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THE IMPACT OF VIRTUAL VISUALISATION: PERCEPTION AND DESIGN OF SPACES IN ETHNOGRAPHIC PROJECTS

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ABSTRACT
The use of VR technology within education is an area that has generated great interest in recent years, so this work follows that trend and contains nuances related to user-centred design education. The objective of this work is to identify students' perceptions of the use of VR technology for ethnographic research. A group of 20 industrial design students from Tecnologico de Monterrey conducted a field investigation, which included interviews and surveys, using HMD with videos and stereoscopic images of a public park in Monterrey, Mexico. Based on the research and information analysis, areas of opportunity were identified and urban furniture proposals for the public park that place were generated. Once the design process was completed, an evaluation instrument was applied to measure, through statistical analysis, the students' perceptions of their experience using technology in the design process; gender, qualification obtained and the relevance of the technology used was also considered.

Keywords: educational innovation, stereoscopic images, urban space, furniture, didactic.

1. INTRODUCTION

The visualisation techniques employed by mobile devices have changed a lot in recent years, to the point that the quality of visualisation is comparable to any other display device, such as High Definition (HD) or high resolution television screens. However, this reality has impacted the different standards, uses and available applications of display options.

The perception of different scenarios, landscapes, etc., involve multisensory and simultaneous processes. These actions involve active observation that requires action, control and manipulation by those in contact with the scenario being perceived, in addition to the content of meaning and emotional messages that the people are subjected to (Zube, Sell, and Taylor 1982). In this sense, the concept of architecture or the visualisation of space are largely conditioned by issues related to identity and to the socio-cultural sphere (Leila and Naima 2016). Hence why the perception of spatial elements or architecture is related to several factors that include the socio-cultural exploration of different regions (Zube and Pitt 1981).

Environmental simulations, which play a fundamental role in the practice of certain disciplines, such as architecture and design (Sainz 2005), are not exempt from the use of more traditional techniques, such as paper, until new technologies – in this case, the use of stereoscopic vision devices and virtual reality – are incorporated (Ackerman 2002, Ervin and Buhmann 2003). All of these techniques are also conditioned to the theme of culture and use, which is why the implementation of any type of simulation system should be carefully considered through the practice of space and element perception. This initiative is based on the fact that the use of technology for the purpose of visualiation may be subject to the expertise of both designers and users, so care must be taken to develop valid proposals (Llinares and Iñarra 2014).

With regard to the adoption of virtual reality technology and visualisation, the current trend suggests that a common language is needed, that the technologies are intuitive and that such adoption primarily occurs naturally (Chang and Huang 2014). In the context of architectural and design applications, virtual reality and similar technologies provide opportunities to train professionals in a process of natural adoption, giving them new competencies (Fonseca et al. 2014).

There are, however, additional examples of how to use VR technology and how it can impact an individual's perception of reality and ability to visualise real and virtual spaces, as well as about the places or experiences that can significantly influence an individual's emotional state or quality of life (Rojas et al. 2018, Higuera-Trujillo and Rojas 2019). Among academic subjects, the application of technology is considered one way of improving the experiences of engineering and design students, since technology can create emotional bonds and impact students' performances, as illustrated by Núñez, Rojas and Rodriguez-Paz (2019).

This paper is about the use of stereoscopic images as a didactic element (Baeten, Kyndt, Struyven, and Dochy 2010) to identify different aspects of urban places

(Jordan 1998), with the idea that this technology allows users to generate furniture improvement proposals and, from their usage experiences, consider the impact of different times of day and weather conditions (Aylon 2013).

2. METHODOLOGY

This work was implemented in a second-year course in the Industrial Design bachelor's program of Tecnologico de Monterrey. The goal of the project, which was developed by 20 design students (11 female, 9 male), was to determine opportunities for improvement to the experiential experiences and interactions with urban furniture (Norman 2011) at different times of the day and under different atmospheric conditions, allowing for immersion in the environment regardless of whether they were in the same place.

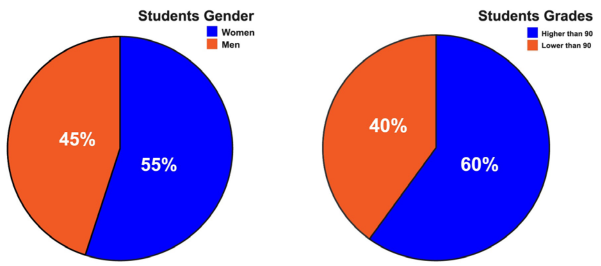

Figure 1: Students who used HMD to analyse the images and videos.

To start the process, a specific urban place was analysed based on 360° videos and images captured using stereoscopic image viewers or Head Mounted Display (HMD) units and smartphones with the THETA S® app (Fu and Hwang 2018). The selected urban space was a 'pocket park' created for the Distrito Tec project, in the city of Monterrey, Mexico (see Figure 2).

