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Investigating Trainee Perspectives on Virtual Reality Environments: An In-Depth Examination of Immersive Experiences with Haptic Feedback Vibration

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***Abstract*—This research investigates trainee reflections on Virtual Reality Environments (VREs) within educational training centers, aiming to understand their experiences, perceptions, and preferences. The study focuses on the impact of haptic feedback vibrations, examining both their general effects during VRE interactions and the specific influence of adaptable vibration configurations triggered by user errors. A convenience sample of 81 participants/trainees, 41 from the computer science and 40 from the aviation engineering departments of a major higher education institution in the U.A.E., was used to run four variations of the same VRE, with two from each field. Results indicate that participants largely embraced the VRE experience, reporting feelings of contentment, joy, and competence. Haptic feedback, particularly in non-adaptable forms, was acknowledged as enhancing the immersive experience. However, the study suggests that further research is needed to explore the nuanced role of adaptable vibration, especially in more complex interactions. Notably, participants expressed a preference for a blended approach, advocating for both VREs and physical labs in their training. The study acknowledges limitations, such as the predominantly single-user focus, and recommends future research extensions into collaborative VRE settings, more intricate interactions, and potential technical issues in multi-user scenarios. Overall, this research sheds light on the evolving landscape of educational training, emphasizing the importance of understanding trainee perspectives to optimize the integration of VREs in learning environments.**

***Index Terms*—Virtual reality (VR), haptic feedback vibration, algorithm, immersiveness, reflections**

I. Introduction

Dating back to the 1930s, the history of Virtual Reality (VR) is rich, with the emergence of the ”Link Trainer” flight simulator as an early application that showcased the potential of VR technology. This vacuum-based device allowed pilot training without actual flight, highlighting VR's capacity to create realistic, immersive experiences. Another milestone in VR's development occurred in 1935 with ”Pygmalion's Spectacles,” a pair of goggles enabling users to step into imaginary worlds [1], [2].

The utilization of VR is motivated by the understanding that humans are multi-modal perception creatures, capable of combining and analyzing information from various sensory modalities, such as vision, audio, touch, and smell. The brain identifies if these modalities belong to the same event, facilitating a meaningful experience. Changes in one sense can impact another; for example, variations in the soundtrack can enhance the vividness of the three-dimensional (3D) environment [3]–[5].

Ongoing efforts to advance VR technology are centered on enhancing immersion and faithfully replicating the real world. This involves the incorporation of multi-sensory cues, including visual, auditory, and haptic feedback [2], [6]. In VR, users can fully immerse themselves in computer-generated environments, thanks to technologies like Head-Mounted Displays (HMDs), which block visual access to the real world but enable complete engagement with simulated environments featuring comprehensive visual and audio properties [7], [8].

Within VREs, users can manipulate physical or virtual objects through interactions. Basic interactions include gestures and movement-sensing, while more advanced interactions involve collaborative work in the same VRE, such as communication with other users and access to their spaces [9]. Devices like headsets grant users the ability to exist in a virtual space as avatars with diverse characteristics and motor effects like mimicry [6], [9], [10]. However, display notifications, even if related to real-world events, can interrupt users in VREs with negative effects [7].

II. Aims and Contribution

The primary aim of this research project is to evaluate the impact of adaptable haptic feedback vibration configurations in single-user VREs. It also attempts to comprehend students' perspectives and reflections arising from their interactions with these configurations, investigating whether such experiences influence their inclination to favor VREs as a substitute for

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physical laboratory environments. To elaborate further, the research project focuses specifically on the following aspects:

1) Collecting trainees' reflections on their overall learning experiences in VREs.
2) Exploring trainees' willingness to transition from traditional physical labs to virtual lab environments.

The theoretical contribution of this research lies in its potential to enhance the use of VR in training, whether in a central or complementary role, by transforming courses into highly interactive, digitally-driven learning experiences. This substantial step bridges the gap between theoretical knowledge and authentic learning, enabling trainees to engage with real-life situations and acquire knowledge through VR settings, particularly when physical presence is hindered by factors such as high costs or geographical distance. It facilitates the recruitment of trainees from remote regions or different countries without compromising education quality.

The practical contribution of this research involves the development of a highly extendable VR prototype for training activities, tailored to the cognitive level of the course at the time. As part of this contribution, an algorithm for adaptable haptic feedback vibration settings is formulated and suggested in the context of the interactions and manipulations of 3D objects in the VRE.

