Analysis of the User Experience (UX) of Design Interactions for a Job-Related VR Application

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Keywords: Usability, Intuitive Design, Virtual Reality, Handling, PrEmo, SUS, Design Methodologies.

Abstract: A study was conducted to assess the user experience (UX) of interactions designed for a job-related VR application. 20 participants performed 5 tasks in the virtual environment, using interactions such as "touching", "grabbing", and "selecting". UX parameters were assessed through PrEmo, SSQ (Simulator Sickness Questionnaire) and SUS (System Usability Scale) methods. Overall, participants ended their sessions demonstrating positive feelings about the application and their performance, in addition to reporting that they had a positive user experience. Nevertheless, some issues related to ease of learning and satisfaction were identified. 2 tasks in particular proved difficult for participants to complete. While various data-gathering methods were used, the present work only focused on analysing the results from the questionnaire tools and the post-tasks questions. Future work will focus on analysing the data gathered from these other methods, as well as on using the results from this work to improve the application for future uses.

1 INTRODUCTION

Virtual reality (VR) technology has, for several years, been considered a promising new medium to provide users with immersive and engaging virtual environments. Its use has been extensively proposed both for entertainment purposes (allowing greater engagement on alternative realities) and practical applications, such as flight training (Oberhauser and Dreyer, 2017) or teleoperation of robotic devices (Rosen et al., 2018).

VR has also been proposed as a tool for virtual assembly and rapid prototyping. However, these kinds of tasks entail particular challenges, most notably those tasks involving the manipulation of virtual objects (in itself a technological challenge), raising issues regarding the usability of the systems.

Mäkinen et al. (2022) point out that analyzing the user experience (UX) within VR applications allows for the creation of more comprehensive experiences, among other benefits. The authors point out that usability and technology adoption are the most researched points of UX and refer the need for more UX studies in immersive environments.

Some studies have analysed the usability of VR systems through self-report tools, such as Butt et al. (2018) who used the SUS and a faculty-designed user-reaction survey to measure VR with haptic for skill acquisition. Kardong-Edgren et al. (2019) also used the SUS in conjunction with the User Reaction Survey (URS). Süncksen et al. (2018) used the UEQ (User Experience Questionnaire) and asked users to rate the user interface of the application they studied, in both desktop and VR modes, on a scale from 1 to 6 (best-worst). Bracq et al. (2019) used SSQ, SUS, NASA Task Load Index, Task-completion time, UTAUT2 questionnaire, and interviews. Several different methods have thus been used to analyse and seek improvements in VR and UX. Still, and as Park et al. (2018, p. 2) puts it, only "a limited number of

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Silva, E., Margolis, I., Nunes, M., Sousa, N., Nunes, E. and Sousa, E.
Analysis of the User Experience (UX) of Design Interactions for a Job-Related VR Application.
DOI: 10.5220/0011657800003417
In *Proceedings of the 18th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2023) - Volume 2: HUCAPP*, pages 169-176
ISBN: 978-989-758-634-7; ISSN: 2184-4321

research used a truly immersive system to examine the difficulties and benefits of using it (VR systems)."

In a literature review analysis on VR training, ranging from 1992 to 2019, Abich et al. (2021) point out that the benefits and problems with VR are difficult to generalize, but that the training time, the usability of the VR hardware, and the acquisition of procedural knowledge, are influencing factors. This includes retaining and acquiring knowledge and reducing errors and increasing agility in response time, which converges to the fact that familiarization helps performance.

Given the above information, the present work aims to evaluate the intuitiveness and usability of a set of basic actions to interact with a VR-based interface design application, as well as the user's experience when interacting with said application. Fundamentally, it aims to answer the question: How is the user experience of interactions, designed for virtual object handling, when applied on a job-related VR application?

2 USABILITY AND UX

In an analysis of the definition of user experience, Gómez-López et al. (2019) defined it as a complex term that describes the relation between the user and the product, system, or environment under analysis. It addresses the efficiency and effectiveness of the interaction as well as the perception and feeling of the user. To Hassenzahl (2008), UX has a direct link to usability and user-centred design.

