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A Virtual Promotional Tool for Student Enrolment

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Abstract

Virtual Reality (VR) has become more of a commodity in the past years due to the emergence of mobile VR head-mounts, which present a more affordable provider of VR by combining smartphone sensory data, and head-mount with applications made for the platform using the infrastructure of the smartphones. The VR phone application designed for the purpose of this study enables a realistic 360° virtual environment. The application is designed with the Aalborg University Esbjerg public relations department staff as stakeholders. The content displayed within is designed to attract potential students of Aalborg University Esbjerg, thus the scenes depict facilities provided by the university and its surrounding areas. Achieving this is possible using a Samsung Gear VR head-mount and one of its compatible smartphone attachments (Samsung Galaxy S7). The content displayed within the app is live-action and shot with a Samsung Gear 360 camera. A presence questionnaire is used to measure the level of involvement the user experienced. This facilitates a comparison study between the VR application and a more traditional tablet application. A secondary study was conducted in order to further analyse the possible impact that the addition of sound to the VR application might have over the level of presence. Results indicate that the users wearing VR head-mount experienced a higher level of presence compared to the ones using the tablet version. However, results show that the addition of sound has not statistically contributed to the increase in the level of presence as expected.

Keywords: Virtual Reality, VR promotion, student enrolment, 360° imagery, immersion, presence

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1. Introduction

This study focuses on the design of a virtual reality promotional tool through a user-centered approach. The application was designed in collaboration with the public relations (PR) department of Aalborg University Esbjerg as prototype tool for recruiting new students. This collaboration determined members of aforementioned department along with other university representatives (ambassadors) to become stakeholders in the project.

The quality of the experience, and the possibility of becoming a successful student enrolment tool, is interpreted through the level of presence generated by the VR experience. Having this in mind, researchers of this study have analysed the distinct features of the virtual environment and how they impact the level of presence. The promotional tool was created with the Unity game engine and displayed using the Samsung Galaxy S7 placed in the Samsung Gear VR head-mount. The Samsung Gear VR uses the technology developed by Samsung for the phones (initially the Galaxy Note 4) such as the GPU/CPU capabilities and the screen design and adds technology similar to previous Oculus products (Oculus VR, 2014) [1]. The promotional tool created for this study experienced two major iterations. The first one focused on designing a virtual reality experience through the comparison with a traditional system. The second iteration studied the addition of sound to the VR system.

Virtual Reality (VR) is defined as "an artificial environment which is experienced through sensory stimuli (such as sight and sound) provided by a computer and in which one's actions partially determine what happens in the environment" [2]. It has been a rising point of interest in

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the tech industry, especially due to the launch of commercial models, such as the Oculus Rift, Samsung Gear VR, and the HTC Vive [3].

The usage of VR covers a wide variety of applications and industries, such as healthcare, rehabilitation, sports, education and the media. Therefore, there are various ways in which VR can be implemented, that can provide enormous benefits for its users [4].

Designing a virtual environment that could successfully meet the users' expectations in terms of immersion and presence is achievable using User-Centered Design (UCD) techniques that involve the active focus on end-users, as well as their implications in the design process of the virtual world, as observed by Kujala (2003) [5]. For this reason, the authors of this current study have taken a user-centered approach to the construction of the prototypes.

In the early development stages of the virtual reality application several prototype design techniques were considered such as brainstorming, storyboards and role play prototyping. Categorized as *ideation* design methods, these techniques share the common goals of achieving better visualization of design ideas and effective concept testing, as detailed in Design Kit (2015) [6].

Designers of this study have prototyped early ideas through storyboards, which provided a better understanding of the application's intended layout. Following the implementation of storyboards as part of the initial prototype development stage stakeholders were allowed to directly interact with this early prototype and explore the environment through the perspective of potential AAUE students. The benefits brought by role playing consisted in designers' ability to become more considerate and empathetic towards the content created and displayed within the virtual environment.

Presence has been considered to have an important role in improving attitudes and behaviours towards the content displayed. The ability of virtual reality to create a sense of presence has been considered a positive quality, especially when promoting location or being used as a tourism tool. VR has been found to be an effective tool in marketing, improving attitudes towards potential destinations [7]. While the VR tool used within this study is not used for tourism, it still promotes a university and, to an extent, the city in which it resides, therefore there are some similarities in their purpose.

It is argued that "The key to defining virtual reality in terms of human experience rather than technological hardware is the concept of presence" [8]. As a result, defining presence has proven important in furthering the understanding of virtual reality. Presence is defined as a feeling of being present in a virtual environment [9] [10]. Gibson (1979) suggests that presence is "the experience of one's physical environment; it refers not to one's surroundings as they exist in the physical world, but to the perception of those surroundings as mediated by both automatic and controlled mental processes" (as mentioned in Steuer, 1992) [8]. What creates the illusion of presence is the cameras' omnidirectional perspective through which users observe the virtual environment [11][12].This type of environment can be created with multiple methods including computer generated imagery, but the virtual environment used for this study was made using live-action footage shot with a Samsung Gear 360 camera.