III. Background

VR systems comprise both hardware and software components. HMDs incorporate processors, sensors, cameras, microphones, various input devices, as well as location and orientation sensors. These components collectively generate sensory experiences encompassing visual, auditory, haptic, smell, and taste elements. The software is responsible for device control, analyzing user interactions (e.g., haptic feedback), and delivering real-time responses [11].

A. Interaction within a VRE

Interactions and manipulations in VR play a crucial role in creating immersive and engaging experiences [12]. Users in VREs interact with the virtual world through various means, and developers employ different techniques to enhance these interactions [11].

In VR, interactions are organized around three primary virtual behavioral primitives. Firstly, in the realm of navigation, users can achieve continuous motion through physical movements such as walking or climbing, facilitated by hand-based controllers. Alternatively, techniques like teleportation allow users to select a destination using targeting lines and click metaphors, ensuring seamless transitions without perceptible delays [13]. Secondly, manipulation involves users selecting specific objects from a set of options and executing various actions like rotation, zooming in, zooming out, or flying over selected objects. These manipulation actions empower users to perform specific commands and modify chosen objects within the VRE [14]. Lastly, the system control functionality enables users to communicate and interact with others sharing the same virtual space [14].

B. Object Manipulation

The manipulation process within VRE involves several key facets. First and foremost, the **selection** aspect requires users to point at and validate virtual objects, allowing for precise and intentional interactions. Beyond selection, the **translation** facet enables users to alter the positions of virtual objects, providing a means to arrange and organize elements within the virtual space. Additionally, the **rotation** component allows users to change the orientations of selected objects, offering a dynamic and comprehensive control over the spatial configuration of the VRE. Together, these manipulation facets contribute to a nuanced and immersive user experience within VRE, allowing for a seamless interaction with and modification of virtual elements [15].

Object manipulation in VR has emerged as a transformative and captivating aspect of immersive experiences [16]. The advent of sophisticated controllers equipped with sensors has empowered users to interact with VREs in unprecedented ways. These handheld devices, often an extension of the user's physical hands, enable precise and intuitive manipulation of digital objects [17]. Whether it's grasping a virtual tool, pushing a button, or delicately picking up an object, the responsiveness of these controllers contributes to a heightened sense of presence, bridging the gap between the physical and digital realms [15].

Objects become more tangible with haptic holograms, taking the experience to the next level. Now, one can interact with a 3D projection or a virtual object and genuinely feel it. Haptic holograms generate virtual objects equipped with a digital interface that is not only visible but also tactile. This is achieved by molding sound to give the digital features a physical feel, bridging the gap between the virtual and physical realms [18]. Additionally, the evolution of hand tracking technologies has taken object manipulation to the next level by allowing users to engage with virtual elements using natural hand movements [19], unencumbered by physical controllers [20]. This advancement not only enhances the realism of interactions but also opens doors to more immersive and fluid virtual experiences [21].

Furthermore, the incorporation of haptic feedback adds a layer of sensory richness to object manipulation in VR. Users can now feel the texture, resistance, and even the subtle vibrations associated with interacting with virtual objects. This tactile feedback enhances the overall user experience, making the digital world feel more tangible and engaging [21]. Whether it's experiencing the recoil of a virtual firearm, the resistance of turning a virtual knob, or the sensation of holding a virtual object in the hand, haptic feedback deepens the connection between the user and the VRE. As VR continues to evolve, these innovations in object manipulation not only redefine gaming experiences but also hold great potential for applications in fields such as education, training, and simulation, where realistic and interactive object manipulation is paramount [22]. The trajectory of object manipulation in VR showcases the ongoing efforts to create a seamless and

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immersive bridge between the physical and virtual worlds [23].

C. Controllers and Input Devices

Haptic devices, designed to generate physical forces, often include motors or actuators with functionalities like clicks, scrolls, and drags, using vibrations to create haptic feedback sensations. This enhances VR immersion and realism, aligning with user interaction goals. While controllers have limitations in conveying realistic haptic responses, ongoing studies aim to address these constraints [24].

Haptic devices, wearable and finger-friendly, come in various types, including gloves, exoskeletons, finger-mounted actuators, and handheld controllers [19], [20]. Gloves and exoskeletons, though offering high fidelity, tend to be relatively costly, whereas finger-mounted actuators offer multi-finger feedback. Handheld controllers, user-friendly and common in commercial applications, can provide haptic effects like vibrations [17], [21].

Most current VR systems excel in visual and audio experiences but lag in delivering realistic haptic sensations and external forces. Controllers, compact and adaptable, struggle to simulate natural object manipulation. To enhance the haptic feedback, diverse haptic force rendering is essential, covering aspects like touching, grasping, gravity, and inertia [25].

