app.

Conclusion

The experimental procedures conducted throughout this study have focused on analyzing whether or not a user-centered approach impacts the design of virtual reality environments. Particularly, the impact of personas (as UCD methodology) on the use experience and presence generated by PathVR.

The difference in presence between the two consecutive prototype iterations did not show any statistically significant difference, despite their design methodology taken into consideration. In regards to the level of user experience felt by the three user categories, during their interaction with both versions of PathVR, results have shown that the users who seemed to have enjoyed PathVR the most were represented by international students, whose persona design differed than the others.

Therefore, one can conclude that applying a user-centered approach within the development of an interactive virtual environment may be beneficial for the design of a virtual reality experience.

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9. Appendix

A. Presence Questionnaire

"Q1. How much were you able to control events?

Q2. How responsive was the virtual environment to actions that you initiated/performed?

Q3. How natural did your interactions with the virtual environment seem?

Q4. How much did the visual aspects of the virtual environment tour immerse you?

Q5. How natural was the mechanism which controlled movement through the virtual environment?

Q6. How compelling was your sense of moving around inside the virtual environment tour?

Q7. How involved were you in the virtual environment tour experience?

Q8. How well did you adjust to the virtual environment experience?

Q9. To what extent was there a delay between your actions and their effects in the virtual tour?

Q10. How much did the visual display quality interfere or distract you from performing the virtual tour?

Q11. To what extent did events occurring outside the virtual environment distract you from your experience in the virtual environment tour?

Q12. How much did your experiences in the virtual environment tour seem consistent with your real world experiences?

Q13. How well could you concentrate on the assigned task or required activities rather than on the mechanism used to perform those tasks or activities?"

B. System Usability Scale

"1. I think that I would like to use this system frequently.

2. I found the system unnecessarily complex.

3. I thought the system was easy to use.

4. I think that I would need the support of a technical person to be able to use this system.

5. I found the various functions in this system were well integrated.

6. I thought there was too much inconsistency in this system.

7. I would imagine that most people would learn to use this system very quickly.

8. I found the system very cumbersome (difficult) to use.

9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system."

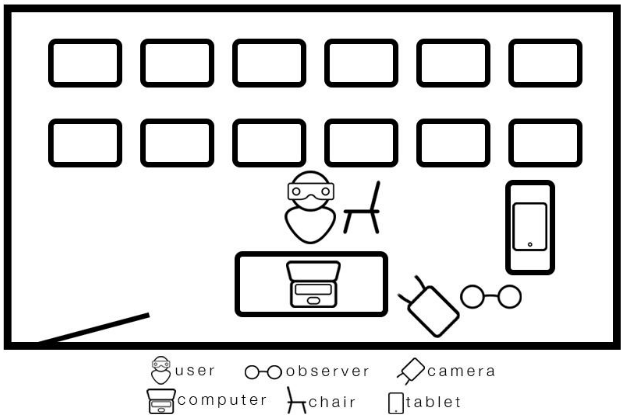
C. User-Experience Questionnaire/ Scale

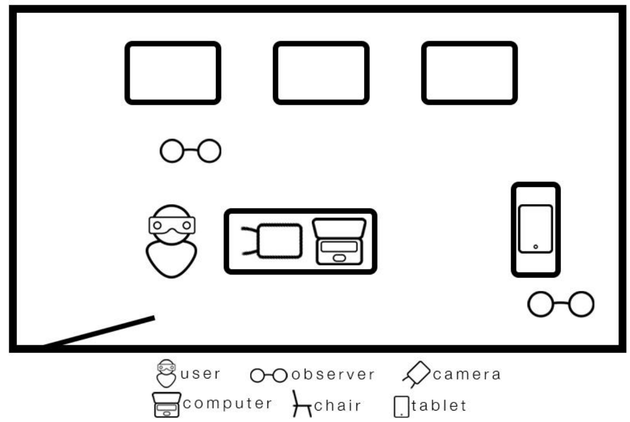
	1	2	3	4	5	6	7		
annoying	○	○	○	○	○	○	○	enjoyable	1
not understandable	○	○	○	○	○	○	○	understandable	2
creative	○	○	○	○	○	○	○	dull	3
easy to learn	○	○	○	○	○	○	○	difficult to learn	4
valuable	○	○	○	○	○	○	○	inferior	5
boring	○	○	○	○	○	○	○	exciting	6
not interesting	○	○	○	○	○	○	○	interesting	7
unpredictable	○	○	○	○	○	○	○	predictable	8
fast	○	○	○	○	○	○	○	slow	9
inventive	○	○	○	○	○	○	○	conventional	10
obstructive	○	○	○	○	○	○	○	supportive	11
good	○	○	○	○	○	○	○	bad	12
complicated	○	○	○	○	○	○	○	easy	13
unlikable	○	○	○	○	○	○	○	pleasing	14
usual	○	○	○	○	○	○	○	leading edge	15
unpleasant	○	○	○	○	○	○	○	pleasant	16
secure	○	○	○	○	○	○	○	not secure	17
motivating	○	○	○	○	○	○	○	demotivating	18
meets expectations	○	○	○	○	○	○	○	does not meet expectations	19
inefficient	○	○	○	○	○	○	○	efficient	20
clear	○	○	○	○	○	○	○	confusing	21
impractical	○	○	○	○	○	○	○	practical	22
organized	○	○	○	○	○	○	○	cluttered	23
attractive	○	○	○	○	○	○	○	unattractive	24
friendly	○	○	○	○	○	○	○	unfriendly	25
conservative	○	○	○	○	○	○	○	innovative	26