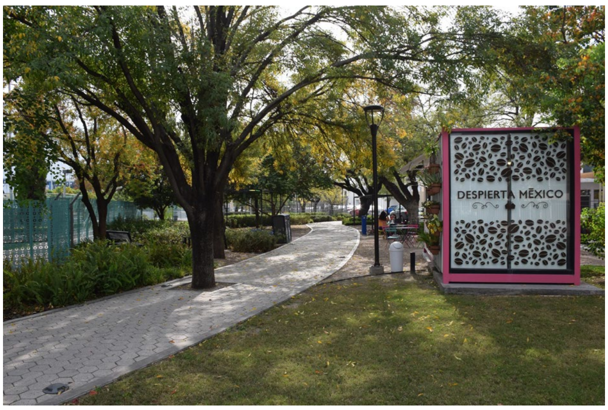

Figure 2: Selected urban space. Pocket park near the Tecnologico de Monterrey campus in northern Mexico.

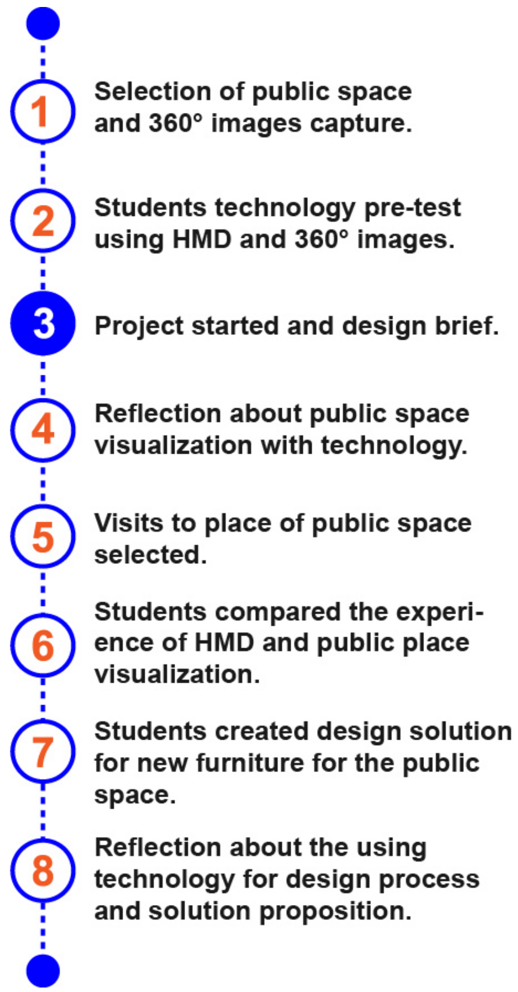

Figure 3: Sequence of the methodological process followed by the students who participated in this project.

Using the videos and stereoscopic images, we sought to determine areas of opportunity where user experience and interaction with street furniture could be improved (Norman 2011). We considered different times of day and different weather conditions (cloudy, sunny, rainy, etc.), which allowed us to appreciate possible changes in the user experience depending on the environmental conditions and time of day (see Figure 4 for an example of a stereoscopic image).

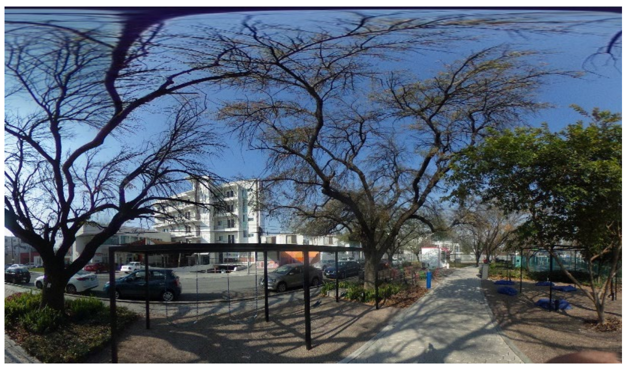
Figure 4: Stereoscopic image of the selected urban space. Pocket park near the Tecnologico de Monterrey campus in northern Mexico.

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Figure 5: Students in the classroom using HMD to analyse the images and videos.

The course focus allowed students to introduce visual technology to the user-centred design process (Figure 5). Subsequently, the class was split into seven groups in total to perform two ethnographic exercises (10 interviews and 30 surveys) (Hernandez, Fernandez, and Baptista 2010; Zapata 2005). Students used a comparative dynamic between traditional visual elements and visual elements perceived using the HMD to determine the influence of technology on the results obtained from the ethnographic exercises.

Figure 6: Example of the HMD devices used.

