Virtual Reality versus Desktop Experience in a Dangerous Goods Simulator

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Abstract

Virtual Reality applications have become a trend in training simulators as an alternative to desktop applications. However, further study is needed on how these types of serious games, which often include several modes of interaction, can improve the user experience. In this sense, this paper analyzes the differences between playing serious first-person games on a desktop computer versus playing in Virtual Reality. For this purpose, two versions of a dangerous goods unloading simulator have been implemented. The first one was developed as a classic desktop game with keyboard and mouse-based interaction, while the second was for Virtual Reality devices. The user experience has been measured with the In-game version of the Game Experience Questionnaire. With this, aspects related to immersion, flow, positive emotions, and psychological needs have been compared for these two platforms. The study shows that the Virtual Reality experience produces a better overall game experience for most analyzed items. Nevertheless, the results highlight a significant dependence between the application type and the game experience induced on the player.

Keywords: Serious Games, Virtual Reality, Game Experience.

1 Introduction

Virtual Reality (VR) increases the reality experience felt by the user, including sensations such as touch, vision, and sound within a virtual environment created by a computer [1]. Consequently, advances in the development of VR hardware devices and computer graphics technology have enabled the generation of several applications, allowing the user to enjoy spatial and temporal experiences virtually. In addition, there is a growing demand for research into technologies that support these applications, as well as an increase in total consumer spending in the video game industry using VR systems [2–4].

VR supposes progress in terms of interaction and complete immersion of the player in the game. Moreover, VR games provide interesting advances in the contemporary video game scene. In this way, it is possible to afford innovative experiences for present and future players [5]. However, the studies carried out on how VR affects gameplay are still limited, and it is not clear how interaction through VR controllers can help or harm the player's experience.

In this sense, the player's experience is more related to personal and individual enjoyment while playing with the game, which determines a subjective assessment of the quality of the game. Although we cannot establish a unique definition that defines this experience from literature, we can indicate that several elements can influence the feelings and experiences that people have when they play digital games such as enjoyment, immersion, challenge, etc [6].

In the literature, several questionnaires have been developed that offer different significant elements in the player's experience [7, 8]. Among them we can highlight, the Game User Experience Satisfaction Scale (GUESS) [9] that performs an exhaustive study of the different aspects that influence the development of a video game, the Core Elements of the Gaming Experience questionnaire (CEGE)[10] in which aspects such as enjoyment while playing are considered, the interaction formed by the player's sense of control and ownership, and the video game itself formed by the environment and the gameplay, and the Game Engagement Questionnaire [11] that analyzes what aspects are associated with the negative effects of violent video games.

This paper evaluates a serious game through VR by comparing it to viewing the same game in First Person (FP) on a desktop display. Therefore, and as previous work in the learning process evaluation of this type of games [12], it is proposed to carry out an analysis on the player's experience that allows evaluating which technology could be more useful in this framework. In this sense, and following the work of Pallavicini & Pepe [13], we will use the Game Experience Questionnaire (GEQ) [14] to compare both technologies, and more specifically the *In-game GEQ* version. This questionnaire measures the following seven components: *Competence*, *Sensory and Imaginative Immersion*, *Flow*, *Tension*, *Challenge*, *Negative Affections*, and *Positive Affections*.

Through competence, an attempt is made to measure the intrinsic motivation that players feel when it comes to fulfilling the requirements of the tasks they wish to complete [6]. Emri and Mäyrä [15] studied immersion in the game as part of the player's experience, proposing a model that includes three different aspects in the immersion process: sensory, challenge-based, and imaginative immersion. Referring to sensory immersion as the multisensory properties of a game, in other words, the characteristics of the game that generate a perceptual impact on the user. Challenge-based immersion involves analyzing the cognitive aspects necessary to overcome the game challenges, while imaginative immersion refers to the fantasy created in the game, and depends on the richness of the narrative structure. In the case of VR, this technology supposes a more intense degree of immersion compared to a computer screen, making the user consider the virtual world of the game that surrounds him/her as the real world.

About the *Flow* dimension, we can define it as the sensation of influencing the game activity within the virtual world, and in that sense, we can consider it one of the important aspects involved in the player's enjoyment [16]. Another dimension to consider is the *Positive* or *Negative Affections* related to the emotions that are generated in the player during the game. Positive psychological aspects such as happiness or surprise can increase the success of the game [17]. Nevertheless, when the challenge is unbalanced in its complexity, the player may experience negative emotions, including tension due to poor ability to solve tasks or discomfort if the game offers little difficulty, losing interest in continuing to play [18].