To Nielsen (1993), usability is an attribute to assess the ease of use of an interface, which also encompasses the acceptability of the system regarding the requirements of the user and other interested parties. This concept is part of a system of acceptability within a social context. In addition, ISO 9241-210 (2019) defines usability as a measure of efficiency, effectiveness, and satisfaction, within a specific context of use. This converges to the association with usability attributes, namely: intuitiveness, efficiency, memorization, errors, and satisfaction (Nielsen and Molich, 1990; Nielsen, 2010a). Nielsen (1993) signalled five major attributes of usability, namely easy to learn, efficiency to use, easy to remember, few errors, and subjectively pleasing. Regarding its evaluation, there are several types of UX questionnaires available with different analysis proposals (Hinderks et al. 2019). These are quantitative tools that measure the user's subjective attitudes when interacting with the artefact under analysis.

Furthermore, Tcha-Tokey et al. (2018), in reference to immersive virtual environments, identified 9 relevant components of UX, namely: (1) presence, (2) engagement, (3) immersion, (4) flow, (5) skill, (6) emotion, (7) usability, (8) technology adoption judgment and (9) experience consequence. These components are sometimes interdependent, which makes their analysis both interesting and complex. Some examples of this relationship are that emotions are influenced by presence, flow, and experience; engagement, in turn, influences immersion; skill influences both experience consequence and usability; while presence and experience consequences influence judgment. Conversely, ISO 9241-210 (2019) also links satisfaction with physical, cognitive and emotional responses.

The search for improving the usability, effectiveness, efficiency, and satisfaction of an interface is often a matter of considering both usability related aspects like the ones mostly addressed by Nielsen (1993, 2010b) and use-experience dimensions like the ones address by Tcha-Tokey et al. (2018) and ISO 9241-210 (2019).

3 RESEARCH METHODOLOGY

This study aims to evaluate the user experience of a set of basic actions for object handling interactions on a job-related VR-based interface-design application. The protocol presented below was split into 6 steps: (1) Signing of the informed consent form; (2) Answering a first set of questionnaires on the computer; (3) VR onboarding (tutorial phase); (4) 5 activities on the VR application (experimental phase), (5) Final questionnaires on the computer; (6) Interview.

Technological Instruments

Experiments were conducted using an HTC Vive Pro VR system, composed of a Vive Pro headset, 2 Vive base stations 1.0 (placed around the participant to capture their movements and transpose them to the VR environment), and 1 Vive controller (which participants held on their right hand) (HTC Corporation, n.d.). A GoPro Hero 9 Black camera was used to capture the participant's actions and audio during their session (steps 3 and 4).

An immersive VR application, which is currently in development, was used in this study (Figure 1).

Sessions were conducted in a lab room, in a space isolated from external noise and movement. A desktop PC was used for participants to fill out the questionnaires. A laptop PC was used by the researchers to write down notes.

Procedure

Participants were welcomed by the researcher and introduced to the protocol (6 steps). The main objectives of the study were presented, and participants were asked to read and sign the Informed Consent Form before participating in the session.

Following this, participants were asked to fill in an initial set of questionnaires, namely (1) a sociodemographic questionnaire — which included questions regarding their age, gender, handedness, previous contact with VR systems, visual complications, and if they had any difficulties moving their hands and/or arms (results presented on 3.5) — (2) the SSQ, the (3) Affinity for Technology Interaction (ATI) Scale (Franke at al., 2018), and the (4) PrEmo 2. These questionnaires were filled out on the desktop PC.

Participants were then taken to the area designated for VR use, where they were given more details regarding the procedure and what was asked of them. They were asked to put on the VR headset, with help from a researcher, and to grab onto the controller with their right hand. Following this, the onboarding (training) application was started, which taught participants how to perform 3 interactions with the controller, namely: (1) grabbing objects, by holding the Trigger button; (2) selecting objects, by pressing the centre trackpad button while the virtual hand was not in contact with the virtual object, and keeping it pressed until they touched the desired object; and (3) touching objects, by approaching the index finger of the virtual hand to the desired object, without pressing any buttons. Participants were asked to practice these interactions 3 times before continuing.