In line with Steuer [8], there are two main components in determining presence: interactivity and vividness which, itself, is determined by sensory breadth and sensory depth. As defined by Steuer [8], breath "is a function of the ability of a communication medium to present information across the senses" (p.12). It can be considered as a summation of all simultaneous perceived stimuli. The more sensory rich the technological environment is, the more it creates a sense of vividness for the viewer. Sensory depth refers to the amount of information stored in each stimulus. The addition of an audio stimuli to visual stimuli might reduce the level of depth of the visual, even though the level of breath would have overall increased. However, it is hard to predict how this will impact the overall level of presence and in turn vividness (Steuer, 1992) [8]. Further research puts into question which elements must be taken into consideration when designing a soundscape that aims to increase the presence of a VR user [13].

The sound delivery method should be focused on enhancing low frequency content and possibly across multiple channels. Depending on the playback platform (in the case of this project headphones were used) a spatialized effect should be added to objects in motion indicating their position within the virtual space. Interactivity within the soundscape can provide a larger sense of realism if the audio reacts to the relative position of the users' head. Other adjustments can be considered more common within traditional media as well, such as a variety within the soundscape, exaggeration of certain sounds over others and a control over the quantity of sounds allocated to each object within the scene [13].

In the past, advertisers have used VR in combination with traditional advertising methods, such as talking to them while using a head-mount or while waiting in line to use one [13]. According to Craig, Sherman and Will [13] the use of VR in advertising has a participatory component with direct interaction between people and the advertising campaign. There is a superficial component in using VR for advertisement. People can be attracted to VR due to the novelty of the technology [13].

However, there are multiple practical benefits to using VR, particularly information that should be presented in 3D. In addition, any 2D information can also be mapped and presented in 3D. Using VR as a tool of advertising is still a novelty, and more and more companies and facilities are taking it into account in order to attract potential customers. When it comes to advertising, VR Tours have been made to strengthen the connection between universities and future students by transporting prospective applicants into a three-dimensional world where the immersive experience is built up from photos or videos of the university campus and its surroundings [14].

The organization of this paper is as follows: Section 2 covers related work on VR and advertisement based on VR technology. Section 3 describes the design and development process behind creating the VR experience. Section 4 delves into the methods used for testing the application. Section 5 outlines and discusses the results of the conducted tests, and section 6 gives concluding remarks. The Appendix contains the questionnaires used in the respective evaluations.

2. Related work

Khora-VR (2019) [15] and Virsabi (2019) [16] are two Danish companies that specialise in creating virtual reality experiences for marketing and advertising. Khora-VR developed an application for showcasing the city of Copenhagen using filmed 360° footage. Virsabi did similar work with some of their projects even doing 360° recordings of artistic performances.

When promoting education, Ideal's Insight's [17] 360° Google Tours - Education allows users to showcase their university facilities and create virtual open days for many students and parents that cannot attend school opening ceremonies. Designed in partnership with Google Virtual Tours, this website offers users the possibility to show their university features and overall architecture for the majority of international students. It provides a point of reference for those who have already attended the open days but would like to revisit the university to reflect on whether or not it meets personal educational expectations. What links 360° Virtual Tours with the VR application designed for this study is the main focus for its development: allowing future university students to virtually visit the institute along with its facilities so that they choose according to their educational preferences.

You Visit (2019) [18] is a web-based application used for the promotion of certain university campuses. The fact that it is web based allows for flexibility when it comes to the hardware used to display it. The 360° shots are accompanied by narrations and an overlayed interface.

Apart from being used as both marketing and academic promotion tool, VR has also influenced the tourism branch. Boyle [19] therefore presents Fearless360°, a project created by filmmaker Sandy Cioffi and other collaborators that focuses on showcasing the Seattle area with the use of VR. Their goal is to gather and immerse their audience in reality-based environments in order to exchange community stories and oral histories, reflecting on what might actually influence cities with an increasing cultural richness, such as Seattle. Alike Fearless360°, the VR phone application created within the scope of this project is also aiming to promote the university's city surroundings, which consist of Esbjerg main tourist attractions, as well as Fanø Island.