The reason for using the *In-game GEQ* versus the other different versions proposed in [14] is that the *GEQ - Core Module*, consisting of 33 items that probe players' feelings and thoughts while playing, has been questioned in the [19] work. In Law et al. [19], the authors conclude that some items were inconsistent after measuring psychometric properties in the gaming experience of 633 participants after they had played in the past 24 hours. For this purpose, the authors performed an Exploratory Factor Analysis (EFA) on the seven factors to indicate whether the items correspond to the seven components indicated in the questionnaire. Furthermore, it also emerges from the study that the *Tension* and *Negative Affections* components are too similar and should be merged into a single component.

It is noteworthy that among the questions in which they find inconsistencies (see Table 5 in

[19]) only question 5 appears in the *In-game GEQ*, with the difference that in the *GEQ - Core Module* it is defined as "I was fully occupied with the game" while the *In-game GEQ* is the only one that has been modified in this work and is defined as "I felt completely absorbed". Moreover, at no point is a solution shown to the inconsistencies found in some [14] items. Therefore, for the present work we have chosen the *In-game GEQ* constructed by 14 items.

As a summary, this document is organized as follows. Section 2 presents the references that have been used for the study of previous work in the fields related to the design and implementation of this experience. Next, section 3 details the context in which the application is carried out and continues with the necessary elements for the development of the serious game. Later, in section 4, the hypotheses and general objectives of the study carried out are presented. Sections 5 and 6 show the results and a discussion of them. Finally, section 7 outlines the conclusions obtained from this work and the possible lines of future work.

2 Literature on the state of the art

In recent years, several works have been carried out to address immersive VR, taking into account different aspects such as interaction, the user interface, the haptic system, or the player's movement in the environment [20, 21]. All this allows the user to know where he/she is, with whom he/she interacts, and what actions to perform. In this way, the user perceives the virtual world as a reality where he/she can interact by adding haptic devices and audio sources that maximize spatial presence [22, 23].

Currently, last generation devices include VR headsets such as the *Oculus Quest 2.0* or the *HTC Vive Pro 2.0*. At a more affordable level are the *Samsung Gear VR* and *Google Cardboard* which work by using a smartphone as a display. This has made it easier for consumers who want to experiment with visual immersion to use these types of technologies.

To provide more realistic interactions between the virtual and real worlds, several technological developments have been made. One of them is based on visual satisfaction such as gaze-based hand interaction using *Oculus Quest 2.0* or leap motion device, to represent realistic movements and gesture recognition and analysis [24, 25]. Furthermore, the user's immersion can be enhanced by adding touch processing through a haptic device to enable feedback of physical reactions occurring in a virtual environment or user-to-user interaction [26–29]. About touch accuracy, Leonardis et al. [30] include a three revolute-spherical-revolute (3-RSR) haptic wearable device which allows control of the contact of the fingertips. This is a new three degrees-of-freedom wearable haptic interface that uses force vectors directly on the fingers.

Another aspect to be considered is the specification of displacement or locomotion, which requires providing the user with a way to control their movement in the world. Locomotion in VR involves traveling in a virtual world of infinite scale while remaining in the confines of a real-world at the scale of the room in which the user is located [31, 32]. There are several possible techniques to solve the problem of locomotion [33], with different usability characteristics [34]. Among the most important strategies, we can mention: the use of game controls or joysticks, teleportation, or controller movement [35], head motion sensors [36] or the establishment of reference points [37]. All this is complemented by wayfinding in a virtual environment, that is, the ability to determine a route, learn it, and go back over it or reverse from memory [38]. The virtual environment is often unfamiliar to new users, and therefore it is essential to provide tools to orient themselves [39]. In this sense, the spatial structure of the environment can influence the purposeful and directed movement based on the objectives pursued [40].

However, it is not clear the advantages and disadvantages that VR brings us through a head-mounted display in comparison with viewing the same experience on a desktop screen [13, 41]. While some works indicate that a FP Desktop system visualization implies a higher performance and usability concerning VR [42, 43], other investigations show that these differences cannot be considered significant [44].