D. Haptic Feedback Vibration

The term ”haptic” traces its roots back to the Greek word ”haptesthai,” denoting ”to touch” [26]. In the context of VR technology, this sensory immersion is realized through vibrations or other tactile sensations produced by electronic devices. Force feedback, a prominent type, delivers sensations like hardness, weight, and object inertia, refining the user's interaction with virtual objects through computer add-ons that exert physical forces and rotations. Tactile feedback relies on the sense of touch, utilizing contact points to convey details about object handling, surface texture, geometric shape, smoothness, slippage, and temperature. Additionally, proprioceptive feedback enhances the user's awareness of their body position and posture, contributing to an immersive VR experience [27], [28].

IV. Methodology

The current research study comprises two distinct components: the experimental part and the evaluation and reflections survey. The experimental segment aligns with the Design Science Research (DSR) model, aiming to generate artifacts with practical utility for real-world applications that can yield positive impacts [29], [30]. This DSR study entails an experiment conducted in a VRE, primarily focusing on evaluating the impact of adaptable haptic feedback vibration configurations in a single-user VRE. The experiment is divided into two parts: a. Identifying 3D object models in the VRE and labeling them, and b. Precisely interacting with the same 3D object models and assembling a larger model with them as constituent parts.

The DSR artifact, the immersive VR experience, serves as a vehicle to closely replicate the physical environment, resembling a quiz of a course in a traditional lab setting, for two distinct study programs (as elaborated in the following section). A specific process for sampling, data collection, and testing was followed to ensure the validity and reliability of the results and is explained in the next sections.

A. Course Selection and Description

To enhance the generalizability of the study's conclusions, it was determined to involve two departments in the experiment. The chosen fields, Computer Information Systems (CIS) and Aviation Engineering (AvEng), were selected due to their heavy reliance on interaction with 3D objects. The courses from these departments were specifically chosen to encompass a broad range of cognitive levels based on Bloom's taxonomy, including Remembering, Understanding, Applying, Creating, Evaluating, and Analyzing, as outlined in the revised Bloom's taxonomy documentation [31].

For the CIS department, participants were provided with ten computer components, such as the motherboard, hard disk drive (HDD), graphics processing unit (GPU), solid-state drive (SSD), central processing unit (CPU), CPU cooler, fans, RAM, external HDD, and power supply. Figure 1 illustrates the assets used for the development of the VRE for the CIS. Participants were tasked with identifying and placing these parts in labeled boxes and subsequently assembling a PC using the identified components. The time allocated for the ”identification” task was 5 minutes, and for the ”assembly” task, it was 10 minutes. In the AvEng department, students underwent a similar experiment, identifying and assembling ten airplane parts, including the fuselage, engines, left wing, right wing, horizontal stabilizer, vertical stabilizer, nose gear, left gear, right gear, and central gear to assemble a model airplane. Figure 2 illustrates the assets used for the development of the VRE for the AvEng. The time allowed for this experiment was identical to the CIS experiment. In both cases, participants were not restricted by time if they did not complete the tasks within the allocated time and wished to continue.

B. Sampling

This research employed non-probability sampling, specifically convenience sampling, with a total of 81 participants—41 from the CIS department and 40 from the AvEng department. All participants fell within the age range of 18 to 25. No compensation was provided for their voluntary participation in the experiment, aligning with Harris's guidelines (2008) [32]. Participants were randomly assigned to perform one task without haptic feedback vibration and another task with adaptable feedback vibration. All participants had either completed or were currently enrolled in the relevant courses.

The study included two control input variables: amplitude and duration, each with two specific settings—no amplitude and (hence) no duration, and adaptable amplitude and duration. Participants were randomly divided into equal-sized groups to perform the same tasks with different settings for the control input variables (independent variables). This sampling approach helps ensure the avoidance of bias in obtaining

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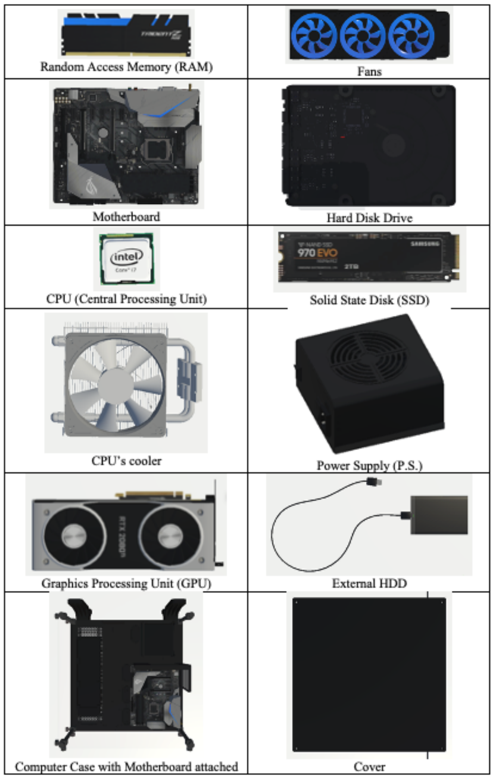

Fig. 1. The assets used for the CIS VRE.