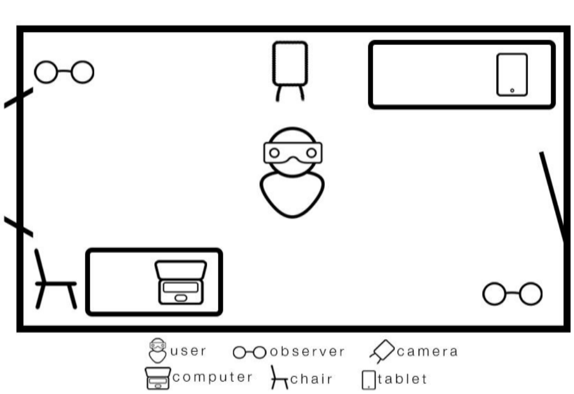
D. Short User-Experience Questionnaire

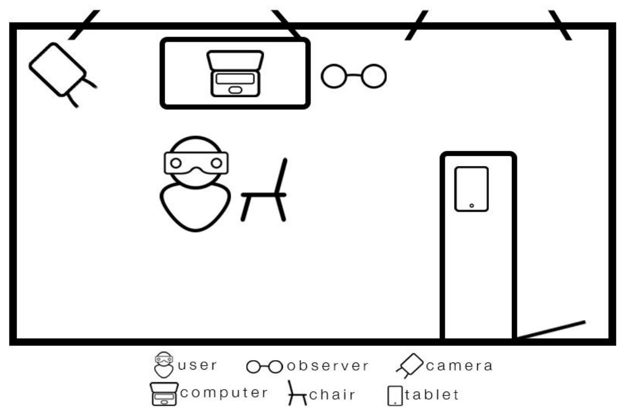
obstructive	o o o o o o o	supportive
complicated	o o o o o o o	easy
inefficient	o o o o o o o	efficient
confusing	o o o o o o o	clear
boring	o o o o o o o	exiting
not interesting	o o o o o o o	interesting
conventional	o o o o o o o	inventive
usual	o o o o o o o	leading edge

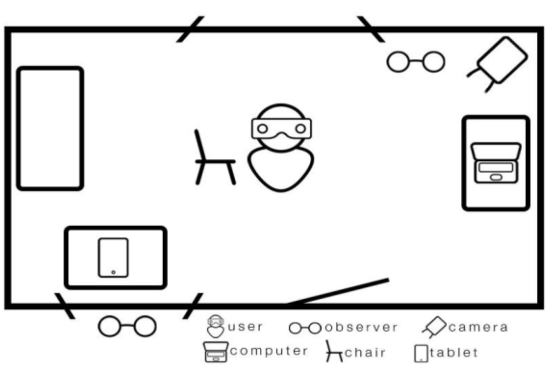
E. Set-up of Experimental Procedures

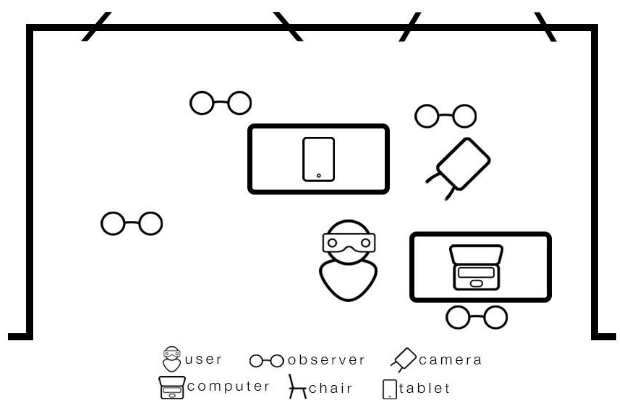












F. AAU Open House Event (23rd of February, 2019)

F. 1. Test Plan

OUTLINE: AAU Open House Test Plan

Date and location: 23.02 / 10.00-14.00 Aalborg Universitet Esbjerg

Data gathered: qualitative ("Think Aloud" protocol, audio/video recordings, additional notes) and quantitative (SUS Scale, UEQ Short Scale).

Testing Procedure Outline:

Greet participants

Invite them over to test

Ask for audio/video consent

If given, turn on a frontal camera (so his/her behaviour and body gestures are analysed) and microphone from phone.

Hand over the HDMI and inform them how the interaction is going to occur: THINK ALOUD PROTOCOL

Possible protocol script:

"*During your interaction with the VRE, we are asking you to vocalize your actions and thoughts as you explore the different virtual settings. By vocalizing, we mean letting us know what are the actions that you are planning to make in the tour. It could be something similar to*

Hmmm, let's see how attraction looks nice! Now I'm curious to see the university/cafeteria/etc. -

If you face any challenges in either navigating the environment or using the controllers, mention them without hesitation. Your feedback is important to us, and it can be related to your opinion about the design or functionality of the product."

It is important to keep in mind that researchers of this study should not intervene while participants are talking, unless a technical problem occurs.

After they have "completed" the VR tour, ask for 5 minutes extra in order to complete the two questionnaires.

Hand over the tablet with SUS and UEQ tabs open.

Thank them for their time.