Adding to the VR experience, 360° videos have also shown to impact how users perceive the virtual environment. A concept that explores this is Elevate, a cinematic VR experience developed by UNIT9 [20] in partnership with Lexus and Team One. Elevate presents a three-minute long film where viewers are guided by pro cyclist Christian Vande Velde through ocean-view mountain roads, offering them an exclusive perspective of what cycling means for professional trainers. A similar experience is provided by the VR phone application developed in this work; the viewers are presented with a short 360° videos of both university and city surroundings that seek to offer the ability to virtually transpose themselves to the real locations.

3. The VR Promotional Tool

In order to avoid confusion and maintain consistency throughout the paper, a naming convention was set in place for the two main prototypes developed for this study. Thus, the VR application displayed using the Samsung smartphone and Samsung Gear VR will from this point on be referred to as the VR-System. The 360° content displayed on a normal tablet using the touch function for navigation will be referred to as the Tablet-System.

For the purpose of this study, an application was developed that could display various locations of AAU Esbjerg as well as the surrounding city of Esbjerg. The mobile VR application uses stereoscopic vision to create the illusion of depth, displayed through a VR head-mount. The ambassador next to the user controls what scenes are shown with the use of a tablet, connected to the VR head-mount via Bluetooth (Fig. 1).

The VR mobile application was created using Unity. The scenes consist of a sphere with the user's perspective camera placed in the middle. The 360° video and images are encoded on an equirectangular plane, which can be described as a stretched plane that can be converted into a spherical object. This gives the viewer a feeling of omnidirectional camera placement, as their viewpoint is in the centre of the sphere. The 360° video was recorded using the Samsung Gear 360 camera, which combines the footage from two fisheye lenses that separately record 180° scenes [21]. These videos are afterwards stitched together in an equirectangular projection [21]. Some scenes are added as images due to little or no motion in the scenes. The application was built with VR Support enabled for Cardboard [22]. In the early stages the footage would render with visual distortions when placed in Unity. This was fixed by increasing the number of texels within the sphere, thereby allowing the images to render in their normal shapes.

Another problem with the visuals concerned the transitions between scenes. The sphere within the virtual environment would load images onto it by default. This would result in issues when trying to switch between scenes with images and scenes with videos. The viewer would experience brief moments when the screen would go black (similar to a flickering effect) interrupting their experience. This was fixed by the use of a loading screen between scenes to mask the unpleasant effect.

Figure 1. The VR-System, consisting Samsung Galaxy S7 phone mounted in a Samsung Gear VR, connected to a Nexus 9 tablet, and a Samsung Gear 360 to film 360° footage.

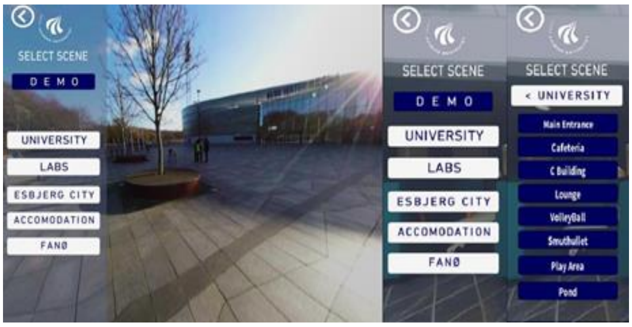

Figure 2. Application interface with the five main categories, and sub-menu with the viewable locations for one of the main categories.

As part of the VR-System a tablet was used to switch between the multiple scenes available within the application. The software used on the tablet was also made in Unity and consists of a preview of what the VR user sees. It also features a dropdown interface overlayed on the preview with buttons corresponding to each individual scene (Fig. 2). The colours and fonts used for the interface were chosen in accordance with the Aalborg University Design Guidelines [23], in order to remain consistent with the university's aesthetics. The interface was designed as a sidebar with a transparent background that can be removed from the scene. The design of the interface aims towards a minimalistic and intuitive approach. The filmed locations are listed in categories dependent on the area in which they were shot (Fig. 2 and Fig. 3). They correspond to five buttons, that when pressed, give access to all the locations within that category (Fig.2). For those wanting a quick experience a demo section was added.

Sound was added to the VR application in order to complement the visuals and increase the overall level of presence. The audio was either recorded with a hidden external microphone or with the microphone within the 360° camera. The motivation behind placing audio in some of the scenes was to give additional context to what was shown. For example, if the scene depicts a chemistry laboratory, then an actor in the scene explains what usually happens in said laboratory. Moreover, the updated VR application also implements a mute/unmute button option, placed on the tablet, as seen in Fig. 5, that would turn off the application's sound.

When the VR application is installed on a smartphone, it functions using stereoscopic vision. The stereoscopic vision is the actual visual output of the application (Fig. 4). This configuration creates two screens showing approximately the same area of a scene. The image creates the illusion of depth by using stereopsis for binocular vision [24]. The camera within the scene uses the readings provided by the gyroscope in the Samsung Galaxy S7 and transforms them into usable camera angles. In comparison, the view seen on the connected tablet shows only one screen (Fig. 2).