Pilot tests were conducted to check the instructions and experimental protocol for errors and potential improvements during both tutorial and experimental phases. Nonetheless, the verbal instructions given during the onboarding segment to the first 8 participants (S01, E01, S02, E02, S03, S04, S05 and S06) did not explicitly mention the interaction that was being taught (grab, select, or touch), which caused confusion. In their final

Figure 1: Objects and Panel of VR application.

interviews, these participants reported that, during the onboarding segment, they had not been able to memorize all the taught interactions. For this reason, this aspect was changed in this segment, to provide a clearer understanding to the following participants.

After finishing the tutorial, participants were loaded into the VR application (mentioned in 3.1). In it, they found an empty panel, with empty slots (to which objects are loaded into during Task 1) above it, and a round button with the “Menu” label (which would open the menu interface after being touched) at its side in front of them. Behind them (180º), in turn, was an image containing all 14 PrEmo stills, numbered from 1 to 14.

While in this application, participants were asked to carry out 5 tasks, in order. At the start of each task, participants were given the goal for that task, followed by step-by-step instructions on how to do it, and, lastly, an indication that they could begin. The instructions, were (translated from Portuguese): (1) Task 1 - Insert 4 objects into the scenario. To do this, touch the menu, then touch the gallery icon inside the menu, then touch each object; (2) Task 2 - Place the 4 objects onto the panel. To do this, grab an object and drag it over to the panel and place it there; (3) Task 3 - Organize the panel. To do this, organize the objects by size, from the smallest to the biggest. Place the objects as close as possible, on their left side, to the previous object, and centre the objects with each other. (4) Task 4 - Switch the 2 bigger-sized objects with each other. To do this, go to the menu, then touch the “Switch” (in Portuguese, “*Trocar*”) icon and select the 2 bigger-sized objects; (5) Task 5 - Group 2 objects of your choice. To do this, go to the menu, then touch the “Positioning” (in Portuguese, “*Posicionamento*”) icon, select the 2 objects you want, and move them to another location. Afterwards, deselect those objects.

After each instruction, participants were asked if they had any doubts or questions, and if so, these were answered, before the command to begin the task was given. After the participant informed that the task was concluded, or that they wanted to give up, regardless of whether the task was performed correctly or not, the following questions were asked (translated from Portuguese): (1) Do you have any questions about the activity you just performed? (2) Is there anything positive or negative about carrying out this activity? (3) Please turn around from your left side and choose one or more images that best express what you are feeling right now. The first two questions were inspired by Bracq et al. (2019). PrEmo was selected to be applied between tasks in this VR procedure because it is easy to fill out, without the user needing to exit the environment every time, it allows assessing changes in emotions throughout each task, and it is a quick procedure.

After concluding the 5 tasks, participants removed the VR headset and were asked to fill out the SSQ, SUS, UEQ, and PrEmo 2 again, at the desktop PC. Lastly, a short interview was conducted to collect a more qualitative and subjective view of the experiment overall.

Questionnaires
In view of Tcha-Tokey (2018), it is understood that the use of a single assessment technique can limit the analysis of an interface, by reducing the number of dimensions under evaluation. Five self-report measurement questionnaires were thus used to analyse complementary dimensions of the user experience, namely: (1) SSQ (Kennedy et al., 1993), used to assess the presence of 16 cybersickness symptoms. The Portuguese version was used (Carvalho et al., 2011); (2) SUS (Brooke, 1996), used to assess participant's perception of the system's usability. It was chosen due to the Lewis (2018)' conclusions regarding the comparison between methods for perceiving usability. The Portuguese version was used (Freire, 2021); and (3) PrEmo 2 Tool (Laurans and Desmet, 2017), used to assess participant's self-reported emotional feelings towards each task and towards the experiment overall, using a pictographic scale.

The complete set of questionnaires used in this study overall provide: 1) the user's innovative profile; 2) two analyses of usability perception; 3) an instrument to assess if the use of VR had an impact on motion sickness; 4) two different perspectives on usability perception (one more focused on experience and the other on usability); and, lastly, 5) an emotional dimension. Some of their results are not presented in this paper.