G. Interview Documentation

G. 1. A/V Consent Form

Samtykkeerklæring

Jeg giver hermed samtykke til at medvirke i studiet omkring promovering af Aalborg Universitet Esbjerg, som udføres af Ilinca-Daria Ostaci, Secara Stefan, Thomas Møller og Esben Nygaard.

Jeg har forstået og giver tilladelse til at de information, videooptagelse, og lydoptagelser der tages af mig, kun bruges til forskningsformål inden for dette studie, og vil ikke blive brugt til nogen former for formål der ikke er relateret til studiet. Jeg har også forstået at de optagelser der bliver taget af mig vil aldrig blive vist offentligt, og vil kun blive set og hørt af de studerende der foretager studiet, deres censorer til eksamen, og ansatte på Aalborg Universitet Esbjergs Kommunikationsafdeling.

Jeg forstår at deltagelsen i dette studie er frivillig, og at jeg til enhver tid kan sige fra overfor de administrerende, hvis der er bekymring eller nogen form for ubehag under deltagelsen. Jeg har endvidere forstået at hvis jeg har nogen former for spørgsmål til studiet, kan jeg spørge de administrerende under testforløbet.

Ved at underskrive dette dokument, konfirmerer du at du har læst og forstået information i denne erklæring, og at du giver dit samtykke til at blive optaget enten ved video eller lyd i dette studie.

Mange tak for Deres deltagelse.

Dato:

Underskrift: _____

_____

_____

Ilinca-Daria Ostaci Stefan Secara Thomas Møller Esben Nygaard

AALBORG UNIVERSITET

Consent Form

I hereby give my consent to participate in the study about advertisement of and for Aalborg University Esbjerg, which is conducted by Ilinca-Daria Ostaci, Secara Stefan, Thomas Møller and Esben Mørch Nygaard.

I understand and give my permission for the use of information, video recording, and audio recording taken during my testing sessions, and that it will only be used for research within this specific study and will not be used for any purpose that is not relevant to the study. I understand that the recordings of me will never be shown public and will only ever be seen and heard by the researchers conducting this study and the censors at the exam.

I understand that participation in this study is voluntary and that I can at any time during the study tell administrators to stop it, should I feel any discomfort in participating or for any other reason. I understand that should I have any further enquiry about the study I can ask the administrators of the test during the test.

By signing this document, you hereby confirm that you have read and understood the information within this document, and that you give your express consent to be recorded with either video and/or audio during this study.

Thank you for your participation

Date: _____

Signature: _____

_____

_____

Ilinca-Daria Ostaci Stefan Secara Thomas Møller Esben Nygaard

AALBORG UNIVERSITET

G. 2. Interview Steps

1. Greeting the other, present yourself, give them a seat across from you
2. Tell them that the test takes between 10-15 min (provide them with water or something sweet)
3. Ask for consent (tell them than collected data will only be used for the project - names, videos will never be given outside of group)
4. Turn on recording device (if consent is provided)
5. Ask if they have any questions before we begin the actual interview.
6. Start the interview (follow questions)
7. Thank them for participating and ask if they have any closing remarks.
8. Turn off camera.

G. 3. Interview Script (Usability Test)

"Welcome! My name is … and before we begin, I am going to shortly debrief you on what is about to happen within this interview session. You might already have an idea of why we have requested your attendance here, today, but I will go over it again.

We are asking you, Ambassadors of Aalborg University Esbjerg, to try the VR application designed for promoting this particular university so we can see whether it works as intended. As you might already know, this application has been designed in collaboration with the PR Department in order to promote AAUE at international university fairs, for prospective students who would like to follow this education in the future. This so called "promotional tool" will be used by you at future educational fairs.

The first thing that I want to make clear right away is that we are testing the application, and not you. You must know that the interview will not have any right or wrong answers, nor would the after questionnaires. Therefore, you don't have to worry about making any mistakes. Also, please don't worry that you are going to hurt us by giving negative feedback in regards to the VR application. We are doing this interview in order to improve the quality of the current prototype, so we need to hear your honest opinions and reactions.

If you have any questions, please don't hesitate to ask. If you encounter any technical difficulties during your interaction with the VR application, I will of course help you. And if you need to take a break at any point during the interview, please let me know.

Any questions so far? (smile)

[*if yes - answer, if not - go on]

Super, let's start!"

G. 4. Interview Questions (Danish Students from Esbjerg)

1. What is your line of study?
2. What year are you in?
3. Are you going to take a sabbath year?
4. What are some essential things you would like to know about a university?
5. What makes you interested in a particular universities?
6. How do you imagine life as a university student?
7. Where do you get your information about universities?
8. Have you been to student fairs? (if yes)What did you learn about universities there?
9. Do you know about AAU Esbjerg? (if yes) What do you know about AAU Esbjerg?
10. How did you get to know about AAU Esbjerg (TV commercial, radio, newspaper, brochures, ads on social platforms, etc.)?
11. How would you like to see university adverts? (pamphlets, newspaper adverts, social media, etc.)
12. Have you used Virtual Reality before?
13. How would you use Virtual Reality?
14. Do you own a Virtual Reality headset?
15. What is your opinion on Virtual Reality?

G. 5. Interview Questions (Danish Students outside Esbjerg)

1. What is your line of study?
2. What year are you in?
3. Are you going to take a sabbath year?
4. What are some essential things you would like to know about a university? (if they

already talked to a university) What did you hear about a university that you felt was essential?