The tablet used as part of the VR-System takes the incoming camera rotation axis of the phone. Firstly, the phone's gyroscope readings are placed in an x-, y- and z-axis coordinate system, in order to read its real-time orientation. Afterwards, the orientation is converted into a string, which is then transmitted to the tablet via Bluetooth. Once the string has been received by the tablet, the data is converted into a three- dimensional vector, for the tablet to track the same head movement as the phone. This enables the guide to determine what the user is looking at and provide an explanation about the virtual setting.

The connection between the tablet and the phone is established via a Universally Unique Identifier (UUID), which is a 128-bit number used to identify another Bluetooth device. This connection would send bytes of string values to each other. The tablet would send continuous updates on the current active scene, and the phone would send the xyz-rotation values from the gyroscope.

Figure 3. Photo examples of locations available to view in the application.

Figure 4. On the left: sphere providing omnidirectional view. In the middle: equirectangular projection. On the right: stereoscopic view.

The tablet is setup with the same UUID, thus being able to connect to the Samsung Galaxy S7 phone using Bluetooth. It uses a pre-connection interface that enables the user to manually search for the phone and connect to it. Once a connection to the phone has been established, the tablet switches to the standard interface (Fig. 2).

One of the main issues encountered in the development of the application was the connection between the tablet and the smartphone. Initially the inputs sent by the phone would overload the tablet system causing it to crash. This was fixed by reducing the frequency of the inputs to every 100 milliseconds.

As part of a comparative study, a Tablet-System was created as an alternative to the VR-System. This version uses the touchscreen of the tablet to rotate the camera in the 360° environment. The Tablet-System also uses the described interface (Fig. 2); however, without the VR support and the Bluetooth connection. Instead, the user watches the same 360° videos on the Tablet-System. Hence, the major differences between the two prototypes being that the users control the tablet themselves and viewing the area on a 2D screen instead of using a VR head-mount.

Unity also contains a component called Audio Source which enables audio within the virtual environment. Once a scene becomes active, it can be set to play this audio file according to the video that is shown to the viewers. The audio can either be taken from the video or a separate audio source can be added. In order to maintain a certain level of control of the visuals a reset function was implemented. This function resets the orientation of the camera to a default when the scene is switched. This gives the viewer a definite starting point for each scene regardless of the rotation of the camera beforehand.

Another function is the mute and unmute button on the tablet, as seen in the top right corner of Figure 5. The Mute/Unmute option turns off the application's sound. Figure 6 presents a guide with steps regarding the start-up process of the application. The empty space beneath the two buttons is allocated to warnings, in cases where the tablet would register a loss in connection.

Figure 5. The Mute/Unmute button

Figure 6. Application start-up guide

4. Methods

Initially the VR application was designed alongside a two-dimensional display on a tablet. Therefore, the initial procedure was created as a comparison study between the two (Experimental Procedure I). After completing this study, it was decided to focus only on the design of the VR application. This concerned solving technical issues and the addition of new features such as sound. As a result, the second procedure focuses on the impact the addition of sound has on the level of presence of the application (Experimental Procedure II).

4.1. Experimental Procedure I

This procedure tested for presence using the VR-System compared to the Tablet-System. An experiment was conducted using a between-group design in which each group experienced the 360° footage in different ways: One group used the VR head-mount (experimental group) while the other experienced it on a tablet (control group) [25]. Both conditions had different, yet similar applications, the distinction being the delivery format of the virtual experience. After participants had tested either version of the prototype, they were requested to fill out a questionnaire regarding presence and partake in an interview regarding presence and the overall experience of the prototype (see Appendix).

The questionnaire used for the experimental test was designed to examine the level of presence experienced by the users while using the virtual reality application. The format of the questionnaire is derived from Witmer and Singer's [26] original questionnaire that measures the amount of presence participants feel during test sessions. The answers consist of ratings on a scale from 1 to 6, where 1 is "Not at all" and 6 is "Completely" and refer to different aspects of the virtual environment (see Appendix).

Twenty-four volunteer gymnasium students participated in this study, with ten of the participants being from Esbjerg Gymnasium and fourteen from Rybners Tekniske Gymnasium. All participated were given a brief verbal description by the test facilitators and had the right to end the experiment at any time they desired. The participants were randomly assigned to either the experimental condition (VR-System) or the control condition (Tablet-System).

In the control condition, participants were navigating through the 360° footage of the university using the Tablet-System. By using the tablet's touchscreen, the users could fully rotate the environment. In the experimental condition, participants used the Samsung Gear VR head-mount while one of the test moderators acted as a guide switching to the destinations the user requested. The moderator used a tablet with all the scenes available and a live view of the user's perspective from inside the 360° environment. The moderator described each setting to the students as they explored different locations of AAU Esbjerg Campus and its surroundings.