Data Analysis
Data analysis of each questionnaire was conducted according to its references. For the SSQ results were analysed according to Kennedy et al. (1993). The parameters from Kennedy et al. (2003) were used for comparison. The SUS was analysed according to Brooke (1996), using the analysis parameters established in Bangor et al. (2009). Additionally, a stratified analysis of SUS, according to the Nielsen scale, based on Boucinha and Tarouco (2013) was also conducted, subdividing the analysis into satisfaction (questions 1, 4 and 9), ease of memorization (question 2), ease of learning (questions 3, 4, 7 and 10), efficiency (questions 5, 6 and 8) and minimization of errors (question 6). In PrEmo the emotions evoked are counted, according to Laurans and Desmet (2017).

Analysis was conducted also on the (qualitative) content of the questions asked between each task, as well as those asked during the interview. However, for the present study, the thinking aloud comments, the timing of each task, and the answers to the final interview, were not analysed, for the sake of brevity.

Participants
A total of 20 participants (8 female and 12 male), with ages ranging from 23 to 69 years-old (M = 36.05 ± SD 13.18) took part in this study. 1 participant was left-handed, and 2 participants had hand handling problems (i.e., tendinitis). 8 participants used their own prescription glasses during the experiment, 8 participants reported no visual issues, 1 participant reported having colour-blindness, and 1 participant reported suffering from macular degeneration.

In general, participants were experienced in playing video games and mobile games, but 7 participants had never used VR. Five participants considering themselves to be experts regarding handling VR. These were thus classified as being experts, identified with "E", while the remaining participants who did not consider themselves experts, or had no prior experience with VR, were identified as "S". The ATI Scale pointed to a neutral technological tendency (between slightly disagree and slightly agree).

4 RESULTS AND DISCUSSION

Throughout the 5 tasks, it was possible to note a variation in usability, satisfaction, and efficiency. The data for this section was gathered from the questions asked after participants concluded each task, from the researcher's observations during participant's performance, and from the participant's "help" requests. The main problems analysed were: (1) placing the objects in the slots in Task 1, which tended to leave participants confused and commenting that the activity did not make much sense; (2) the "select objects" interaction, used in tasks 4 and 5, mainly due to the order of actions required, which demonstrated it to have a confusing usability; and (3) the lack of visual feedback when events occurred, such as when using the switch function, and when interacting with menu items. The Table 1 presents the success' percentage of the tasks, the number of participants that needed help, and the total helps that they asked (some participants needed more than one help in the same task). And finally, the

Table 1: Task success and help analysis.

	Success	Help/ Participant	Total Help	Gave up
Task 1	100%	11	14	0
Task 2	100%	2	4	0
Task 3	95%	2	4	0
Task 4	85%	9	16	2
Task 5	75%	6	12	0

number of participants that gave up in each task.

During the course of Task 1, six participants also completed Task 2 before voicing they had concluded the task. It is important to highlight that Task 3 contained many instruction details, so, for the efficiency analysis, scores were only given regarding the handling of objects on the panel and the placement of them in ascending order. In Task 4, some participants changed the object manually instead of using the switch function, while 9 participants made the switch with the function and did not realize it, resulting in a total of 17 more switches. One participant (S06) made 5 switches using the function, but ended up giving up on the task, not realizing they had completed it. S02 stated that "The instantaneous switching is confusing, ideally, you'd have some movement, at the same time, even more so since the objects have the same size, but a different color". Lastly, in Task 5, some participants moved the objects separately, while others still had issues selecting or deselecting objects.

SSQ

Medium SSQ results at the start of the session was 1.85 (SD = 2.87), and 2.1 (SD = 2.16) at the end of the session. Seven participants did not present any change in motion sickness symptoms between the start and end of the session. Four participants had their symptoms reduced, and 9 participants had their symptoms increased, with a maximum of 4 participants having a 2-point increase in SSQ results. The study was made up of tasks with little movement, and, in total, lasted between 20 to 40 minutes, so we can conclude that overall, there was no impact on motion sickness.

SUS

The SUS had a final score of 68.5, which is above the minimum acceptable limit, according to Brooke (1996), and marginally high, according to Bangor et al. (2009). In Bangor et al. (2009)'s adjective perspective, SUS, in general, is rated as "Ok".