5. What makes you interested in a particular universities?
6. How do you imagine life as a university student?
7. Where do you get your information about universities?
8. Have you been to student fairs? (if yes)What did you learn about universities there?
9. How much do you know about Esbjerg? (if not a lot) What would like to know more about Esbjerg? (If some) What do you know and what do you want to know more of?
10. Would you move to Esbjerg? If yes - what would compel you to move to a different city?
11. Do you know about AAU Esbjerg? (if yes) What do you know about AAU Esbjerg?
12. How did you get to know about AAU Esbjerg (TV commercial, radio, newspaper, brochures, ads on social platforms, etc.)?
13. How would you like to see university adverts? (pamphlets, newspaper adverts, social media, etc.)
14. Do you own a Virtual Reality headset?
15. Have you used Virtual Reality before?
16. How would you use Virtual Reality?
17. What is your opinion on Virtual Reality?
18. How would you feel about having University promoted through Virtual reality?
19. What would you want to see in a university promoted by virtual reality?

G. 6. Interview Questions (International Students)

1. What did you know about Esbjerg city?
2. Why did you choose Esbjerg city?
3. What are some essential things you would like to know about a university?
4. Where did you get your information about universities?
5. How come you chose Aalborg University and not any other?
6. If AAUE was promoted, how was that done? (TV commercial, radio, newspaper, brochures, ads on social platforms, etc.) If possible, please elaborate.
7. What do you like to do in your leisure time?
8. Have you explored the city and its attractions? What do you think about it? Anything

more you would like to explore/see in the city?

9. Have you interacted with VR before? If yes, on what level?
10. What would make a virtual reality environment attractive?
11. Do you have any VR preferences?

H. Field Observation Notes

Experimental Procedure: Danish Student from Esbjerg
Location of procedure: Rybners Gymnasium
Number of Participants: 12

#1

- Help from Thomas with controls
- Controls easier to use
- Issue with getting out of canteen
- Tries to use the map, doesn't work
- Issues with map, technicians hero with crash
- Tutorial clearer
- Uses rotation more frequently
- Thomas and participant compare to street view
- Ask about lab equipment
- Says it's easy to get around and to find things

#2

- Powers through the tutorial, saw participant 1
- His first to the classroom video
- Stands up
- Ask if video is loop
- Asks about the bar and students there
- Has been at aau
- Asks about 360 images
- Tries to walk in 360 images
- Takes quick look
- Zooms around University
- Wants to go closer in 360 images
- Surprised you can walk close to the mail in the entrance
- Really likes the map
- Enjoys the map
- Moves around so much because of possible in entré

#1 and **#2** say it's much better to explore and be told about uni rather than just being showed pictures

#3

- Tutorial useful for first time vr participants
- Surprised with transitions in tutorials
- Laughs about jumping into the map
- Had to be told the the white boxes to move around
- Explanations from researchers about labs helpful
- Scared with teacher moving
- Very interested with explanations
- Likes VR a lot
- Takes a small trip
- Likes the vr and says ‘wow so beautiful’ (paraphrase)

#4

- Completes tutorial on his own without issues
- Explore uni for first time
- Says it's fun
- Seemingly enjoying the explanations with exploring
- Finds it funny that the teacher teleports in wind tunnel
- Finds things based on researcher telling about it
- Forgot about thumbstick movement x2
- Wants to teleport to the places on map
- Stands and looks around in the entry
- Explores rooms
- Looks around bar while smiling
- Good outside, looks a lot
- Reminded he could use the minimap to get around

#3: Says the vr is really creative, only downside is singular headset. The physical medium is much better than paper. Good mix of static and video and it give more life like feeling

#4: Finds it was really good and it gave good impression on how it was at university #Thomas (guy helping us) finds tripod scary tutorials easily done enjoys going around, difference between pictures /videos and entrance, enjoys the map. Says it's very cool

#5

- A little issue with controls
- Issue with minimap when outside
- Like the bar
- Accidentally took a picture
- Enjoys all entrances
- Walks around in pictures

- Keeps walking in pictures
- Compare to Google maps

#6

- Tutorial needed restart otherwise fine
- Laughs at Henrik in group room
- Find university “big”
- Looks around a lot
- Never been to uni before
- Controls easy enough for him
- Finds map in entry to be really cool, likes the models that are on it
- Enjoys trip

#5 and **#6:** Classrooms cool, and take it with to fairs but would rather go to it on their own. But generally a cool concept

#7

- Found getting a controller “super weird”
- Blazed through the tutorial but forgot buttons immediately after
- Doesn't know if she needed to move around in pictures
- Rotation button smart but forgot about it
- Teleport movement smart
- Really likes the vr experience
- Laughs found it super scary to lean guard
- Needs some explanation on how movement in hallways
- Need a little help with minimap because she pressed blue button
- Enjoys looking around, really likes the vr and the environment

#8

- Video helped with learning controls
- Surprised about the Teleport
- Need more explanation with the thumbstick control, and found it “super weird (vr)”
- Smiles while in vr
- Needs help understanding minimap

#7 and #8 found out it is “super fun”, and they were much more keen to listen because of it (overall a great experience).

