Developing a tutorial for improving usability and user skills in an immersive virtual reality experience

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Abstract. The fast development and progressive price reduction of Virtual Reality (VR) devices open a broad range of VR applications. Especially interesting are those applications focused on educational objectives. However, before these VR applications can be extensively presented in the educational system, some main issues to optimize their efficiency in the student's autonomous learning process should be solved. While in non-VR games designers have consistently developed introductory tutorials to prepare new players for the game's mechanics, in the case of VR, the design of these tutorials is still an open issue. This research presents a tutorial for VR educational applications to help the users to become familiar with the virtual environment and to learn the use of the interaction devices and the different mechanics within the experiences. In addition, the usability of this tutorial was tested with final users to assure its effectiveness.

Keywords: Virtual Reality, Tutorial, Education, E-learning, Novelty Effect

1 Introduction

In recent years, Immersive Virtual Reality (iVR). This type of Virtual Reality (VR) allows the interaction in the environment versus the non-Immersive Virtual Reality (i.e CAVE-type system [1]). Although virtual reality technologies have been around since the late 1950s, their mainstream adoption has been very limited due to the high cost of the equipment. Nowadays, the wide availability of affordable software and hardware tools on the market opens the door to a variety of new teaching and entertainment virtual reality experiences. Furthermore, several studies suggest that the use of immersive virtual reality in education or training can substantially improve interest in learning in

adfa, p. 1, 2011.

these scenarios [2], as well as facilitate the understanding of complex concepts [3] and reduce misconceptions [4].

This rapid growth is producing that many developers focus on developing new iVR experiences. Although, as iVR is still a novel technology, it is likely that most users have not used it before. The unfamiliar experience associated with the use of Head Mounted Displays (HMDs) and the novelty of using unnatural Virtual Reality interfaces could be a source of extraneous cognitive load [5]. This extra cognitive load can lead to lower satisfaction and learning rates in the case of iVR educational experiences. Slow and progressive familiarization, visual clues, and guidance incorporated in the educational iVR experiences can be used to help the user to overcome these limitations.

In non-VR games, game designers have consistently designed introductory tutorials to prepare new players for a game. Usually, these tutorials are the user's first exposure to a game. Therefore, it is crucial that tutorials are effective in order to engage and retain players [6]. Another objective of these introductory tutorials is the acquisition of basic skills. These tutorials should prepare players by providing basic instructions and allowing them to practice without a time limitation. By the end of the tutorial, the players' skills should match the challenges so that they can enjoy the game [7].

The design of these tutorials for iVR experiences poses different challenges than those of a conventional non-VR game. Players must use an HMD that fully immerses them in a strange environment while they must acquire the basic skills of the experience. When an introductory tutorial is not included in the iVR experience, players are likely to devote their initial attention to experimenting. Besides, they will begin to acquire interaction skills with the iVR environment during the game, rather than to concentrate on the content (narrative, objectives...). In this way, an introductory tutorial provides an opportunity for new players to acquire knowledge and skills before starting the virtual experience. Therefore, the objectives of these tutorials on iVR are to make the user familiar with the virtual environment, with the interaction devices and with the way to interact with the objects in the virtual world [8].

These tutorials play an essential role in any educational or training iVR applications, since their main purpose is to improve the learning or skills of the trainee. Typically, the most common experimental designs in these studies compare learning outcomes between a desktop solution and an iVR environment after testing for differences through pre- and post-testing within a group of participants. However, many of the virtual reality experiences found in the literature do not use an introductory tutorial and do not consider in their research the possible differences, in terms of acceptance of the technology, between the two digital approaches. Although a large variety of research literature points to the fact that the use of iVR experiences improves learning, it is also fair to highlight that some studies found no positive effects. Some studies reported negative effects of using iVR on learning even when learners were reporting very high satisfaction rates [9], [10] and some others presented no effects on learning outcomes

[11]–[14]. Although inexperienced users may see their results compromised because they are not sufficiently proficient in the iVR environment, there is a lack of research on the effectiveness of using tutorials to bridge the gap responsible for these negative results. This fact only underscores the need for further research on the role of the design elements to explore the potential of iVR to enhance learning.

For this reason, this research focuses on the development and validation of an iVR tutorial to reduce the novelty effect in virtual reality environments. The conclusions obtained are intended to guide the design of iVR applications and maximize the potential of iVR in instruction.