The construction of ethnographic instruments was a fundamental part of the process. The instruments were designed to contemplate the intrinsic relationship while considering real and virtual immersive visualisation (Higuera-Trujillo, Rojas, Perez, and Abad 2017; Russell 1979). Other relevant questions included estimated time of use, activities carried out, individual or shared use and identification of problems. Data analysis was completed via open coding (Strauss and Corbin 2002), along with multiple choice questions that allowed us to establish patterns, before passing through selective coding (Hernandez, Fernandez, and Baptista 2010) to finalise certain design requirements and key specifications (Ulrich and Eppinger 2013).
To complete the project implementation, a survey-type evaluation was completed by the 20 students who participated in the study in order to assess the impact of technology on their perceptions of their learning. The survey consisted of eight questions, which the students ranked on a scale of one to five. This evaluation allowed us to develop three types of statistical analyses and revealed information about the impact of technology on the perception and design of products and spaces, as presented in the analysis, below.

3. ANALYSIS

The data analysis was divided into three parts, or observations, in order to distinguish the students' VR technology experiences and performance. The first analysis was an observation of the final instrument and the results of the students' general perception based on the eight-question survey. The second analysis was a revision of the statistical comparison obtained by segmenting the data based on gender, opinion and perception of the final instrument. The third analysis was a revision of the statistical comparison obtained by segmenting the data based on the students' performance and perception of the final instrument.
The first analysis assessed the questions about the users' perception of the VR technology, all of which were possible to measure, except for the question of whether the interviewed user was intimidated by VR, as the scale marked a lower value. The data is presented in Table 1.

Table 1: Descriptive statistics of instrument perception.

Opinion perception questions	Mean	Std. Dev.
How much do you consider the use of VR impacts the proposal's relevance?	3.80	0.834
Do you consider the use of VR increases the number of proposals generated?	4.05	0.999
Do you consider that, without VR, you would not have reached the final proposal?	3.05	1.14
Do you consider the interviewed user was intimidated by the VR experience?	2.45	0.999
Do you consider the use of VR influenced the opportunities for detection?	3.90	0.912
How useful do you consider VR to be for ethnographic research for the purpose of design?	4.10	0.912
Do you feel there is a significant difference between using and not using VR technology?	3.65	0.875
How probable is it that you will use VR technology again for future ethnographic research?	4.15	1.040

For the second analysis, a one-way analysis of variance (ANOVA) was performed to compare the opinions gathered from the VR technology experience questions against the students' genders. A complete table of descriptive and statistical results is presented in Table 2. This analysis revealed that two of the eight variables offered significant value (<0.05). Gender represented a significant value for the questions, 'Do you believe the use of VR increases the number of proposals generated?' gender factor showed a significant value ($p=0.008$) and 'How useful do you consider VR to be in the design of ethnographic research?' ($p=0.040$).
For the third analysis, another one-way ANOVA was performed to compare the students' opinions that were

Table 2: Descriptive and statistical results of assessment questions, based on gender.

Opinion perception questions	Factor	Mean	Std. Dev.	F	Sig (ANOVA)
How much do you consider the use of VR impacts the proposal's relevance?	Women Men	3.55 4.11	0.820 0.782	2.454	0.135
Do you consider the use of VR increases the number of proposals generated?	Women Men	**3.55** **4.67**	1.036 0.500	8.801	**0.008**
Do you consider that, without VR, you would not have reached the final proposal?	Women Men	2.73 3.44	1.104 1.130	2.045	0.170
Do you consider the interviewed user was intimidated by the VR experience?	Women Men	2.45 2.44	0.820 1.236	0.000	0.983
Do you consider the use of VR influenced the opportunities for detection?	Women Men	3.64 4.22	1.027 0.667	2.169	0.158
How useful do you consider VR to be for ethnographic research for the purpose of design?	Women Men	**3.73** **4.56**	1.009 0.527	4.928	**0.040**
Do you feel there is a significant difference between using and not using VR technology?	Women Men	3.55 3.78	0.820 0.972	0.337	0.569
How probable is it that you will use VR technology again for future ethnographic research?	Women Men	4.00 4.33	1.183 0.866	0.495	0.491

gathered from the questions about their experiences with VR technology and their performance (grades) on this project. A complete table of descriptive and statistical results is presented in Table 3. The test revealed that only one of the eight variables presented a significant value (<0.05). For the question, 'How probable is it that you will use VR technology again for future ethnographic research?', grades represented a significant value (p=0.031).

4. RESULTS AND DISCUSSION

This work is the beginning of a series of studies that seek to expose the relevance of VR technology within the design process and the teaching of them. In general, the students felt that VR was relevant, and they had a positive experience using this technology. The students primarily found VR helpful in generating new proposals (M = 4.05), useful as an ethnographic method (M = 4.10) and would probably use it again for the same purpose (M = 4.15).