#9

- A little difficulty with tutorial but still got through it, got an explanation on movement with thumbstick
- Needed help with entré
- Needed reminder on rotation by thumbstick
- Easily goes through the university
- Asked about video of engineering lab
- Uses rotation by stick

- Stood up in still image
- Double clicked to go outside
- Surprised you can move into the map on the table

#10

- Water Bottle moved in tutorial
- Needed a bit of help with movement in 360 images
- Kept adjusting headset
- Rotates using thumbstick
- Surprised about teacher in wind tunnel
- Interesting things
- Adept at using controls
- Needed reminding about controls to move forward
- Finds the cars “super cute”

#9 and **#10**: found vr a better idea, and easier to relate to the university and build relation to the university.

#11

- Finds library super creepy, because it's so big
- Tutorial alright need a bit of help
- Found minimap a bit Creepy
- Got a bit sick because of height difference and how that felt

#12

- Found getting the controller a bit funny
- Confused how to start….
- Needed a bit of direction to get to somewhere
- Found group room super creepy / felt uneasy
- Found the classroom super funny
- Movement weird in still images
- Movement in entré hard felt like being a drunk
- Tripod shot was weird because it felt you stood on something

#11 and **#12:** found VR to be fun and give a better view of things, but fast movement makes you sick better to sit down. A good thing for PR department to consider.

Experimental Procedure: Danish Student from Esbjerg
Location of procedure: Rybners Tekniske Gymnasium
Number of Participants: 12

#1

- Found headset a bit blurry in the side
- Went through tutorial without issues
- Goes very fast through the university
- Forgot about green thumbstick
- Recognise area
- Positive talk
- Previous been to aau abs explore
- Likes the map table
- Found ball and water bottle, played with them
- Checked out B-wing
- Wanted to have classroom recording in head height
- Talking to the researchers was a choice so it wasn't distracting

#2

- Blaze through the tutorial
- Funny loading screen
- Cafetiere picture was strange
- Accidentally hit the wall
- Remembers being at uni explores places she's been
- Looks around a lot
- Feels a bit weird in chemistry lab
- Found it very surprising to be in classroom
- Likes the map table

#1 and **#2** agree: Information is better presented (better than on paper), pictures are comical. Runs fine enough though but headset is a little blurry in the periferien.

#3

- Blazes through the tutorial
- explained about the blue boards to go through
- learns quickly
- explores canteen looking around
- quietly goes through the university
- had been to aaue by exploration
- has no problems with any of the controls or exploration
- stays in each room for a short time

- asked about if he has questions, asks about the energy lab
- looks around in the smuthul
- likes the idea of the map table
- got very surprised when he accidently walked into wall and got pushed back

#4

- Table was in different place causing a need for some help, otherwise no problem with tutorial
- immediately found the bottles and ball in the lobby and played with hem
- went to map
- quickly learned how to navigate through the VR environment
- comment on picture for hallway for C-building "realism" (laughs a little)
- also note same thing with outside
- looked
- found it funny how teacher in windtunnel teleported
- remembers energy lab
- often looks down at the tripod in every scene
- **due to all participants sitting down they use thumbstick much more
- very handily moves around the vr environment
- classroom is funny, due to perspective

#3 and **#4** agree: a better experience to come see if you can't get there, VR is good alternative if one cannot attend university days

#5

- Sides of screen a bit blurry
- Blazes through the tutorial without any real issues
- learns teleportation + rotation before going to uni
- Stands up in lobby
- needs a bit of guidance on what to do
- looks around in classroom, rotates view by rotating his body
- has been to uni before to explore it
- stops early

#6

- had no troubles with the tutorial
- had an easy time going through the university
- stops early

#5 and **#6** agree: it's "cool" you get a better view of how it is and you get a sense where

things are in relation to each other instead of looking at a map.

#7

- A little issue with water bottle again
- A little confused with blue button but finds out
- Uses the big map in the lobby
- A little knowledge of VR
- Seemingly having little problem navigating around
- Doesn't use thumbstick in images or movies
- Wants to click image over map table
- Told that he can rotate with thumbstick
- Starts using the thumb stick in images
- Feels a little like google street view
- Impressed by the big red 3d printer
- Quickly moves around the vr environment

#8

- Blazes through the tutorial with no issues whatsoever
- Needs a bit help with teleportation though
- Has no problem navigating through the university
- Uses the thumbstick to rotate in pictures
- Quickly goes through the sences
- leaned in over the map

#7 and **#8** agree: VR programme much more fun - it's a way to go round and look and get much more of the atmosphere, you get to choose yourself where you go. As a tour thing it is very good.

#9

- No problems with controls other than aiming
- didn't know what to do in lobby before being told about the banners
- found the canteen funny
- had been at aaue before
- walking around canteen and place to eat
- use the big map, needed help with selecting a place room
- went into the plant in the entrance
- says i am tiny in classroom
- says in a sort of funny voice i am in the university
- found classroom video a bit creepy
- found the statues weird
- easily goes around the university
- notes the tripod in the outside
- threw ball out of map
- found the table map and all of the things super cool

- teleport movement system is standard and good
- has very little issues with movement
- surprised about guy teleports
- movement system smooth, natural for somebody who have tried for the first time

#10

- Easily completes the tutorial, mumbles some of the control
- finds the lobby wicked
- finds table map more detailed than expected
- started to look for house in table map
- wanted to point at map with hand but can't
- finds himself a bit too high in the 360 library
- really enjoys exploring the university
- big smile
- reminded by early school year
- really finds the group room picture funny
- has no issues whatsoever getting around and looking around in pictures
- wants more interactiveness in pictures
- a bit too much like a slideshow
- fancy
- it's a cool thing but a bit effy due to slideshow thing
- Square hitboxes for water bottle
- really like the hubworld style of the entrance

#9 and **#10** agree: much better than information presented on paper, made by students is a sell point, "cool it's made by students" because it shows that what you make can be used.