In particular, although a greater intensity has been demonstrated in terms of immersion and presence in VR games compared to desktop games, it does not mean that its use is ideal for all types of games. In the case of driving simulators, it was seen that VR technology is not the best solution, preferring a flat-screen condition, where the participants were seated in front of three flat screens with a combined resolution of 5760 x 1080 pixels and a field of view (FoV) of approximately 135° depending on the size of the participants [45].

3 Serious game description

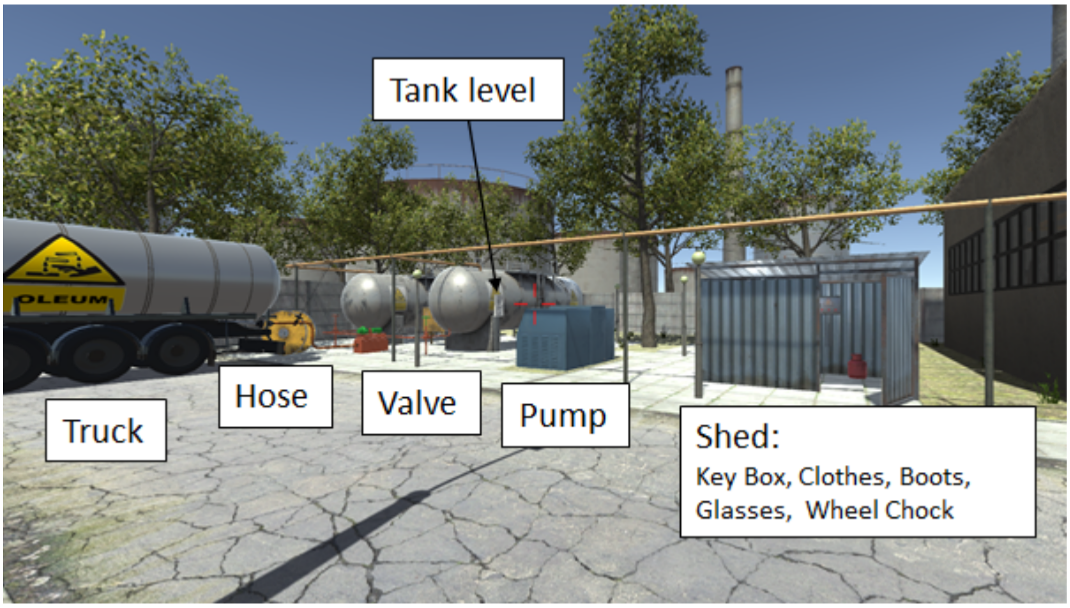


Figure 1: *Virtual Simulator for Learning Dangerous Goods Operations*

The simulator developed allows training the workers of a chemical company in the unloading operations of dangerous goods. The environment includes the necessary elements to perform the usual tasks in these types of operations. First of all, there is a shed where the safety equipment is kept, the wheel chock to stop the truck and the box to keep the keys while the unloading operation is being carried out. In addition, the environment has a representation of the truck and the two unloading tanks. There are also elements to interact with such as the hose, the unloading valves, the pump, and the truck driver. Figure 1 shows a screenshot of the scene. The application has been developed to be able to design different unloading conditions. In this respect, it is possible to choose the type of substance to be unloaded (oleum or caustic soda), the filling level of the unloading tank (empty or full) as well as the atmospheric conditions to simulate the unloading with or without rain.

The sequence of actions to perform the assigned tasks involves the locomotion or displacement of the operator as shown in the floor diagram (see Figure 2). This locomotion is performed without teleportation. The sequence is made up of seven routes. First, the player must go to the driver (route 1), then to the shed (route 2), after this he/she returns to the truck to place the chock on the wheel (route 3), then goes to check the tank level (route 4) and to place the hose (route 5), then the player must go to the valve (route 6) and finally turns on the