4.2. Experimental Procedure II

A second version of the VR application was designed later in the process that incorporated audio into the environments. A test was conducted to analyse how the addition of audio would impact the level of presence in a Virtual Reality experience. Developed within the same experimental design as the aforementioned procedure, this experiment aimed to compare responses in a control condition (original VR application) and an experimental condition (updated VR application). A total of forty-four gymnasium students participated in this study. They were randomly assigned to two different groups: one group interacted with the first version of the VR-System, whereas the other experienced the updated VR application that incorporated audio.

During the control condition, participants were navigating through the university's Virtual Reality Environment (VRE), by using the Samsung Gear VR headset while one of the test moderators acted as a guide, transporting them to distinct virtual locations by using the tablet for a preview. The moderator guided the users through the different settings of both Aalborg University Campus and Esbjerg, providing short oral descriptions of what was being displayed.

In the experimental condition, participants were navigating within the same VRE but without a moderator present to describe the settings. The (updated) VR application used in this testing procedure implemented the use of both narrative structures and audio descriptions of virtual locations: scenes which showcase various university facilities where students and staff are describing undergoing projects or everyday student life.

Both testing conditions lasted for an average of 10 minutes each. Once done testing, participants would fill out a questionnaire, designed such that researchers would investigate the level of presence generated by VR application. The questionnaire format is derived from the Witmer and Singer's (1998) [26] original questionnaire which analyses the amount of presence felt by participants during testing sessions. Its design is similar to the questionnaire used in the first experimental procedure, but it also incorporates questions regarding the impact of an audio feature implemented in an interactive application, as can be seen in Appendix.

5. Results and Discussion

There were two testing procedures implemented within this study, therefore to two sets of results were gathered. The first set of results (Experimental Procedure I) showcase the difference in terms of presence between the VR-System and the Tablet-System as part of a comparative study. The second set of results (Experimental Procedure II) focuses only on the VR-System and difference the addition of sound has on the application in terms of presence.

5.1. Experimental Procedure I

The rated feeling of presence in the VR-System ($\overline{x}$= 3.95) compared to the Tablet- System ($\overline{y}$ = 3.70) shows a difference in means of 0.25. The collected data was tested for normality (Shapiro-Wilk test) and homogeneity of variance (F-test). Both conditions showed to be fulfilled; hence, a one-tailed independent t-test was applied to test if the experienced level of presence is statistical significantly higher in the experimental condition than the control condition. While it was hypothesised that the VR-System would result in a higher feeling of presence compared to

Table 1. Results and statistics of the presence questionnaire

Question	$\bar{x}$	$\bar{y}$	$\bar{x}$ - $\bar{y}$	S_x	S_y	U_{stat}	U_{crit}	z	r	p
Q.1	4.58	4.58	0.00	0.51	0.67	68.5	42	0.17	0.04	0.4325
Q.2	5.00	4.08	0.92	0.74	1.38	43.5	42	-1.62	-0.33	0.0526
Q.3	4.33	4.25	0.08	0.89	0.87	67.5	42	-0.23	-0.05	0.4901
Q.4	4.58	4.75	-0.17	1.38	0.87	71.0	42	0.03	0.01	0.4880
Q.5	4.83	4.83	0.00	1.11	0.94	70.0	42	-0.09	-0.02	0.4641
Q.6	2.25	2.00	0.25	1.36	1.21	65.0	42	-0.38	-0.08	0.3520
Q.7	3.25	2.42	0.83	1.29	0.90	45.5	42	-1.50	-0.31	0.0668
Q.8	2.50	2.25	0.25	1.57	1.22	67.0	42	-0.26	-0.05	0.3974
Q.9	4.25	4.17	0.08	0.75	0.72	67.0	42	-0.26	-0.05	0.3974
Total	3.95	3.70	0.25	0.46	0.41	-	-	-	-	0.0885

the Tablet-System, which is also indicated by the difference in the means, the one-tailed independent t-test showed no statistically significant difference ($p = 0.0885$) using a level of significance $\alpha = 0.05$.

Statistically significant results may be achieved with a larger sample. Considering the possible future use of the VR application as an advertising tool for both Danish and international fairs, a potential course of action could be to use the VR phone application at student fairs while still gathering constructive feedback from users.

To investigate if any particular aspect of the presence questionnaire is statistical significantly higher for the VR-System, statistical tests of the ratings of each question were conducted. For this purpose, a non-parametric test (Mann-Whitney test) was applied, since the data could not be assumed to normal distributed. The Mann-Whitney test revealed no significance within the results. In Table 1, the results are listed per question, and the questions can be found in the Appendix.