#11

- No problems with tutorial
- tries to pick up table map
- very quickly moves around in uni
- can see the wind tunnel teacher talks
- likes the idea of ambassadors explaining what happens in scenes
- has been to the university before
- good usage of the thumbstick
- has no issues moving around the university
- would like to have games in scenes that responds to those scenes or something along the lines of diagrams that explain what they are doing
- the environment can be improved but how much effort would you

want to put into it. Getting games into it

- "a bit more fun, you can choose where you want to go which makes it a bit easier; if people have VR headsets you could sent a link to this, you can also get more around and listen to what you want and then just explore around". Having text for things to explain what they are about.

#12

- No problems in tutorial
- needed a tip with banners to get around in uni
- once in uni hallway no problem moving around
- taken back on height of ceiling
- uses thumbstick to rotate in images
- has no issues moving around
- quickly goes through the lab
- likes the map notices things on the map
- much more exciting than something like a powerpoint, getting to walk around and be told by someone. Would like to have some audio in videos.

Experimental Procedure: Danish Student from Esbjerg
Location of procedure: Kobenhavn Sukkertoppen Gymnasium
Number of Participants: 12

#1

- Needs help navigating around
- But after a while gets a hang of controls
- Got dizzy by wearing the headset
- Very fun to be in as long as you don't walk into stuff
- **No video recording**

#2

- Learns controls fast
- Super fast at learning controls
- Impressed with moving in entrance
- Teleports with map
- Wants things to interact with
- Thinks AAU is big
- Likes the exploration aspect
- Much exciting than physics

- "Creepy and cool"
- Oil platforms super good quality
- Table card is the best
- **Video Recording:** Controls are smart but difficult feeling where you are in the real world. Says where he goes, comments on perspective. Looks around a lot but not so much behind himself.
- Needed help with finding certain things, wanted stuff to pick up. Found a lot to explore. Tried to open the minimap in outside area to see layout. Leaning in over table map was creepy but good (best part). Wants to get into stadium.

#3

- To controller up side down
- Point controller down towards ground to Teleports
- Walking is weird
- Wants to find bar
- Perspective is deceived
- Found group room
- Look cool
- Looks around alot
- Heard about the other labs
- Bit blurry in VR
- **After test Question (#2 and #3):** nice to get to experience uni and get to walk around and get a feel about the uni.
- **Video Recording:** Needed clarification about teleporting, thanked for clarification. Wanders a bit away. Ask questions about pictures. Looks around a lot. Quite.

#4

- Completed the tutorial fast
- Has no problems moving around the uni
- Controller manipulation felt sluggish
- Explorers the university slowly and every room
- Interested in studying chemistry
- Likes the exploration
- Fine would be better with audio track and no one to talk to the person exploring
- **After test Question.** Better way to show off the university than than pictures
- **Video Recording:** Didn't need rotation thanks to space available. Felt there was a problem (lag) with controls (acceleration not proper when interacting with objects). Walked around a bit in the room. Noticed windows (OS) in chemistry lab.

#5

- Calibration the headset
- Verbalise his tutorial
- Recognise 360 camera
- Forgot trigger
- Likes the video
- Rotates 90 down halfway
- Wants to explore the wind tunnel
- **After test Question.** Overall gives a much different view but not the same overview as paper and talk
- **Video Recording:** Talks out loud. Was told about the map. Wanted to know more about the videos and wanted to move in pictures. Looks around a bunch. Wanted to know more about wind tunnels. Not entirely sure what's in pictures or videos.

#6

- Completes the tutorial with no problems
- Goes to group room says oh
- Goes to class room
- Feels like you are there
- Finds it super cool with movement in lobby
- Super excited by what is shown - "seems super interesting"
- Likes the video in canteen
- "Cool" parking lot
- Explores with no issues
- A lot of labs
- Finds the entire university
- **After test Question.** Good way to get better overview, you get to move around to get a better view of how big the university is
- **Video Recording:** Teleportation help given, somehow teleported back to tutorial. Ask where it is (AAUE), needed explanation for blue boards. Really taken back by table map, wanted to press overview of esbjerg. Looks around quite a bit, surprised that canteen was a video.

#7

- Not first time in vr
- Plays with stuff in entré
- Disoriented by perspective on atrium
- Figures out the blue and white button
- Tree looks "funky"
- Likes the small table map
- Plays king Kong, gasps at brewery
- Notes the brewery is cool
- Likes the labs
- Wind tunnel is "cool"
- Find the labs super "cool"
- Competently moves around

- Camera perspective is “cool”, trapped between giants
- Iris shine is “cool” is pond is nice
- **After test Question.** Interaction, innovation, technical production with vr is nice as it shows technical competences. Depth perception is very nice to show how big a place is
- **Video Recording:** Tried VR before, perspective in atrium overwhelming? (leaned back, says it’s disorientating) Accidentally hit the blue button and removed the path. Likes the brewery equipment. Looks around a bunch, reeled back from algaes in energy lab. Found things in AAUE cool. Perspective weird, ask about certain things (such as wind tunnel, what’s been 3d printed etc.)