When fragmenting the analysis between experts and participants without VR experience, this scenario changes. Participants without VR experience had a general score of 65 (which remains on the high marginal), but experts had a score of 79, which is rated as "good" (score between 70 and 79).

Throughout the experiment, it was possible to note that experts, due to already knowing how a VR environment worked, were more focused on the functionality aspects of the application. The presentation of these results was divided into two graphics (Figure 2 and 3) for ease of readability. In both graphics, the acceptability ranges of Bangor et al. (2009) and Brooke (1996)'s limit of acceptability have been highlighted. From the perspective of Bangor et al. (2009), 3 participants (S02, S04, and S08) had their scores classified as not acceptable, and 5 participants perceived usability in the marginal area (E01, S03, S06, S07, and S11). In Brooke (1996)'s parameters, 12 participants (S01, E02, S05, E03, S09, S10, S12, E04, E05, S13, S14, and S15) perceived the application as acceptable. It is also possible to see that a third of the participants that took part in the study after the changes to the onboarding segment (SUS Score in dark blue on Figure 2), perceived the application as having low usability, compared to the participants before the onboarding changes (SUS Score in light blue on Figure 2).

In light of Nielsen's heuristics, difficulties in ease of learning and satisfaction could be noted (Figure 3). They were at the marginally acceptable, for Bangor et al. (2009), and not acceptable, for Brooke (1996). Nonetheless, all other points were within the acceptable range according to both authors.

PrEmo 2

Regarding PrEmo 2, it is possible to note a very clear manifestation of positive emotions. A comparison was made between the participant's initial and final state. There were slight increases in both the positive and negative emotions (Figure 4). Furthermore, there were significant changes in "Fascination", which many interpreted as "Curiosity". It was also possible to notice an increase of "Joy", "Pride", "Desire", and "Satisfaction" in at least 3 participants. At these stages, participants were answering the PrEmo using the PC.

Analysis between tasks (Figure 5) was slightly different. From the general results, a high indication can be noted on "Fascination" and "Joy". "Fascination" has a gradual fall throughout the activities. It should be noted that many participants interpreted it as "Curiosity". "Joy" was stable (with little variation) except on Task 4, where participants had more trouble completing the task. The least indicated emotions were "Fear" and the only emotion which was never reported was "Disgust". "Contempt", and "Boredom", were reported only once each, and "Sadness" was reported 3 times.

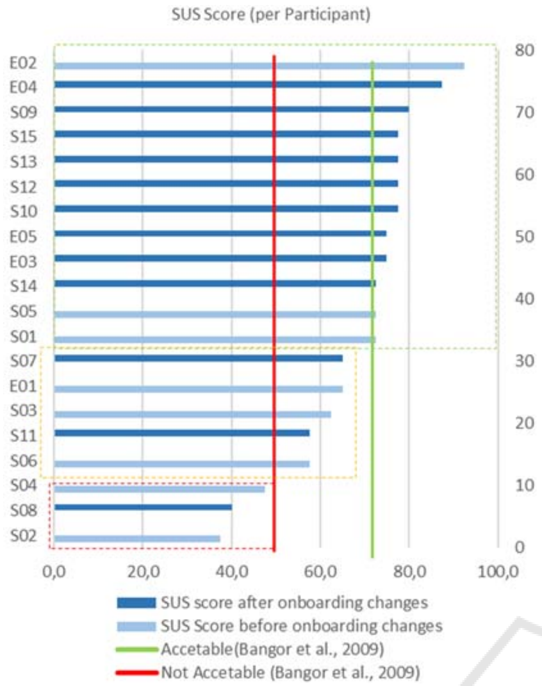

Figure 2: SUS Score per participants.

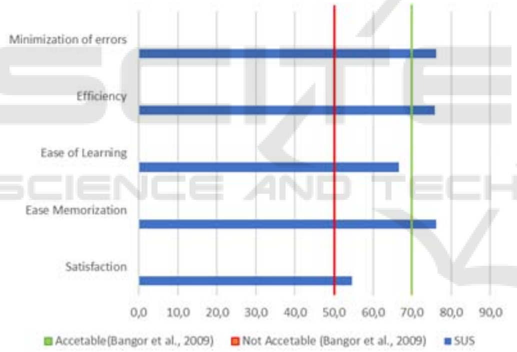

Figure 3: SUS – stratification.