The remaining sections of this paper will be organized as follows: Section 2 will present an analysis of the most recent work on the use of tutorials in iVR. In Section 3, the design of an iVR tutorial will be described. In Section 4, the usability evaluation will be analyzed with its procedure and results. Finally, in Section 5 the main conclusions of this research are highlighted, and future lines of work are established.

2 Related work

For non-VR games, the influence and need for tutorials varies depending on how complex the game is. In a study with 45,000 players and 3 video games of varying complexity researchers found that tutorials were only justified in the most complex game when analyzing game´s duration, levels completed, and return rate [6]. In addition, players who used tutorials played longer and completed more levels than those who did not have tutorials. This study implies that tutorials may not be necessary for simpler games because their game mechanics can be discovered through experimentation but are a must in complex games.

In commercial iVR games, it is common for the game to start with a tutorial teaching the player how to play [15]. They also come to the same conclusion that using a tutorial makes little difference in simple VR games. On the other hand, in complex VR commercial games, a tutorial can influence controls learnability, engagement-related outcomes, and performance [15].

With respect to iVR research experiences committed to improving learning or improving skills, the scenario is very different. Very few of these research experiences use or report the use of a tutorial. Based on an extensive literature review previously presented here [2], a re-analysis of the papers included in this investigation shows that only 10% of the total number of articles used a tutorial in their experiments. This disclosure becomes even more relevant since for inclusion in this review the articles had to include an evidence-based approach evaluation. Their conclusions about whether or not a virtual reality experience is effective in enhancing learning or skill acquisition may then be compromised on commitment-related outcomes and performance. Among the articles that do include a tutorial, it can be noticed that these tutorials are commonly used to make the players know what to do during the game. They are usually included as an initial level [9], [16]–[19]. However, other tutorials were used for accommodating users and making them get acclimatized to the VR environment. For instance, the tutorial used by Bhargava et al. [20] is used in a way that the user gets accustomed to select and manipulate elements. Shewaga et al. [21] uses the pre-created SteamVR Tutorial in order to let them learn how to handle the basis of the HTC Vive controllers. This group of tutorials, whose main objective is to introduce users to the VR environment, aims to familiarize the user with the virtual environment by teaching them how to use the interaction devices and interact with the objects in the virtual world. Consequently, the novelty effect is mitigated. This effect causes discomfort when users must perform specific VR video game tasks and do not feel sufficiently prepared or comfortable with the VR equipment because of its complexity [8]. In other research, users can choose whether or not to play the tutorial [22], [23] or do not specify how to use the tutorial [24].

Finally, other studies go beyond the introductory tutorial and use real-world tutorials [25]. This strategy increases people's sense of familiarity and confidence with a game. This study conducted an experiment in which players practice in a real or virtual environment before playing an iVR game. The study found that practicing in a familiar reality makes them feel as confident and familiar as someone who has practiced in VR. This implies that practicing indistinctly in the real world as well as in the virtual world has positive effects.

3 Designing an effective and engaging tutorial

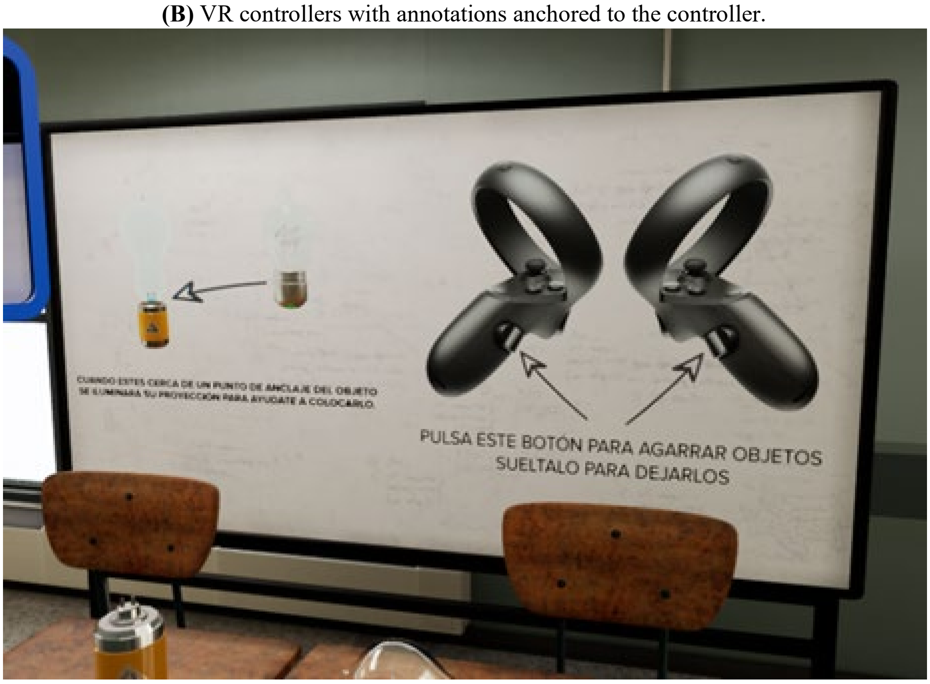
Before designing a tutorial, it is important to keep in mind that there is a lot of information to convey before players begin the iVR experience. For example, the context of the game, the goals, and different operations of the game's functions and its utilities. In an analysis of most successful commercial iVR games, the majority had in their introductory tutorials some form of text help (88%), diagrams or images (56%), and a small number of research use labels on those controllers to instruct the player (22%) [15]. The design of these games, according to their developers, rely on intuition, personal experience, existing examples, and user testing to create the tutorials [6].