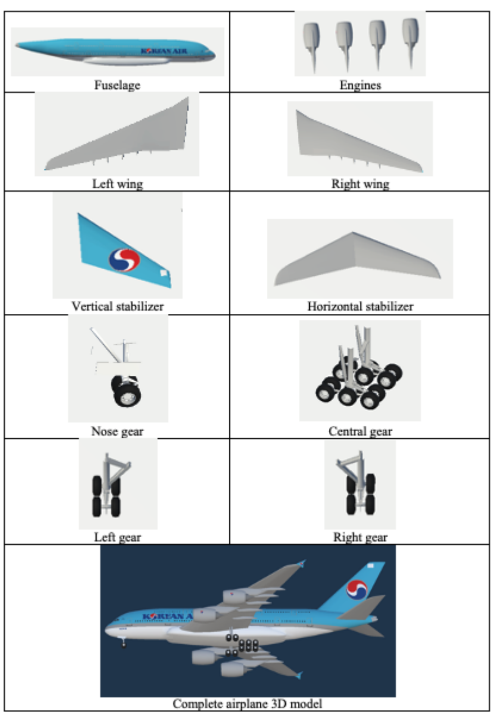

Fig. 2. The assets used for the AvEng VRE.

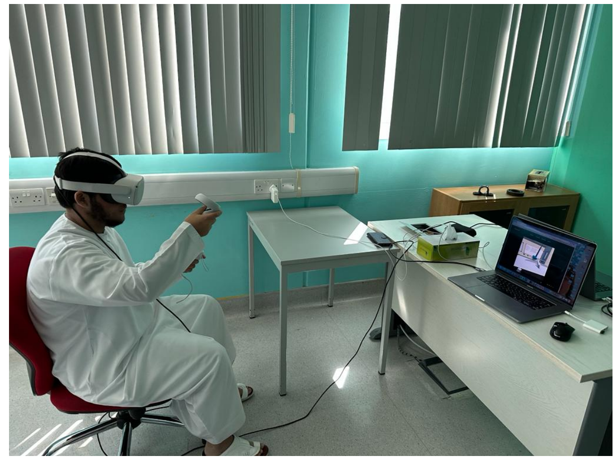

Fig. 3. Running the experiment

outputs from various groups, given that all other settings and environmental conditions remain consistent.

C. Data Collection

After obtaining approval from the relevant research ethics committees at the involved universities, a ”Participants Information Sheet” was provided to the selected students during the respective course lectures, offering a brief overview of the experiment and its objectives. Upon arrival at the lab test center, participants read and signed a printed ”Consent Form” due to the involvement of human subjects. Both the ”Consent Form” and the ”Participants Information Sheet” underwent moderation by 11 experts to ensure clarity for all participants.

Regarding the actual experiment, researchers refrained from providing solutions or guidelines to influence participants. Participants were assured that their personal details would be used solely for statistical analysis, kept confidential, and promptly deleted from records after completing the test result analysis.

The experiments were conducted in a standard classroom during course lectures, where each participant had a dedicated computer desk and chair. The ”Oculus Quest 2” HMD and controllers were readily available on the table for use, and participants were familiarized with the equipment. For health and safety, researchers and administrators ensured thorough cleansing and sanitization of all equipment before each use. Participants were informed that they could stop the test at any time if they experienced discomfort. They underwent an introductory tutorial to acquaint themselves with the basics of the VRE. Figure 3 depicts a participant engaged in the experiment, with the laptop capturing and screen recording the entire experience.