From the perspective of the Tasks, it is possible to see that Task 1 was the one in which participants most reported “Fascination” (which many related with “Curiosity”) and “Admiration”. It was the only task in which “Contempt” was reported. 4 negative emotions (“Disgust”, “Boredom”, “Fear”, and “Sadness”) were not present in this task. Task 2 was the one in which “Desire” was reported the most. Task 3 was the one which generated the highest number of positive emotions, with 38 reports. It was also the only activity that didn’t generate any negative emotions. Task 4 was the one which generated the lowest number of positive emotions (a total of 22) and the one that generated the highest number of negative emotions, totalling 14 emotions. Task 5 was the second to last task to trigger the least number of positive emotions, and the second to last task to trigger the most negative emotions. It was also the task with the least number of reports of “Desire”, “Sadness”, “Fear”, “Contempt”, “Boredom” and “Disgust”.

It should be noted that all positive emotions were reported on all tasks, with the exception of “Desire”, which was not found on tasks which made use of the select interaction (Tasks 4 and 5). Positive emotions were reported 6.6 times more often than negative emotions. Lastly, an analysis was made to the emotions reported before the onboarding modification. Significant changes in emotions were noticeable between the 2 groups. The first group reported more negative emotions.

Discussion

After analysing all dimensions presented here, it was possible to note some issues with the application’s usability, regarding factors of intuitiveness, like learnability and memorability. These items, alongside the aspects mentioned by participants in the interview, converged to the results found on the SUS.

They were also reflected in the results from PrEmo. This reinforces the relation between the analysis focused on (1) the use-experience dimension, as well as the emotional issue analysed in this study and highlighted by Tcha-Tokey et al. (2018), (2) the aspects of usability, addressed by Nielsen (1993, 2010b), such as the improvement that must be made for ease of learning, or (3) the satisfaction, as addressed by ISO 9241-210 (2019).

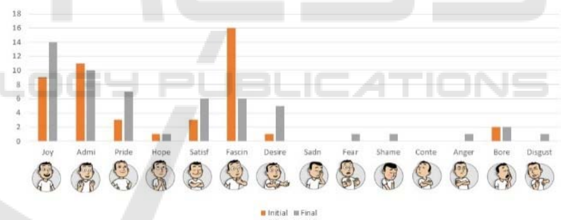

Figure 4: PrEmo results, before and after the experiment.

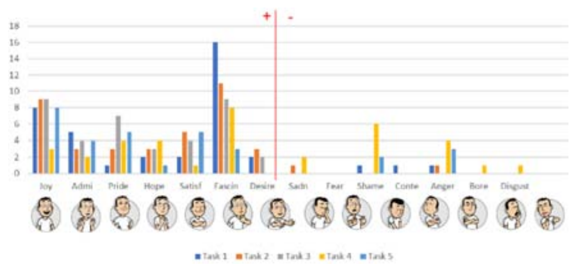

Figure 5: PrEmo results, per task.

Regarding the tasks, the grabbing (Task 2) and handling objects (Task 3) tasks were considered intuitive and as having good usability. However, it was possible to note that Task 1 can be simplified and removed, as its more intuitive to grab objects from the "gallery" and drag them directly onto the scenario. On Task 4, it is necessary to improve the feedback provided when switching the position of objects, as well as which buttons are associated with this interaction in the controller itself.

In the usability questionnaires, it was possible to perceive an "ok" acceptance, in Bangor et al. (2009) adjective scale, with potential for improvement.

Regarding PrEmo, it was possible to note that when tasks went very well, such as Task 3, they generated mostly positive with little to no negative emotions being reported. However, when tasks started to present usability issues, negative emotions were evoked, the main ones being "Shame" and "Anger". It was also possible to perceive the difference in emotions with the changes to the onboarding segment. This converges to the notes of Abich et al. (2021), who see training as an important point in the face of immersive interactions, and as being quite effective for those who are less familiar with the training content. Another important factor is that after failure, and with the acquisition of knowledge, positive emotions are generated again.