The categorization of these tutorials can be established according to whether they are used to teach by instruction, teach by example, or teach by a carefully designed experience [26]. If taught by instructions, the tutorial should present a set of instructions explaining the rules of the game. In the case of teaching using examples, the tutorial should present demonstrations that demonstrate to the player what to do. Finally, in a carefully designed experience, the tutorial should be designed so that the player can explore and try out actions in an environment that should be easier to interact with without time constraints or attempts. In this research, the model of a carefully designed experience was chosen. This approach allows the user to practice in a quiet environment the different mechanics that will be used throughout the experience.

Likewise, this development is based on the cognitive theory of multimedia learning [27] which explores effective principles in designing multimedia experiences for learners. However, most of the literature investigating its application has been conducted on desktop 2D games, so certain principles need to be adapted for use in iVR. The principles followed or adapted from this model are:

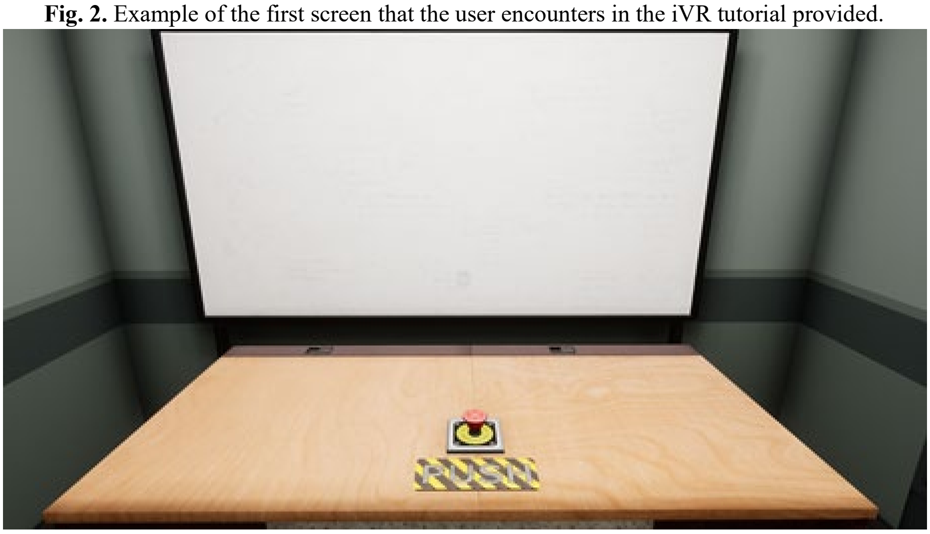
- **Use text and graphics together:** One of the principles of multimedia learning is that it is more effective to combine graphics with text, instead of presenting only words. It is recommended to use images that help the user to understand the material. In iVR, one of the main problems is learning how to operate the virtual controllers. Organizational graphics and diagrams that annotate different controller buttons with their purpose are commonly found in VR tutorials. In this research we chose to apply it in a way that the user could understand the use of the controllers through diagrams that use graphics and text together as illustrated in Figure 1A. As well as a more novel and effective way by placing these texts directly on the controller as can be seen in Figure 1B.