In accordance with the Mann-Whitney test, the statistical value (Ustat) has to be less than the critical value (Ucrit) for the U-value to be statistically significant. According to the Mann-Whitney critical value sheet for one-tailed tests, the critical value for the experimental test is Ucrit = 42 at $p < 0.05$, due to the number of participants in each group being 12 (Table 1).

Statistically, the results proved to be not significant. The Ustat-values are all greater than Ucrit-values (Table 1). From the z-score, the r-value and the p-value can be calculated, and just as the U-values, they proved the results to not be statistically significant ($p > 0.05$). While none of the results showed any statistical significance, the lowest p-values and the largest differences in means are for questions Q.2 (revolving immersion by the visual aspects) and Q.7 (How distracted by visual display quality).

5.2. Experimental Procedure II

The rated feeling of presence in the original VR application compared to the updated VR version shows a difference in means of 0.18. The collected data was tested for normality (Shapiro-Wilk test) and results indicated that only condition I (control condition) had data normally distributed. Due to non-normality, a Mann-Whitney test was conducted in order to check if the null hypothesis (H0) can be rejected, and if yes, provide an alternative (H1):

H0: The addition of sound does not impact the level of presence.
H1: The addition of sound does impact the level of presence.

While it was hypothesised that the addition of sound to the original VR application would impact the overall level of presence in comparison with previous findings, the Mann-Whitney test indicated that the null hypothesis is not rejected, meaning that there is no statistical significant difference ($p = 0.157 > 0.05$) using a level of significance $\alpha = 0.05$.

Table 2 illustrates the two testing conditions, specifically, calculations and comparison of the means for each question. Despite of not showing any statistical difference between the two conditions ($p > 0.05$), there are several results worth analysing.

As it can be noticed, the scores registered in Q5 (regarding adjustment to the virtual environment) do not present any difference in mean, outcome possibly due to the randomization of users within the two groups. On the other hand, Q7 (how distracted by visual display) showed that participants who interacted with the updated VR application have scored higher than others, even though all users have navigated through the same virtual environment.

The most noticeable difference between the means of the two conditions were registered when researchers analysed the data collected from Q9 (*"How much did your*

Table 2. Results and statistics of the presence questionnaire

Question	$\bar{x}$	$\bar{y}$	$\bar{x}$ - $\bar{y}$	U – Value	z	r	p
Q.1	4.45	4.05	0.4	181.0	-1.51	-0.23	0.13
Q.2	4.55	4.36	0.19	215.0	-0.70	-0.11	0.48
Q.3	4.77	4.59	0.18	228.0	-0.34	-0.05	0.73
Q.4	4.68	4.50	0.18	214.5	-0.69	-0.1	0.49
Q.5	4.45	4.45	0	241.0	-0.25	-0.04	0.98
Q.6	3.50	3.36	0.14	227.0	-0.36	-0.05	0.72
Q.7	3.59	3.77	-0.18	222.5	-0.46	-0.07	0.64
Q.8	3.77	3.50	0.27	221.5	-0.49	-0.07	0.62
Q.9	4.36	3.91	0.56	177.0	-1.60	-0.07	0.11
Total	4.23	4.05	0.18	-	-	-	0.16

experience in the virtual environment tour seem consistent with your real-world experiences?"): control condition - 4.36 and experimental condition - 3.91. Moreover, this difference in scores disproves the assumption that the addition of audio would have a positive effect on the overall level of presence. Further results show that the implementation of sound within the application had adverse effects on the users' experience with the virtual environment. The overall score analysis points out that participants were more involved when navigating through the VRE with no audio included. The addition of sound was analysed by adding four question to the questionnaire used in Experimental Procedure I, taken from the Witmer and Singer (1998) [24] questionnaire (see Appendix).

Table 3. Descriptive statistical analysis of presence (with audio)

Question	Mean	Median	Variance	Std. Deviation
Q.10	3.95	4.00	1.448	1.203
Q.11	3.90	4.00	1.490	1.221
Q.12	3.90	4.00	1.590	1.261
Q.13	4.67	5.00	1.233	1.111

The statistical analysis presented in Table 3 shows little difference in the means of each question, exception being the mean registered for Q.13 (regarding localization of sounds). While it was expected that Q.10 and Q11 would achieve higher scores due to their main points of analysis (how involved were users by the auditory aspects), results have shown no statistical difference among the four VR-sound related questions.

5.3. Test Interviews

To establish how many of the participants had previously interacted with the technology, the participants were questioned whether they had tried a VR head-mount or viewed 360° video prior to the test. Twelve of the participants had previously tried a VR head-mount, and fifteen of the participants had previously encountered 360° videos on platforms such as YouTube or Facebook.