#8

- No problem with tutorial
- Teleport point towards the ground
- Clocks are wrong (joke)
- Likes the atrium
- Likes the relax area
- Super likes the brewery
- Thinks we have everything
- Sounds cool energy lab
- Labs looks really nice
- Forgot about the map (blue button)
- Perspective makes people look big
- Like the exploration of university
- Like the bar a lot
- **After test Question.** Much more exciting, it's a lot cooler way to look at than paper or folders. Very cool idea
- **Video Recording:** Needed clarification with teleportation. AAUE seems comfy, looks around quite a bit. Comments on what is in AAUE. Likes the university, finds the university beautiful.

#9

- No problems in tutorial
- Problems with the blue button removing the way out of a scene
- Found the video from canteen cool
- No problem with the white boxes
- Very quickly through
- Doesn't talk much
- Thumbstick was a little hard for him
- Killed the ball
- **After test Question.** Feel like it was quite cool to give tour in VR, kind of cool.
- **Video Recording:** Needed explanation on mini map + had issues with controllers (issues was related to which button does what).Turns around quite a bit,

smiled a lot. Needed some clarification on how to get around entrance and hallways. Doesn't always look directly behind. Needed some extra help with controls (teleportation).

#10

- Needed help with control and navigation
- After being told how to go through the hallway
- Likes the labs
- Leaning, like the map table
- Things look very big in the perspective
- Classroom kinda scary because perspective
- "Weird" to look down and not see legs
- **After test Question.** Would have liked to have vr tour of school before going here. Feels like you have been there when you haven't.
- **Video Recording:** Unsure of point of VR. Needed a refresher course on controls. Looks around a bunch. Asked about resolution of headset. Asked about 3d printers and materials it prints with. Perspective in classroom makes it look like you are a tiny mouse.

#11

- Teleport point in ground need explanation
- Likes that you can physically move yourself to see the map.
- Used big map to Teleport
- Wants to move in pictures
- Likes the atrium
- Blue map button a bit confusing
- Doesn't talk much
- Uses map extensively
- Got a bit of help to navigate around
- Perspective makes people look big
- Likes to look around
- **After test Question.** Relativ cool, Needed a bit of help with controls
- **Video Recording:** Was told about movement in entrance, does it. Map explained to participant. Reminded about trigger. Wanted to walk in pictures, walked around in real world.

#12

- No major problems in tutorial
- Really cool that you walk around
- Needed reminding about trigger
- Cool that you can see on screen
- Surrounding by people (group room) is "cool"
- Likes the classroom
- Used big map to Teleport

- Finds it cool to see the labs and what they are doing
- Very smart moving around
- Likes Moving objects around
- **After test Question.** Smart works well, virtual experience do remember better. Extra depth better and felt like being there

- **Video Recording:** Needed to find water bottle in tutorial. Likes to walk in entrance. Cool idea to show off vr to others (allow bystanders to see what happens in vr on pc screen). Seems content with expectations of different labs

Experimental Procedure: Danish Student from Esbjerg
Location of procedure: Kobenhavn Mediagymnasiet
Number of Participants: 9

#1

- Needed a bit of help with tutorial bottle part
- Needed explanation for blue button
- Confused on how to select to get to places
- Gets the hang of getting around
- Clicks often on blue button
- Like the table map
- Is mostly quite
- **After test Question.** Better insight, you also get a more personal welcome to uni
- **Video Recording:** Some difficulty with controls, turns around a lot. Quite. Only talks when he needs help.

#2

- Confused about left /right controller
- Teleport point on ground
- Learned teleportation easy enough
- Quickly Learned how to move around the picture
- Uses pictures s to go to hallways
- Looks happy, laughs a bit
- Quickly through the university
- Found out you can only use the Teleport in entrance
- Tries to lean forward in picture
- Verbalise his action

- Looks to have enjoyed his trip
- **After test Question.** Visuals much easier and you can walk around, better view of how it really is
- **Video Recording:** Surprised about controller video is left handed. Thought map was of copenhagen. A lot of movement. Seems very interested in exploration. Comments about relax area looking good and a bit unsafe. Likes Brewery. Warms up over course of exploration, asks what camera stands on (tripod). Comments on size of uni seems small. Finds it really cool to be in VR.

#3

- No issue with tutorial
- Needed reminder you can walk around
- Quickly moves around
- Doesn't seem to interested
- Seems to have few issues moving around
- Uses rotation Thumbstick a lot
- Quickly scouts rooms with rotation and leaves
- **Video Recording:** Ask if it was a tour of university (yes). Likes the table map, ask if we made it. Asks about brewery. Smiles about comments. What university is this (AAUE). Doesn't move too much.

#4

- Tutorial no issue
- Got help with bottles to throw
- Tried to see what was written on blackboards
- Verbalise their action
- Likes to see the labs and what they offer
- Very quick through the entire thing
- Fun to be really low in the videos
- Loves to explore games translate to explore uni
- Finds the university super chill and comfy
- Table map super cool and where uni is
- **After test Question (#3 and #4)**: how it really is and get a better feeling. Paper better for many but VR gives a better individual experience about uni
- **Video Recording:** Says nice when welcomed to AAUE. Ask about the point of VR program. Tries to go to the toilet. Moves around a bunch. Impressed by brewery. Asks about university, likes to explore things in games. Finds the university cozy.