As part of this study, we wanted to observe students' perceptions regarding the use of VR technology for ethnography subjects in design courses. Hence why gender comparisons were made; as there was a high proportion of female students in the class, this observation was relevant. The question, 'Do you consider the use of VR increases the number of proposals generated?', produced a noticeable difference between women (M = 3.55, SD = 1.036) and men (M = 4.67, SD = 0.500), with men appearing to be more invested than women in technology. The question, 'How useful do you consider VR to be for ethnographic research for the purpose of design?', also showed a relevant difference between women (M = 3.73, SD = 1.009) and men (M = 4.56, SD = 0.527), with men apparently considering VR to be an ideal technology for this type of project.

We also observed, with particular interest, the perceptions of students who achieved high or regular grades (on a scale of zero to 100) for their performance on the project. To obtain this result, one of the eight survey questions asked, 'How probable is it that you will use VR technology again for future ethnographic research?' There was a difference of opinion between the students who scored higher than 90 (M = 3.75, SD = 1.138) and those who scored lower than 89 (M = 4.75, SD = 0.463), where students who scored below 89 responded that they would use technology more safely. This difference can open a window to related research, such as the relevance of this technology for similar projects and empathy for students who seek higher qualifications. These results are presented in Figure 7.

Table 3: Descriptive and statistical results of assessment questions, based on performance (grades).

Opinion perception questions	Factor	Mean	Std. Dev.	F	Sig (ANOVA)
How much do you consider the use of VR impacts the proposal's relevance?	Higher than 90 Lower than 89	3.92 3.63	0.900 0.744	0.575	0.458
Do you consider the use of VR increases the number of proposals generated?	Higher than 90 Lower than 89	4.17 3.88	1.267 0.354	0.396	0.537
Do you consider that, without VR, you would not have reached the final proposal?	Higher than 90 Lower than 89	3.08 3.00	1.311 0.926	0.024	0.878
Do you consider the interviewed user was intimidated by the VR experience?	Higher than 90 Lower than 89	2.67 2.13	1.155 0.641	1.445	0.245
Do you consider the use of VR influenced the opportunities for detection?	Higher than 90 Lower than 89	3.83 4.00	1.193 0.000	0.153	0.700
How useful do you consider VR to be for ethnographic research for the purpose of design?	Higher than 90 Lower than 89	4.17 4.00	1.115 0.535	0.153	0.700
Do you feel there is a significant difference between using and not using VR technology?	Higher than 90 Lower than 89	3.83 3.38	0.937 0.744	1.340	0.262
How probable is it that you will use VR technology again for future ethnographic research?	Higher than 90 Lower than 89	**3.75** **4.75**	1.138 0.463	5.486	**0.031**

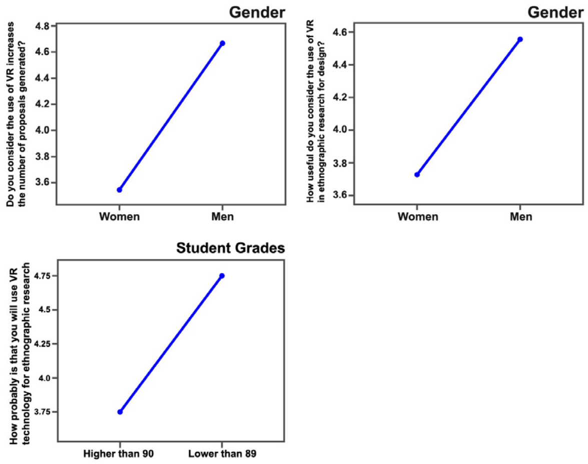

Figure 7: Graphic results of the comparison analyses for gender and grades.

Finally, all of these results allow us to establish a very interesting relationship between the impact, the use of technology and the direct results of the design projects completed by the students. This relationship allowed the students to identify, immerse themselves within and understand the influence of a space (pocket park) under different conditions. Likewise, it was possible to observe the differences and similarities when traditional and 360° visual elements were introduced. The students developed seven proposals that consider design aspects that were enhanced by the use of immersive, more so than traditional, visualisation.

5. CONCLUSION

This paper creates an opportunity to continue researching the relevance and impact of virtual visualisation technology in areas that require constant use of spatial perception. Thanks to cutting-edge technologies, new application possibilities have been developed that have not yet been explored in-depth. Additionally, the use of different technologies within educational environments offers the possibility of relating different elements that exist not only for the communication or transmission of content, but also to allow for the integration of different variables that can directly affect the teaching-learning process and help each individual develop different professional competencies.

This particular research, despite the inherent limitations, allows us to generate important approximations regarding the significance of technology usage for generating design projects and, in general, for ethnographic research.

Finally, it is important to emphasise that this research project is ongoing and will continue with another group of students, with whom the process will be repeated for the same subject and under similar conditions, in order to finish consolidating the results and to generate more consistent conclusions regarding the impact of VR technology on the teaching of design.

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