Fig. 1. A) diagram showing the user the different controller buttons used in this experience. **(B)** VR controllers with annotations anchored to the controller.



- **Coherence Principle:** According to this principle, extra material hurts learning. Therefore, any material that is unnecessary for the purpose of the instruction should be avoided [28]. This fact includes limiting the use of extraneous words and graphics as they can lead to distraction (directing the learner's attention to superfluous material), disruption (preventing the learner from constructing a mental model due to irrelevant material), and seduction (prioritizing an irrelevant knowledge domain). In this tutorial, as Figure 2 shows, efforts have been made to limit any source of superfluous extra material that could distract the user. Likewise the environment has been designed to provide neutral colors with no distracting elements.

Fig. 2. Example of the first screen that the user encounters in the iVR tutorial provided.



- **Signaling Principle:** This principle is based on using visual cues to direct the user's attention. Different research shows that the use of visual clues speed up the learning of information and improve learning efficacy [29], reduce cognitive load [30], [31], and improve the speed and accuracy of completing tasks [32]. These clues can be of different types. The most common forms are arrows, large text, bolded text, and color. In this research, the use of an assistant robot that guides the user through the tutorial is proposed. This feature allows the robot to offer its help when we look directly at it, as Figure 3A shows, or to wait for our help´s call, as shown in Figure 3B. This functionality enables not overloading the environment with information, while offering relevant information to the user when is needed.

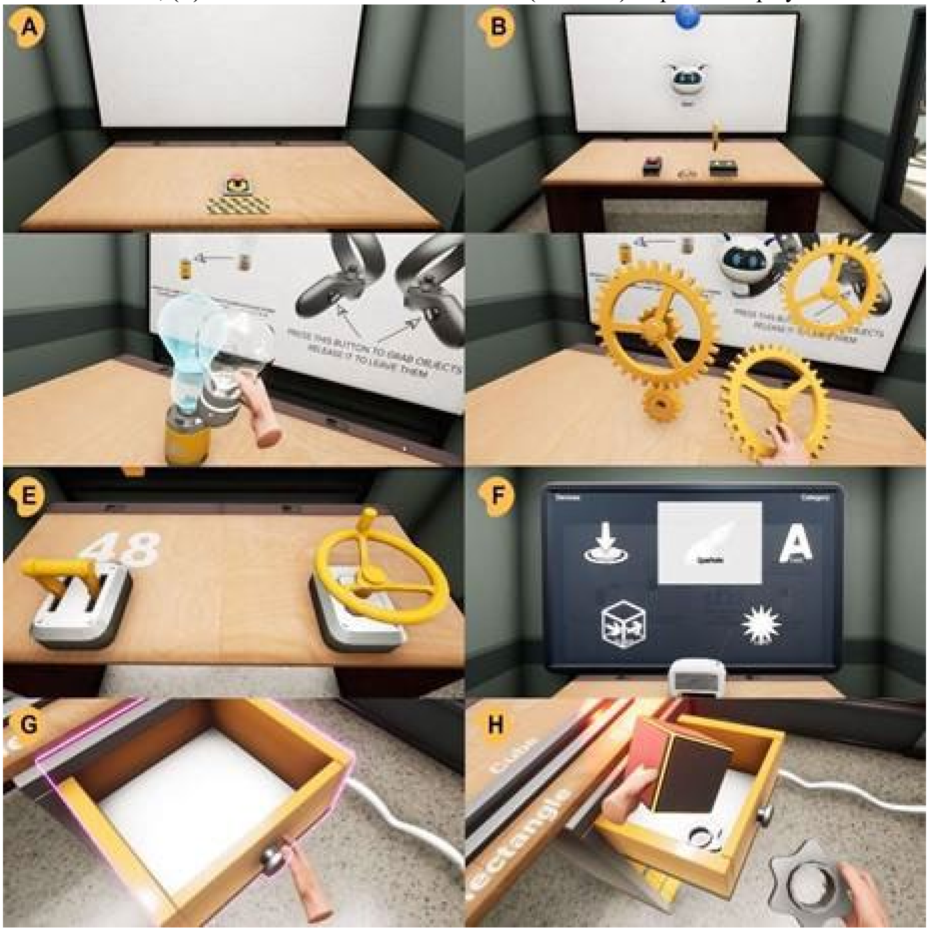
Fig. 3. (A) Robot assistant displaying information. **(B)** Robot assistant in standby mode.