Likes the table map and how it shows where things are in Esbjerg.

#5

- No problem with tutorial
- Quickly found out control
- Camera position made him feel wired
- Wants to move in pictures
- It's surprised about amount of labs
- Thinks it’s quite fun how everything is in VR
- Has to bend to use Teleport to move on map table
- Forgot about the map
- Map delay felt like a real thing instead of 2d
- **Video Recording:** Asks about VR entrance. Found out how interactions with images work (surprised). Felt a bit high in the images. Asks about what happens within the labs. Noticed tripod can live with it. Looks around a lot. Likes the bar.

#6

- No real problems with tutorial
- Found ball to play with
- Quickly learns how to travel
- Has no issue navigating around
- Looks around a bunch in each picture
- Plays with the ball.
- Seem that the VR experience is a chill endeavour
- **After test Question.** Would rather see uni in vr then paper
- **Video Recording:** Needed a little help with teleporter. Would like to interact with something in brewery, walks around. Ask questions about uni.

#7

- No problem with tutorial
- Confused about flying
- No issue going through uni
- Explore quite fast
- Full control over controls
- **After test Question.** Much cooler and you get to see uni
- **Video Recording:** Smiled after tutorial, looks around. Wants to know what to do. Missed the food part of the canteen. Smiles and think there are so many labs (good).

#8

- A little help with tutorial
- Needed quick reminder that red button for selection
- Wants to teleport within pictures
- Closed big map in lobby

- Very quick in and out of pictures
- Missed Smuthullet - the university student pub
- **After test Question:** Very cool because you get to explore the entire university
- **Video Recording:** Seems happy. Says “i feel a bit low”. Has trouble looking at the table map. Told he could select the blue boards (to explore university). Moves around quite a bit, has no questions and had not real problems getting around.

#9

- No issue in tutorial
- Puts on headset in a strange manner
- Minimap not working properly
- Height in lobby kind of broke
- “Almost feel like you are there” - got distracted by background
- A lot of people look in ground
- No issue with getting around
- **After test Question.** Much better than having information on paper
- **No Recording.**

Experimental Procedure: Field Testing (AAU Open House)
Location of procedure: Aalborg University Esbjerg
Number of Participants: 20

#1

- got used with controllers quite fast;
- Answered questionnaires;
- Spent more than 5 min in the city;
- Immediately interested in testing the product since he first saw it;
- Sometimes confused about locations;

#2

- Auxiliary participant;
- Just interested;
- A short tutorial was given as intro;
- Adjusting to the controllers took time;
- Smiled a lot; enjoyed the app;
- “Controllers were weird”;

#3

- no camera recordings; answered questionnaires
- Assistance needed for controllers (before and during interaction)

#4

- no camera recordings;
- Trouble understanding how
- controllers work;

- Once adjusted to controllers, explored a lot of AAU

#5

- AAU STAFF MEMBER - probably a teacher at Electronics Department
- Had troubles using the system (mainly controllers);
- We need to make instructions more clear;
- Really seemed to enjoy the way VR could display the university and city;

#6

- enjoyed the application;
- Navigating the VE was not easy;Navigation problems were due to poor understanding of controllers

#7

- no A/V
- Enjoyed the VRE a lot - smiles a lot;
- Wondered for a while in the VRE and explored a lot of its facilities;

#8

- needed assistance with controllers;
- Enjoyed it a lot;
- Smiled a lot;
- Confused with the navigation within the VE;

#9

- Considered Aux* (child < 14)
- Enjoyed the application a lot - had lots of fun;
- He was good with using the controllers and navigating within the VE

#10

- filled in questionnaires but no AV.
- Quite impressed by the prototype;
- Difficulties adjusting to the controllers;

#11

- AV yes; Smiled; answered the questionnaires;
- A bit of assistance with the controllers;
- Got a good hold of the navigation within the VE;

#12

- AV yes;
- Assistance needed with controllers;
- Smiled a lot; really impressed by the application;
- Answered questionnaires;

#13

- Auxiliary test (child < 15 years);
- He really got into the application;
- Would have continued playing if his parents hadn’t taken him away;

#14

- AV yes;
- Assistance needed with the controllers;
- Navigated through the system with the TRAVEL MENU ON.

#15

- wonders through the city longer than the rest of participants;
- Doesn't seem that interested;
- Enjoyed the experience but not as much as previous users;

#16

- Explored the VE into detail;
- Understood the controllers fast after a short explanation was given;

#17

- Considered Aux* (adult > 30 years);
- Assistance needed with controllers;
- Positive attitude towards the ending of the testing;
- Interacted a lot with Thomas;

#18

- AV yes;
- Smiles a lot and seems to be very excited about what is about to happen
- Thomas gave him a brief, short explanation in regards to using the controllers;
- During the city tour, he talked with thomas;
- ! 1st crash: VR EX stopped working

#19

- AV yes;
- Smiles;
- Technical support needed throughout entire testing procedure;
- Seems to enjoy the VR app quite a lot

#20

- Considered Aux* (child < 14 years);
- Got a hold of controllers surprisingly fast;
- Answered the questionnaire but was not taken into account for analysis