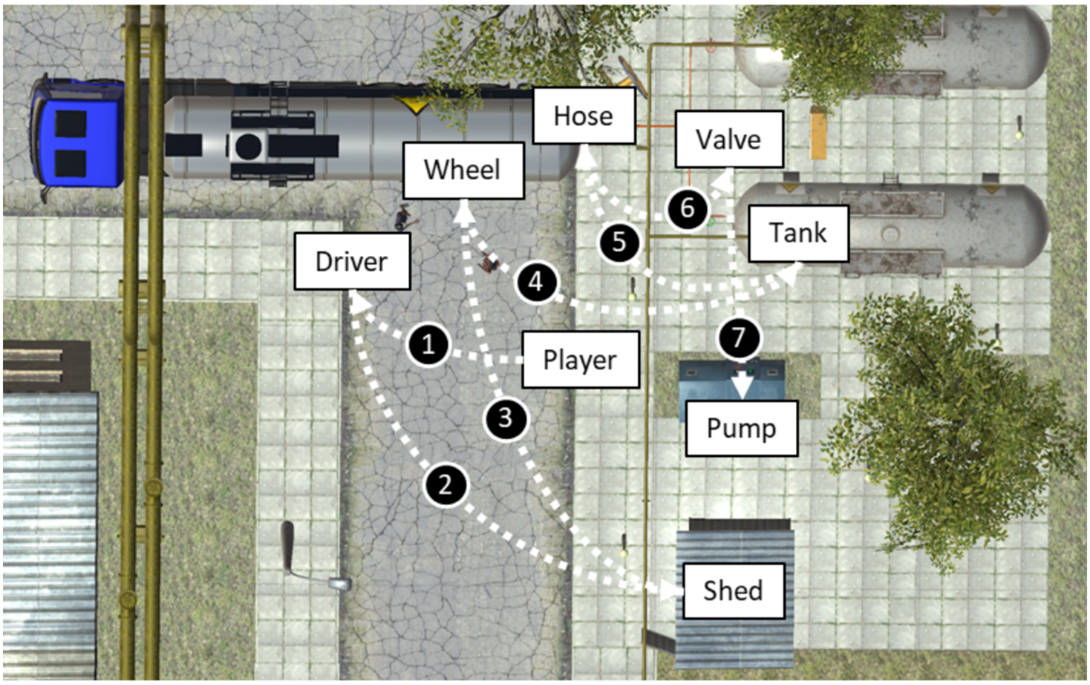


Figure 2: *Sequence of actions map*

pump (route 7). After this, the process is performed in reverse to undo all actions and finally return the keys to the driver to end the experience. During its execution, the system keeps track of the actions performed by the user and displays error messages if the correct sequence is not performed, indicating which of the listed actions will be the next to be performed. Finally, the application generates a report to validate the operator's performance.

The system was developed to allow different types of interaction with environmental elements (see Figure 3), beyond moving around the stage. For example, some objects can be picked up, carried, and deposited, for instance, the driver's keys (Figure 3(a)) and the wheel chock (Figure 3(b)). Other objects can simply be picked up, such as clothing, boots, or glasses, and others can be pressed, including the tank emptying (Figure 3(c)) and pump start/stop buttons (Figure 3(d)). Finally, two-handed interaction is possible when connecting and disconnecting the hose (Figure 3(e)) or turning the valves (Figure 3(f)).

Starting from the initial configuration generated with the variables defined for the experience (type of load, filling level of the receiving tank, and weather conditions), the operator must complete the following actions, performing when necessary the displacements indicated in the paths shown in Figure 2:

1. Wait for truck entry and parking for unloading and then go to the driver (route 1).

2. Take the keys from the driver after he/she gets off the truck.

3. Take the keys to the key box in the shed (route 2).

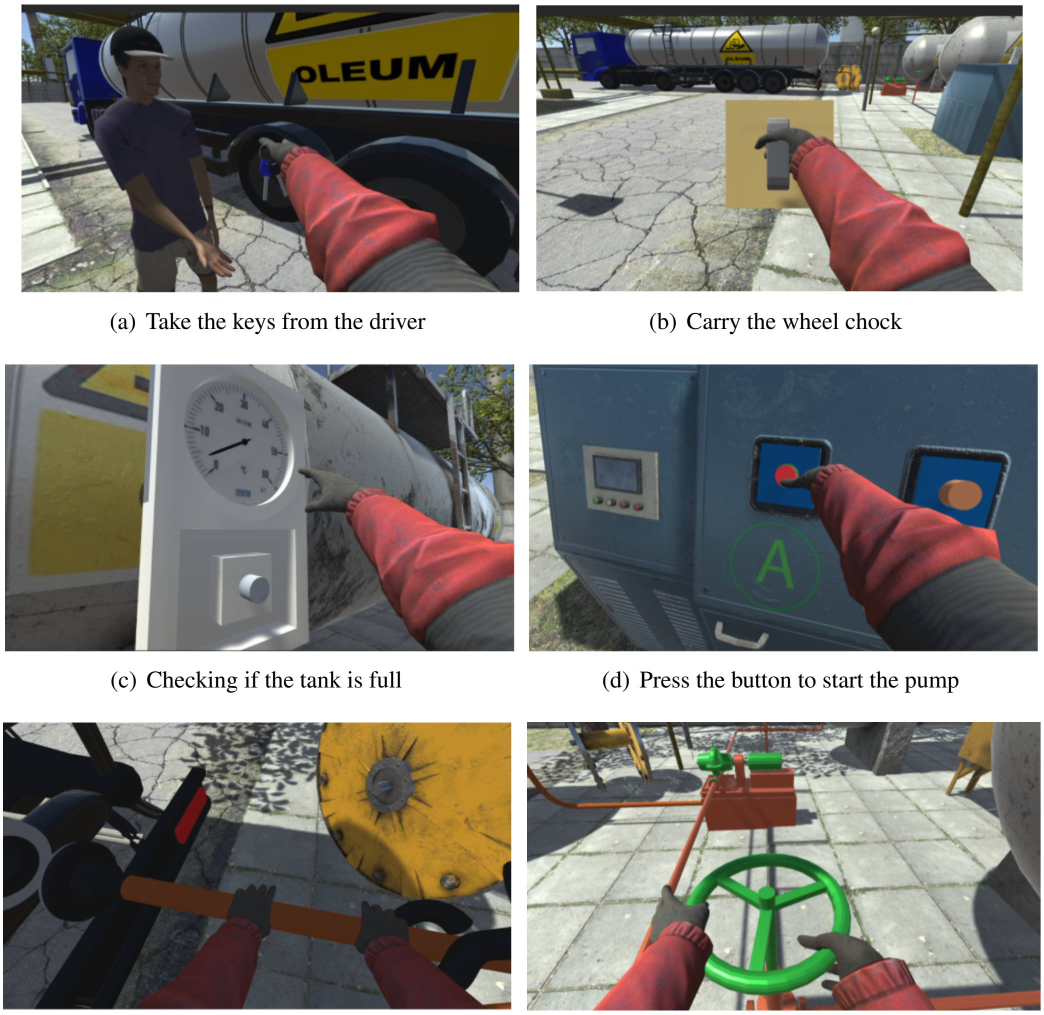
4. Dress according to the type of load.

5. Put on non-skid boots if it rains.

6. Put on safety glasses.

7. Take the wheel chock to secure the truck.

8. Carry the wheel chock and place it on the rear wheel of the truck (route 3).
9. Go to the tank to check its level and empty the discharge tank if it is full (route 4).
10. Go to the discharge hose to connect it (route 5).
11. Go to the corresponding valve depending on the type of product to open it (route 6).



(a) Take the keys from the driver
(b) Carry the wheel chock
(c) Checking if the tank is full
(d) Press the button to start the pump
(e) Disconnect the hose from the truck
(f) Close the oleum valve

Figure 3: *Interaction examples in the simulator*

12. Go to the corresponding pump and press the start button (route 7).
13. Wait for the end-of-load sound signal.
14. Press the button to stop the corresponding pump.
15. Close the valve that has been opened (reverse route 7).
16. Disconnect the hose from the truck (route 6).
17. Remove the wheel chock that brakes the truck (reverse routes 5 and 4, it is not necessary to check the tank level after unloading).

18. Carry the wheel chock to the shed (reverse route 3).

19. Take the keys from the key box in the shed (reverse route 2).

20. Carry the keys and return them to the driver (reverse route 1).

To test the differences in terms of gaming experience of a simulator developed for desktop computers versus the one developed for VR, two versions of the simulator have been developed. Both versions have the same functionalities and simply differ in the interaction and display devices. The interaction in the Desktop application is done with keyboard and mouse and the visualization is on a computer monitor, while in the VR application the interaction is done with the controllers, and the scene is seen through the helmet. It also changes the position of the player, who is sitting in the desktop version and standing in the VR version (see Figure 4).

Figure 4: *Players testing both versions of the serious game*

4 *Experiments description and scope*

Nowadays, VR serious games have proliferated due to their unique immersive and interactive features. These video games are used in the industry as an instructional tool. However, there is no scientific evidence to justify their use against games developed for conventional desktop display devices [13]. For this reason and as a previous work to the evaluation of learning outcomes [12], it is proposed to conduct a study on player experience to initially assess which technology might be most useful in this context. In this sense, and following the work of Pallavicini & Pepe [13], the *In-game GEQ* [14] will be used to compare both technologies.