The development of a tutorial in iVR is a time and resort consuming task. To reduce this effort, a previously tested and validated framework was used [33]. This framework simplifies the development of iVR applications and allows researchers to focus on the design once the framework already solves the main technical issues of the iVR environment´s development. This framework has been developed in Unreal Engine™. This game engine stands out in its high capacity to create photorealistic environments and the ease of use. In addition, it is compatible with most iVR HMDs on the market. The framework includes tools for the most common tasks when it comes to creating iVR experiences: movement of the player, interactions with the scenario and objects, the creation of scene objectives and data collection.

The developed tutorial has been designed to be useful in a wide variety of applications. Firstly, this tutorial should help the user to become familiar with the virtual environment. Secondly, it should help to understand how to use the interaction devices and to learn how to interact with the objects in the virtual world. However, this goal can be difficult, as not all iVR applications use the same forms of interface or interaction. For this purpose, different modules have been developed that can be combined so that the tutorial can be adapted as much as possible to the user's subsequent experience and so that at the end of the tutorial the players' skills match the challenges they will face in the experience. The following phases are required for this purpose:

- **Introduction:** This is a distraction-free space where the user can become familiar with the virtual environment. Also, following the principle of coherence, the use of extraneous words and graphics has been limited as they can lead to distraction.
- **Basic interactions:** Once the user has settled into the virtual environment, in front of him, the button to start the tutorial can be pressed, as Figure 4A shows. This interaction is very basic and accessible. Moreover, in this way, the user manages the pace of the tutorial on his own. The next module helps the user to deepen the basic button-pressing interaction (Figure 4B).
- **Grab:** One of the most common interactions is grabbing objects. Usually, these objects fulfill a certain purpose and it is necessary to perform an attachment. As Figures 4C and 4D show, in this module of the tutorial the user can learn to grab the objects as well as to attach them to other objects.
- **Complex interactions:** Some experiences require more complex interactions than those already presented. This module aims to introduce some of them, such as interacting with levers (Figure 4E).
- **Interact with User Interfaces:** Another important interaction to practice are the ones related to User Interfaces. This type of interface is often used to interact with menus or information screens. In Figure 4F, an interaction with a complex user interface can be observed.
- **Explore and play:** This final module has been conceived as an assembly of all the previous ones, where the user can explore and practice again all the previously introduced mechanics (Figure 4G and 4H). When the user feels ready, the experience can begin, with the advantage of feeling prepared for the tasks that the user will face next.

Fig. 4. Modules of the tutorial: **(A** and **B)** Basic interactions, **(C** and **D)** Grab, **(E)** Complex interactions, **(F)** Interact with User Interfaces and **(G** and **H)** Explore and play module.



4 Usability evaluation

The usability of the iVR tutorial was tested as an introduction to the iVR experience "Computer Assembly VR" [34]. This VR experience was designed to study the enhancement of learning about computer assembly and its component parts. It seeks to reinforce users' knowledge of basic computer concepts such as cooling a desktop computer, identifying the parts of a motherboard or assembling a desktop computer with certain characteristics.

The tutorial was included at the beginning of this experience, in order to help the users become familiar with the virtual environment and to understand how to use the interaction devices and the different mechanics within the experience.

In order to study the effectiveness of the tutorial with those goals, an iVR experience was organized to measure the usability of the tutorial itself. The study sample consisted of 10 first-year students of Computing and Communications of a Vocational Education and Training (VET). Nine of them are men and one woman. Their mean age is 18.9 years old. The entire experience was executed following the security measures for the prevention of COVID-19 transmission. In addition, it complies with data protection regulations.

4.1 **Preparation and procedure**

The setup of the experience consisted of three workstations equipped with Intel Core i7-10710U, 32GB RAM, with NVIDIA GTX 2080 graphic cards connected to the HTC Vive Pro Eye HMDs.

Fig. 5. User interacting with the iVR experience.

This iVR experience began with a brief explanation of the HMD and the experience itself. Then, 3 of the participants put on de HMDs and begin with the tutorial. In this particular event, and in order to test the usability of all the modules developed, the users tested all the modules. In addition, in the Explore and play module, the users were forced to stay for a certain amount of time, so that the total duration of the tutorial was never less than 5 minutes. The tutorial allowed the user to move all around the scenery and to squat to reach objects scattered on the virtual ground. The space was enabled to permit all the movements mentioned in dimensions of approximately 2x2 meters.