When questioned whether the participants had a feeling of presence or not while using either of the prototypes, all participants replied positively. When questioned about why they had this feeling of presence, the participants explained it was affected by the motion of the footage as it helped give a feeling of being part of the scenery, rather than watching a still-image. However, the feeling of presence varied from one individual to another. Two of the participants testing the VR-System explained that while they had a slight feeling of being present at the shown locations, they were still aware of their actual surroundings. One participant testing the VR-System explained that he/she visually felt present at the locations, but otherwise did not feel as if they were present at the locations.

Afterwards, the participants were questioned on what their experience was with the prototype. While there were similar answers in both groups there were a few answers focused towards on specific issues. Overall, the participants were positive towards both prototypes, and they expressed it gave a different view and better look into the daily life of Aalborg University Esbjerg rather than what a still-image would offer them. Furthermore, some of the participants thought it was a fun way to do promotion and created curiosity about the locations that were shown on the prototypes.

Ten people wished the video quality to be improved, as they believed a sharper picture would help increase the visual feeling of presence. Three of the participants also suggested the addition of realistic sound to the scenes, so not only would they be able to see what was happening in the different scenes they were shown, but also hear it. To this end, four other participants suggested to decrease external noise. The tests were conducted in fairly crowded areas creating noise, which was distracting for some of the participants. Two of these four participants suggested noise-cancelling headphones, though this would be problematic when the moderators should be able to explain what the user is seeing. A solution for this situation involved a pre-recorded scenario that has an audio track following the scene they are watching.

6. Conclusion

The collaboration with the stakeholders, AAU Esbjerg PR department, has resulted in a functional VR prototype that can be brought into a real-world scenario, and has proven to be a promotional tool that attracts people and can keep them invested. Experimental results indicate that the users wearing the VR head-mount experienced a higher level of presence compared to the ones using the tablet version. However, due to statistical uncertainty, no statistically significant difference between the tablet and VR version was found. The most important issue with the current version of the VR-System is the video quality. The study revealed that both the VR-System and the Tablet- System show potential for effectively using 360° footage for promotional purposes.

The low performance of the prototype version that incorporates sound could be related to faulty sound design. Due to lack of proper equipment, the audio from the actual shooting location was recorded with either a phone microphone or with the internal microphone of the Samsung Gear 360° camera. In addition, some of the filmed laboratories had a high amount of background noise from machines which made it hard to hear the people.

In conclusion, further research is required to determine by how much a UCD approach is affecting the level of presence in a Virtual Reality promotional tool. In order to achieve more significant results, a larger sample size of participants would be required for further field-testing sessions, as well as a more constant implication of stakeholders within the prototypes' development stages.

Appendix

Presence Questionnaire

- Q.1. How natural did your interactions with the virtual environment seem?
- Q.2. How much did the visual aspects of the virtual environment tour immerse you?
- Q.3. How compelling was your sense of moving around inside the virtual environment tour?
- Q.4. How involved were you in the virtual environment tour experience?
- Q.5. How well did you adjust to the virtual environment experience?
- Q.6. To what extent was there a delay between your actions and their effects in the virtual tour?
- Q.7. How much did the visual display quality interfere or distract you from performing the virtual tour?
- Q.8. To what extent did events occurring outside the virtual environment distract you from your experience in the virtual environment tour?
- Q.9. How much did your experiences in the virtual environment tour seem consistent with your real-world experiences?

Presence Questionnaire (addressing audio)

- Q.10. How much did the auditory aspects of the virtual environment involve you?
- Q.11. How much did the audio descriptions of the virtual locations involve you?
- Q.12. How well could you identify the sounds?
- Q.13. How well could you localize sounds?

Test Interview

- Q.1. Have you tried to use 360° video and/or a VR head mount before?
- Q.2. How was your experience with the prototype you tested?
- Q.3. Did you get a feel as if you were on any of the shown locations? If not, why?
- Q.4. What would you change about the prototype if you could?

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References

[1] Oculus VR. (2014). Introducing the Samsung Gear VR Innovator Edition. [online] Oculus.com. Available at: https://www.oculus.com/blog/introducing-the-samsung-gear-vr-innovator-edition/?locale=en_US [Accessed 10 Apr. 2019].

[2] Merriam-webster.com. (2019). Definition of VIRTUAL REALITY. [online] Available at: https://www.merriam webster.com/dictionary/virtual%20reality [Accessed 10 Apr. 2019].

[3] Wareable. (2019). Best VR headsets 2019: HTC Vive, Oculus, PlayStation VR compared. [online] Available at: http://www.wareable.com/headgear/the-best-ar-and-vr-headsets [Accessed 10 Apr. 2019].