For this purpose, some key aspects such as the immersion level, fluency, positive or negative emotions, challenge, competition, and tension/anxiety, will be analyzed with the same game played on a desktop screen and in VR. The main hypotheses of this study were:

- **H1**. The dangerous goods serious game played in VR produces more positive emotions than the Desktop one.
- **H2**. Immersion and flow are more intense in the VR version than in Desktop version.
- **H3**. Differences in psychological needs (i.e., sense of competence, tension/annoyance, and challenge) could be relevant between the two technologies for this experiment.

Concerning the design of the experiments, the comparison conditions for each of the experiments were as follows:

- **Simulation in Desktop**: Participants were seated in front of a 27-inch *iMac* personal computer with the Desktop simulator version running in full screen. User interaction with the simulator was performed with keyboard and mouse as is typically done in these games.
- **Simulation in VR**: Participants put on the VR headset *Oculus Quest 2* with the VR simulator version running. The interaction was done with the VR controllers provided by the system.

About both games' implementations, the Desktop version of the simulator was developed with *Unity 3D 2019.2.2* and the *Kineractive 1.11* plugin that allows the creation of complex reverse kinematic interaction. And the VR version of the simulator was developed for *Oculus Quest 2* with *Unity 3D 2019.2.2* and the *HurricaneVR 2.3* plugin which consists of a physical interaction toolkit that allows the creation of immersive VR games. The software used for the statistical analysis was *Matlab R2018b*.

For the experiment's procedure, the experiment was carried out by 60 participants, 31 women and 29 men, with a mean age of 23 years (Standard Deviation = 7.3; minimum age 18 years, maximum age = 56 years). The only condition to participate in the study was that the participants did not have any significant visual impairment (all have normal or corrected to normal visual acuity). The study has received the approval of the Ethics Committee of the Jaume I University of Castellón. The participants were scheduled in pairs and in 20 minutes time slots. One of them had to pick one of the two experiences at will, and the other would go directly to the other. In both experiences, users had a few minutes to get used to the application environment and interaction mechanisms. Once ready, users played with the game for 10 to 15 minutes. For the simulation to be carried out successfully, participants had to perform the sequence of actions presented in Figure 2 and outlined in Section 3. Since the participants had no previous training in dangerous goods unloading, an assistant guided them and explained the steps to be taken in case of doubt. At the end of the experience, they filled out a questionnaire about their game experience.

The questionnaire chosen for both experiences was the GEQ [14] using its *In-game GEQ* version. This questionnaire consists of 14 items for users to express their impressions, rating each item on a five-point Likert scale ("very unfavorable" = 0 to "very favorable" = 4). The *In-game GEQ* collects the following seven different components and two items are used for every component. The items for each are listed below: *Competence* (items 2 and 9), *Sensory and Imaginative Immersion* (items 1 and 4), *Flow* (items 5 and 10), *Tension* (items 6 and 8), *Challenge* (items 12 and 13), *Negative Affections* (items 3 and 7) and *Positive Affections* (items 11 and 14). In addition, item 1 has been slightly modified from "I was interested in the game's story" to "I was interested in the operations sequence of the game" as it deals with actions on a serious game of dangerous goods. Table 1 shows the statement of the *In-game GEQ* questions associated with their corresponding components.

5 Results

After collecting and analyzing the data collected in the questionnaires, the results obtained from the experiments are presented in the following. To analyze the degree of the normativity of the different items, a Lilliefors test was performed for the Desktop and VR simulators, calculating their statistical value and their p-value. To compute the critical values for the hypothesis test, interpolated values are calculated on a table of previously calculated critical values using Monte Carlo simulation for sample sizes less than 1000 and significance levels between 0.001 and 0.50. The cutoff value with this statistic for 60 samples is 0.114 for a 5%

Competence	Item 2. I felt successful Item 9. I felt skilful
Sensory and Imaginative Immersion	Item 1. I was interested in the operations sequence of the game Item 4. I found it impressive
Flow	Item 5. I forgot everything around me Item 10. I felt completely absorbed
Tension	Item 6. I felt frustrated Item 8. I felt irritable
Challenge	Item 12. I felt challenged Item 13. I had to put a lot of effort into it
Negative Affections	Item 3. I felt bored Item 7. I felt it tiresome
Positive Affections	Item 11. I felt content Item 14. I felt good

Table 1: *List of the items in the In-game GEQ.*

level test. For all items the Lilliefors test statistic is greater than the cutoff value, so we reject the normality hypothesis. Consequently, an ANOVA test does not demonstrate the statistical significance of the responses to the questionnaire for the two simulators.