Immediately after the iVR experience, the participants completed a satisfaction and usability survey. This test includes a question for cybersickness assessment, 22 Multiple-Choice Questions (MCQ) for usability rating each aspect with 1 to 5 points in a Likert scale and 3 open questions for giving their positive and negative aspects and suggestions of the iVR experience.

This Likert scale was converted to a scale of 1 to 9 to analyze more precisely the results of the survey. The conversion was done by making an equivalence between both of the scales. The 0 and 10 points were dismissed because the 0 means no data in this question.

The questions were divided into categories to evaluate 5 different aspects of a VR experience: engagement, presence, immersion, flow, and skill, as Tcha-Tokey, et al. [35] proposed.

- **Engagement,** commonly known as involvement, is defined as the commitment that exists between the user and their actions in VR. If a user is not so motivated with the environment and the tasks to do in there, the engagement will be low. Also, engagement is related to presence and immersion [36]. Engagement was evaluated with 3 questions.
- **Presence** is the behavior and feeling as a result of believing the VR environment is real, also defined as the illusion of 'being there'. The user feels the VR environment as the dominant reality [37] and their behavior tends to be like if they were living in a real situation [38]. For assessing the presence, 5 questions were used.
- **Immersion** is related to the hardware. The immersion is the perception of being physically in the VR environment, as if all the stimuli came from the virtual world. For the evaluation of the immersion, 4 questions were asked.
- **Flow** is a psychological state that occurs when the user feels control and enjoyment. Flow was evaluated with 3 questions.
- **Skill** is the evolution of the user's knowledge in certain activities during the VR experience. To evaluate, 6 questions were used. The questions with their type of knowledge are collected in Table 1.

Table 1. Usability and satisfaction survey used.

Engagement	● This tutorial could be useful for learning. ● The information given by the tutorial was clear. ● The VR environment was realistic.
Presence	● The interactions with the VR environment were natural. ● An objects' examination from diverse points of view and distances was possible. ● The interaction with VR controllers was natural.

	● The VR controllers that monitor the interactions resulted distractive of doing the assigned tasks.
Immersion	● The enjoyment of the experience was possible. ● The involvement in the VR environment was so high that the notion of time was lost. ● The VR experience provoked the sense of feeling physically good. ● The involvement in the VR environment was so high that what occurred around was not perceived.
Flow	● The VR environment responded to the initiated actions by the user (e.g., taking an object was working well). ● The actions were perceived as they can be controlled perfectly. ● In each proposed task, it was known what to do.
Skill	● The VR controllers were easy to use. ● The VR interaction was fast to get accustomed to. ● At the beginning of the experience, the interaction with the VR environment felt well. ● At the end of the experience, the interaction with the VR environment felt well. ● The first time the computer components were collocated (first level), interacting with the VR environment, grabbing, and collocating objects was easy. ● The last time the computer components were collocated (last level), interacting with the VR environment, grabbing, and collocating objects was easy.

4.2 Results

This section analyses the results of the usability and satisfaction survey. During the iVR experience, performance data was collected to measure the duration of the experience for each participant. The average duration of the tutorial was 456 seconds and the total time of the rest of the iVR experience was 648 seconds on average.

In comparison to a previous experience in which a tutorial was not included in the "Computer Assembly VR" [34], different performance was noticed, although no quantitative indicators were recorded to ground this result. The direct observation of the users' performance shows that the users demonstrate better and faster movements while they were interacting in "Computer Assembly VR" when they previously played the tutorial. The tutorial made them lose the novelty effect in the iVR environment. Participants were more confident and relaxed. Nevertheless, more experimentation and future research are required to corroborate it.

Furthermore, the usability and satisfaction with the tutorial provide useful conclusions. Participants reported high averaged rates of engagement (7.73), presence (7.34), flow (7.10), immersion (7.88) and skill (8.04). All these data and standard deviations are collected in Table 2.