[4] Virtual Reality Society. (2019). How is Virtual Reality Used? - Virtual Reality Society. [online] Available at: https://www.vrs.org.uk/virtual-reality/how-is-it-used.html [Accessed 10 Apr. 2019].

[5] Kujala, S. (2003). User involvement: A review of the benefits and challenges. [ebook] Available at: https://www.researchgate.net/publication/220208710_User_involvement_A_review_of_the_benefits_and_challenges [Accessed 10 Apr. 2019].

[6] Design Kit (2015). Methods: IDEATION. In Design Kit (Eds.), The Field Guide to Human-Centered Design. (pp. 113-114, 118).

[7] Tussyadiah, I., Wang, D., Jung, T. and tom Dieck, M. (2018). Virtual reality, presence, and attitude change: Empirical evidence from tourism. Tourism Management, 66, pp.140-154.

[8] Steuer, J. (1992). Defining Virtual Reality: Dimensions Determining Telepresence. Journal of Communication, 42(4), pp.73-93.

[9] Bates-Brkljac, N. (2012). Virtual Reality. Hauppauge, New York: Nova Science Publishers Inc.

[10] Sanchez-Vives, M. and Slater, M. (2005). From presence to consciousness through virtual reality. Nature Reviews Neuroscience, 6(4), pp.332-339.

[11] Bessa, M., Melo, M., Barbosa, L. and Raposo, J. (2016). Does 3D 360 video enhance user's VR experience? An Evaluation Study. In: Proceedings of the International Conference on Human Computer Interaction. [online] Salamanca, Spain: ACM, pp.1-4. Available at: https://dl.acm.org/citation.cfm?id=2998669 [Accessed 10 Apr. 2019].

[12] Zimmermann, M., Helzle, V. and Arellano, D. (2016). Longing for Wilderness. In: ACM SIGGRAPH 2016 VR Village, pp. 1-2. Available at: http://epicscapes.de/ longing-for-wilderness.html [Accessed 10 Apr. 2019].

[13] Craig, A.B, Sherman, W. and J.D., W. (2009). Developing Virtual Reality Applications: Foundations of Effective Design. New Jersey: Morgan Kaufmann.

[14] Lister, D. (2016). How Virtual Reality Tours Are Changing the Way Universities Recruit Students. [online] Statusdigital.co.uk. Available at: https://www.status digital.co.uk/blog/how-virtual-reality-tours-are-changing-the-way-universities-recruit-students [Accessed 10 Apr. 2019].

[15] Khora Virtual Reality (2019). We are Virtual Explorers! [online] Available at: https://khora-vr.com [Accessed 16 Jun. 2019].

[16] Virsabi - virtual reality in business, Strategy, Design & Development. (2019). [online] Available at: https://virsabi.dk [Accessed 16 Jun. 2019].

[17] Ideal Insight - Specialist Video & Photography Agency. (2018). 360° Google Virtual Tours | Ideal Insight A Google Trusted Agency. [online] Available at: https://ideal360.co.uk/google-virtual-tours/ [Accessed 10 Apr. 2019].

[18] YouVisit – Create, Share, and Explore Interactive Virtual Reality. (2019). [online] Available at: https://www.youvisit.com [Accessed 16 Jun. 2019].

[19] Boyle, A. (2017). How artists add humanity to virtual reality. [online] GeekWire. Available at: https://www.geekwire.com/2017/artists-add-humanity-virtual-reality [Accessed 11 Apr. 2019].

[20] UNIT9. Lexus: Elevate. [online] Available at: https://www.unit9.com/project/lexus-elevate [Accessed 11 Apr. 2019].

[21] Barazzetti, L., Previtali, M. and Roncoroni, F. (2017). 3D MODELLING WITH THE SAMSUNG GEAR 360. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-2/W3, pp.85-90.

[22] Google Developers. (2019). Quickstart for Google VR SDK for Unity with Android | Google VR | Google Developers. [online] Available at: https://developers.google.com/vr/unity [Accessed 11 Apr. 2019].

[23] Aalborg University (2018). Design guide for Aalborg Universitet. [online] Available at: http://aau.design guiden.dk/ [Accessed 11 Apr. 2019].

[24] Armbrüster, C., Wolter, M., Kuhlen, T., Spijkers, W. and Fimm, B. (2008). Depth Perception in Virtual Reality: Distance Estimations in Peri- and Extrapersonal Space. CyberPsychology & Behavior, 11(1), pp.9-15.

[25] Harboe, T. (2013). Research Design. In: Method and Project Writing - an Introduction, 2nd ed. Narayana Press, Gylling, Denmark.

[26] Witmer, B. and Singer, M. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. Presence: Teleoperators and Virtual Environments, 7(3), pp.225-240.