In this work, two non-parametric statistical tests have been used to determine the statistical significance of the results: the Kruskal-Wallis and Friedman test. Kruskal-Wallis test is a non-parametric version of classical one-way ANOVA, and an extension of the Wilcoxon rank-sum test to more than two groups. It compares the medians of the data groups to determine if the samples come from the same population. The approach uses data ranks, rather than numeric values, ordering the data from least to greatest in all groups and calculating the sum. Friedman's test is similar to classical balanced two-way ANOVA. This approach compares the means using data ranks. In both statistical tests use the Chi-squared statistic and the p-value. The criterion to reject the null hypothesis at the 5% significance level will be when the p-value > 0.05.

Table 2 shows the items associated with their components for both simulators (Desktop and VR), where column 4 shows their mean and standard deviation and where bold values indicate the simulator with the highest score. As for the components related to *Tension* and *Negative Affections*, it should be noted that the score interpretation for these two components is different, being better when lower values are obtained in them. Columns 5 and 6 show the statistical significance of the Kruskal-Wallis and Friedman tests indicating their Chi-squared and p-value. Based on this information, if one of the two statistics is not significant, it is considered that the item does not have sufficient statistical significance and, therefore, only items with statistically significant results are marked with an asterisk in column 2.

Overall, the results presented in Table 2 reveal that participants' ratings for the different items are better when playing the VR experience than when playing on the Desktop mode. These differences are seen in the components of *Competence*, *Sensory and Imaginative Immersion*, *Flow*, *Challenge*, and *Positive Affections*. In the case of the item related to *Tension*, there is no significant difference between the two simulators, producing in both cases a low-stress level. As for the *Negative Affections*, there is no significant difference about item 7 "I felt it tiresome", while for item 3 "I felt bored" the VR simulator scores better, probably due to the "wow effect" when using this type of technology.

Components	Item	Simulator	Average± Std Deviation	Kruskal-Wallis Test	Friedman Test
Competence	2 *	Desktop **VR**	2.55 ±1.17 **3.12 ±0.87**	$\chi^2(1)$ = 7.305 p=0.007	$\chi^2(1)$ = 7.989 p=0.005
	9 *	Desktop **VR**	2.00 ±1.19 **2.78 ±0.88**	$\chi^2(1)$ = 13.695 p<0.001	$\chi^2(1)$ = 14.291 p<0.001
Sensory and Imaginative Immersion	1 *	Desktop **VR**	2.28 ±1.11 **3.28 ±0.99**	$\chi^2(1)$ = 26.340 p<0.001	$\chi^2(1)$ = 30.613 p<0.001
	4 *	Desktop **VR**	1.91 ±1.14 **3.17 ±0.96**	$\chi^2(1)$ = 13.695 p<0.001	$\chi^2(1)$ = 14.291 p<0.001
Flow	5 *	Desktop **VR**	1.67 ±1.35 **3.10 ±1.08**	$\chi^2(1)$ = 31.466 p<0.001	$\chi^2(1)$ = 40.500 p<0.001
	10 *	Desktop **VR**	1.33 ±1.17 **3.00 ±1.21**	$\chi^2(1)$ = 40.473 p<0.001	$\chi^2(1)$ = 43.667 p<0.001
Tension	6	Desktop **VR**	0.50 ±0.87 **0.22 ±0.52**	$\chi^2(1)$ = 3.472 p=0.062	$\chi^2(1)$ = 5.558 p=0.018
	8	**Desktop** VR	**0.10 ±0.30** 0.15 ±0.66	$\chi^2(1)$ = 0.350 p=0.554	$\chi^2(1)$ = 0.236 p=0.626
Challenge	12 *	Desktop **VR**	1.45 ±1.31 **2.22 ±1.25**	$\chi^2(1)$ = 9.636 p=0.002	$\chi^2(1)$ = 11.757 p<0.001
	13 *	Desktop **VR**	0.83 ±0.89 **1.37 ±0.74**	$\chi^2(1)$ = 12.421 p=0.001	$\chi^2(1)$ = 14.340 p<0.001
Negative Affections	3 *	Desktop **VR**	0.93 ±1.19 **0.20 ±0.55**	$\chi^2(1)$ = 18.002 p<0.001	$\chi^2(1)$ = 24.667 p<0.001
	7	Desktop **VR**	0.35 ±0.78 **0.20 ±0.55**	$\chi^2(1)$ = 1.402 p=0.236	$\chi^2(1)$ = 1.401 p=0.236
Positive Affections	11 *	Desktop **VR**	2.40 ±1.11 **3.30 ±0.91**	$\chi^2(1)$ = 22.407 p<0.001	$\chi^2(1)$ = 32.236 p<0.001
	14 *	Desktop **VR**	2.72 ±1.11 **3.43 ±0.85**	$\chi^2(1)$ = 15.999 p<0.001	$\chi^2(1)$ = 22.801 p<0.001