Although three of the participants reported cybersickness, its level was very slight (rate 3 in a Likert scale in which 1 was a lot of cybersickness and 4 none at all). The experimented cybersickness by these three participants was considered for comparing the data between two groups: one with cybersickness and other without it. The difference between students with cybersickness and none is also collected in Table 2. The comparison between both groups shows that participants who experienced cybersickness had less skill, 7.86 versus 8.12. On the contrary, participants with cybersickness scored the rest of the questions' categories higher than the participants without cybersickness. This fact means that, despite the cybersickness, they got good experience satisfaction.

Table 2. Mean (M) and Standard Deviation (SD) of satisfaction and usability survey, and the difference with participants with cybersickness.

	All participants (N=10)		Participants without cybersickness (N=7)		Participants with cybersickness (N=3)	
	M	SD	M	SD	M	SD
Engagement	7.73	1.38	7.67	1.30	7.89	1.35
Presence	7.34	1.77	7.21	1.76	7.63	1.59
Immersion	7.88	1.40	7.79	1.46	8.08	1.01
Flow	7.10	1.48	6.79	1.57	7.83	0.29
Skill	8.04	1.39	8.12	1.13	7.86	1.47

Participants commented in the open questions that the experience was realistic, easy to control, useful for learning and understanding a computer, it permitted good immersion and it was original. These results show high satisfaction with the experience. The participants who experienced cybersickness commented that, when they had to move too much their head, their vision was blurred, and they suffered from discomfort. They noticed some difficulties in grabbing objects, and they got distracted. The rest of the participants commented that the negative aspects are sporadic mistakes of not grabbing objects and punctual moments where the participants did not know what to do. These suggestions will serve to adjust the experience to make it easier to understand and give clearer instructions.

5 Conclusions

Tutorials can be considered as a lack of time for many users and developers, but they are required to make the users engaged in a video game or a VR application. The purpose of a tutorial is to familiarize users with the controls and the rules of the game. When the user is immersed in a VR environment for the first time, he will focus on learning the controls and paying attention to the details which involve him. Therefore, a lack of attention to the content of the game, for example history and learning tasks, will be experienced by the user. This means that a tutorial is required to make the user lose the novelty effect, and it is in which this research focuses on.

A tutorial was designed, developed, and tested for iVR educational experience. The tutorial is composed of different modules in order to adapt to the experience of the user who has to be capable of completing all the tasks in the experience at the end. This design solves the fact that previous research had demonstrated that the user can not feel prepared to do the tasks of the iVR experience because of its complexity. The users familiarize with the environment and learn how to interact with the elements. The actions they are meant to do are not specific, due to the fact that the tutorial can be used for more than one experience which does not need all the same actions. The tutorial was divided into 6 phases: introduction, basic interaction, grab, complex interactions, interact with User Interface and explore and play. An increasing complexity of the tasks is experimented as the user advances levels.

A framework in Unreal Engine was used to reduce the time of development of the tutorial, so that longer time could be invested in research. So, the production of the tutorial is based on the cognitive theory of multimedia learning. From this research, the tutorial includes text and graphics together in order to understand material and how to operate in the environment with the controls. In addition, it uses the coherence principle which explains that the minimum material it is required to not get users distracted. Finally, the signaling principles to improve learning of information and performing tasks without overloading the environment and being there when the user needs it.

The tutorial was tested in 10 Computing and Communications VET students. Firstly, participants completed the tutorial. Then they were immersed in “Computer Assembly VR” to improve their computer knowledge. Their performance was compared to a previous experience which was done without the tutorial. Participants who took the tutorial showed a better performance, more confident and relaxed than in the other experience. Finally, participants completed the satisfaction and usability survey composed by 22 MCQ to rate them from 1 to 5 in a Likert scale and 3 open questions. The questions were divided into 5 categories: engagement, presence, immersion, flow, and skill. The results showed that participants had a notable satisfaction.

Also, a cybersickness event was collected in the satisfaction and usability survey. 3 of the participants experience a little cybersickness. Therefore, the group with cybersickness and without it were compared. The analysis demonstrated that the group with cybersickness had less skill but a higher satisfaction than the group without cybersickness. In the open questions, participants commented that the application was easy to control, realistic and original. Contrary to this, the cybersickness group showed that they had blurred vision, discomfort suffered in their eyes and distraction.

While it is well accepted that tutorials affect game players in some contexts, there is a lack of research on the relative effectiveness of different tutorial modalities. Further research in this domain can help develop guidelines that will help game designers and researchers make more informed design decisions.

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