Finally, the importance of an initial training to create a better experience was evident, as well as that having a previous experience using VR helps in the mastery of the interactions used in this study.

Limitation and Future Work

This study had some limitations, namely: (1) the analysis of interactions was performed outside the context of a real application, which may cause some divergencies in their real-world applicability. (2) problems related to task instruction (Task 3 and Task 5). (3) here, the partial results of the study were presented, mainly focused on the SSQ, SUS and PrEmo tools. (4) PrEmo answers between activities were given orally, which might have led some participants to be reluctant in sharing their real emotions. Lastly, (5) this study has the potential to be used for handling objects in virtual environments, in work-related settings, so overall interactions may have to last longer in the immersive universe. Therefore, the SSQ results might change from those obtained here with prolonged use of the equipment, even in the face of an activity without major visual or physical movements.

There are also recommendations for future work. In the face of the usability problems that were encountered, and in search of a better user interaction with the VR system, as well as given the limitations exposed in this work, the analysis of all the tools used in the test. Another suggestion is the improvement of the onboarding segment, for a re-analysis of the system. Lastly, for future work, a more in-depth analysis is suggested to access the effectiveness of UX methods in VR.

5 CONCLUSIONS

This study analysed the UX of interactions, designed for virtual object handling, when applied on a job-related VR application. To this end, several analysis tools were used, such as SSQ, SUS and PrEmo 2, in addition to some questions which are made after each task. The results of the analysis of PrEmo pointed to a system that generates satisfaction and arouses positive emotions, but also that still presents some usability and interaction problems. According to the SUS results, the developed application is classified in the adjective rating of "Ok", or, in the perspective of acceptability, as marginally high, with need for improvement in easy to learn and satisfaction. In PrEmo, it was possible to see changes in emotions resulting from the mistakes and successes, which demonstrates the emotional impact on the user experience. The main point of improvement was related to the "select" interaction, but other usability issues were also found, mainly related to intuitiveness, such as understandability and easy to learn. Overall, this study was successful in providing a holistic understanding of the user experience, encompassing not only usability, but also emotional aspects of the interaction, an often-neglected dimension of user-experience.

ACKNOWLEDGEMENTS

This research has been carried out under project "I2AM - Intelligent Immersive Aircraft Modification", funded by the FEDER component of the European Structural and Investment Funds through the Operational Competitiveness and Internationalization Programme (COMPETE 2020) [Funding Reference: OCI-01-0247-FEDER-070189].

REFERENCES

Abich, J., Parker, J., Murphy, J. S., & Eudy, M. (2021). A review of the evidence for training effectiveness with virtual reality technology. *Virtual Reality* 25, 919–933.

Bangor, A., Kortum, P., & Miller, J. (2009). Determining What Individual SUS Scores Mean: Adding an