Table 2: *Average score, standard deviation and statistical significance for questionnaires.*

6 *Discussion*

6.1 *Positive emotions*

Analyzing the results about the starting hypotheses, the following conclusions can be drawn. Firstly for hypothesis H1, the participants' impressions of positive emotions show that the VR experience makes them feel better. There is a clear difference in the average values obtained for both simulators. In addition, these results have statistical significance as can be seen in the values obtained for items 11 and 14 in Table 2. This perception has been demonstrated by other research works, with some exception [45]. Although, the most widespread assumption is that VR causes the so-called "wow effect" [46] that produces such positive emotions.

6.2 *Immersion and flow*

Furthermore, it can be seen from the results that there is a clear difference in the preference of the participants in the questionnaire in favor of VR simulation over Desktop in terms of the components related to immersion and flow. This confirms hypothesis H2 regarding how VR impresses, isolates, and absorbs users from the outside world. Furthermore, the results shown in Table 2 indicate that there is a large difference between the scores obtained on average for these components, which also show statistical significance for both Kruskal-Wallis and Friedman tests.

6.3 Psychological needs

Finally, regarding the psychological needs, it should be noted that hypothesis H3 establishes that the differences between the two simulators could be significant (in contrast with other authors [13, 45]). In this sense, the results show clear differences in favor of the VR experience regarding *Competence* and *Challenge*, and all the items involved show statistical significance. However, about *Tension*, the differences are less visible, and only item 6 "I felt frustrated" which is slightly lower in the case of VR is close to statistical significance. Moreover, if *Negative Affections* are analyzed only item 3 "I felt bored" is lower in the VR experience, while item 7 "I felt frustrated" is very similar.

6.4 Other considerations

Because of the results obtained and taking into account that the experiences are different from others studied in the literature [13, 44], it can be concluded that the dangerous goods unloading simulator does present significant differences in terms of the psychological needs of the participants when they play in Desktop vs VR. About *Competence*, users felt more capable and skilled in the VR experience. In terms of *Challenge*, the VR experience was more challenging and thought-provoking. On the other hand, regarding *Tension*, although the differences are less significant the VR experience provoked slightly less frustration although similar irritability among participants.

It should be noted in any case, that in the proposed experience the level of difficulty for the user is higher since there are tasks in the dangerous goods unloading simulator that require complex actions. In addition, users have to move around a virtual environment to perform different tasks.

7 Conclusions and future work

The continuous advances in the development of VR technologies and their application in training make it necessary to study the advantages of these applications over traditional desktop solutions. In the same way, it is also worthwhile to assess the new forms of interaction that these new technologies provide and their application in specific fields.

In this regard, the developed work performs an analysis to evaluate the game experience in a simulator for learning the tasks of unloading trucks carrying dangerous goods. The study compares two versions of the simulator, the first one running on a Desktop computer and the second one as a VR application. The study shows that the VR experience produces better overall results for most of the components in the *In-game GEQ*. The study results suggest that there are significant differences in the psychological needs of the participants, mainly in terms of *Competence* and *Challenge*. However, with frustration, irritability, and tiresomeness the feeling is similar in both simulators.

However, it seems apparent that there is still research work in this field. There is a dependency between the application type and the game experience raised by the player from the literature [13, 20]. It is not the same to play a game sitting or standing, or with a proxy device such as a steering wheel and VR controllers or hands.

In the future, to verify these guesses and analyze the advantages and disadvantages of using different technologies, it would be necessary to experiment with many more applications that address the problem from different perspectives. For instance, using alternative interaction systems or different physical objects (proxy objects). Another aspect is the user's success and performance analysis. In cases such as dangerous goods handling, the experience has to fulfill its purpose and provides knowledge and practice to improve their working conditions and safety.

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