Adjective Rating Scale. *Journal of Usability Studies*, 4(3), pp. 114-123
Bracq, M-S., Michinov, E., Arnaldi, B., Caillaud, B., Gibaud, B., Gouranton, V., & Jannin., P. (2019). Learning procedural skills with a virtual reality simulator: An acceptability study. Nurse Education Today, 79, 153-160.
Boucinha, R. M., & Tarouco, L. M. R. (2013). Avaliação de Ambiente Virtual de Aprendizagem com o uso do SUS - System Usability Scale. *RENOTE*, 11(3), 1-10.
Brooke, J. (1996). SUS: A quick and dirty usability scale. *Usability Eval. Ind.,* 189
Butt, A., S. Kardong-Edgren, &A. Ellertson. (2018). Using Game-Based Virtual Reality with Haptics for Skill Acquisition. Clinical Simulation in Nursing 16: 25–32.
Carvalho, M. R.., Costa, R. T., & Nardi, A. E. (2011). Simulator Sickness Questionnaire: translation and cross-cultural adaptation. J Bras Psiquiatr., 60(4), 247-52.
Franke, T., Attig, C., & Wessel, D. (2018). A Personal Resource for Technology Interaction: Development and Validation of the Affinity for Technology Interaction (ATI) Scale. *International Journal of Human–Computer Interaction*, 35(6), 456-467.
Freire, L. L. (2022). *Método Integrado para Avaliação de Usabilidade em E-Learning* [Universidade do Minho]. https://hdl.handle.net/1822/78087
Gómez-López, P., Simarro, F. M., & Bonal, M. T. L. (2019). Analysing the UX scope through its definitions. Proceedings of the XX International Conference on Human Computer Interaction - Interacción '19.
Hassenzahl, M. (2008). User experience (UX): Towards an experiential perspective on product quality. ACM International Conference Proceeding Series 339, 11–15
Hinderks, A., Schrepp, M., Mayo, F. J. D., Escalona, M. J. E., & Thomaschewski, J. (2019). Developing a UX KPI based on the user experience questionnaire, *Computer Standards & Interfaces*, 65, 38-44.
HTC Corporation. (n.d.). VIVE Pro Full Kit. Retrieved September 13, 2022, from https://www.vive.com /us/product/vive-pro-full-kit/
ISO 9241-210 (2019) Ergonomics of human-system interaction.
Kardong-Edgren, S., K. Breitkreuz, M. Werb, S. Foreman, and A. Ellertson. (2019). Evaluating the Usability of a Second Generation Virtual Reality Game for Refreshing Sterile Urinary Catheterization Skills. Nurse Educator, 44 (3), 137–141
Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Simulator Sickness. *The International Journal of Aviation Psychology*, 3(3), 203–220.
Kennedy, R., Drexler, J., Compton, D., Stanney, K., Lanham, D., & Harm, D. (2003). Configural scoring of simulator sickness, cybersickness and space adaptation syndrome: similarities and differences. In *Virtual and adaptive environments: applications, implications, and human performance issues.* (pp. 247–278). CRC Press. https://doi.org/10.1201/9781410608888.ch12
Laurans, G., & Desmet, P. M. A. (2017). Developing 14 animated characters for non-verbal self-report of categorical emotions. *Journal of Design Research* (Online), 15(3/4), 214–233.
Lewis, J. R. (2018): Measuring Perceived Usability: The CSUQ, SUS, and UMUX, *International Journal of Human–Computer Interaction*, 34(12), 1148–1156.
Mäkinen, H., Haavisto, E., Havola, S., & Koivisto, J.-M. (2022). User experiences of virtual reality technologies for healthcare in learning: an integrative review, *Behaviour & Information Technology*, 41(1), 1-17.
Nielsen, J. (1993) *Usability Engineering.* Academic Press, Inc., Harcourt Brace & Company, San Diego, USA.
Nielsen, J. (2010a) What is usability? *User experience Re-master*, 3-12.
Nielsen, J. (2010b). Ten Usability Heuristics. Useit.com. Retrieved 29 May 2010. http://www.useit.com/ papers/heuristic/heuristic_list.html
Nielsen, J. & Molich, R. (1990). Heuristic evaluation of user interfaces. In: SIGCHI conference on human factors in computing systems. proceedings. ACM.
Oberhauser, M., Dreyer, D. (2017). A virtual reality flight simulator for human factors engineering. *Cogn Tech Work* 19, 263–277
Park, M., Im, H., & Kim, D. Y. (2018). Feasibility and user experience of virtual reality fashion store. *Fashion and textiles*, 5(32), 1-17.
Rosen, E., Whitney, D., Phillips, E., Ullman, D., & Tellex, S. (2018). Testing robot teleoperation using a virtual reality interface with ROS reality. In *Proceedings of the 1st International Workshop on Virtual, Augmented, and Mixed Reality for HRI (VAM-HRI)* (pp. 1-4).
Süncksen, M., H. Bendig, M. Teistler, M. Wagner, O. Bott, & K. Dresing. (2018). Gamification and Virtual Reality for Teaching Mobile X-ray Imaging. In Proceedings of the 6th IEEE International Conference on Serious Games and Applications for Health, SeGAH, 1–7. Vienna: IEEE.
Tcha-Tokey, K., Christmann, O., Loup-Escande, E., Loup, G., & Richir, S. (2018). Towards a Model of User Experience in Immersive Virtual Environments. *Advances in Human– Computer Interaction*, 2018, 1–10.