D. Artifact - Experiment Design

The main artifact of the experimental part of this research was the VRE that aimed to faithfully reproduce the two quizzes originally conducted in physical labs: one for the CIS

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Module 1 – socketCheck( ): checks the interaction between the target and the selected sockets (box and part) to see if they match. Update the failed attempts and the successes

```
socketCheck ( ) {
  Identify object selected for interaction and target box to place the object
  Loop components to find if successful placement was made
  loop all boxes {
    if (no matching found)
       {increase number of failed attempts}
    if (matching was found)
       {increase the number of successes}
  Show the results of the interaction on the whiteboard
  Call triggerVibration module.
}
```

Fig. 4. Module 1 - socketCheck()

Module 2 – triggerVibration ( ): Changing the setting for amplitude and duration based on the failed attempts; Identify the haptic controller and trigger the interaction

```
triggerVibration ( ) {
   Identify haptic controller that triggered the interaction.
   if (global variable: amplitude is less than max)
      {update amplitude to amplitude + n*failures}
   else {use max amplitude}

   if (global variable: duration is less than max)
      {update duration to duration + n*failures}
   else {use max duration}

   Trigger vibration with new amplitude/duration to interacting controller
}
```

Fig. 5. Module 2 - triggerVibration()

department and another for the AvEng department. The functionality provided through the VR experiment, as explained earlier, included:

- **VR Tutorial:** This quick and limited VR experience assisted participants, especially those with no prior relevant experience, in becoming familiar with the user interface and the equipment, including the HMD and its controllers (following the recommendation of [33]).
- **”Identification” task:** In this VRE task, students had to identify and categorize virtual computer components (CIS) or virtual airplane parts (AvEng) and place them in labeled boxes on the virtual lab desk within the VRE.
- **”Assembly” task:** This VRE task required students to assemble a PC using the computer parts (CIS) or assemble an airplane model using the airplane parts (AvEng) identified in the ”identification” task.

During the interactions, both correct and incorrect interactions were recorded, and a grade was calculated and displayed on the virtual board in front of the desk. In different versions of the VRE, a wrong placement would trigger a vibration with variable characteristics of amplitude and duration. The algorithm that implemented this interaction was divided into two modules, as illustrated in figures 4 and 5. Module 1 checked the interactions between the target and the selected sockets to see if they matched and updated the failed attempts and successes. Module 2 changed the setting for amplitude and duration based on the failed attempts, identified the haptic controller, and triggered the interaction.

Figure 6 illustrate the Hi-Fi prototypes of the ”identification” task for the AvEng department.

Fig. 6. Hi-Fi prototype: Identification task for the AvEng

E. Evaluation - Survey Instrument

At the conclusion of the VR experience, participants underwent a survey containing specific questions related to their VRE encounter. The survey aimed to gather feedback on their sentiments about the VRE and whether they preferred it over a physical lab. The survey encompassed the following constructs:

1) The impact of vibration during the VRE,
2) The impact of adaptable vibration,
3) Positive effect of the VRE,
4) Feeling of competence in using the VR equipment,
5) Feeling of immersiveness,
6) Feeling of tension/annoyance, and
7) Negative challenges during the VRE.

The first two constructs utilized a 5-point Likert scale with the following options: 4: Strongly agree, 3: Agree, 2: Don’t know/Can’t say, 1: Disagree, and 0: Strongly Disagree. The remaining constructs followed a similar 5-point Likert scale plan with slight differences: 4: Extremely, 3: Fairly, 2: Moderately, 1: Slightly, 0: Not at all. In all cases, the constructs were addressed by multiple questions of the same direction placed randomly. The questions related to vibration were drawn from the literature review [15], [24], [28], [34]. The reflection questions were adopted from the relevant questionnaire of the International Telecommunication Union (ITU) [35], [36], and the “Game Experience Questionnaire” [37], [38], which substantially ensures the validity of the instrument.

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V. Results - Discussion

The experiment took place in the regular classrooms of a major academic institution in the UAE between April and May 2023. The following subsections detail the impact of haptic feedback vibration during the VRE and their feeling about the adaptable setting, the reflections of the participants' VRE experience, and their preferences of VR over physical labs (if any).

A. The impact of vibration during the VRE

The impact of vibration during the VRE was measured by two constructs. The first, "the impact of vibration during the VRE", referred to whether the participants found positive or negative the effect of vibration during the VRE. The construct was addressed by the following same direction questions:

1) I felt vibration in a positive way,
2) Vibration made a positive difference,
3) The experience with vibration was improved, and
4) Vibration helped during the experience.

The combined mean was 3.179, indicating that participants generally agreed on the positive impact of vibration. The combined Cronbach's Alpha value was highly acceptable at 0.798 supporting the reliability of the result. This suggests that haptic feedback vibration has positive impact on participants of the VRE.

The second construct, "the impact of adaptable vibration", referred to the positive or negative feeling of the participants when adaptable feedback vibration was triggered during wrong interactions. It was measured by the following questions:

1) I could feel only the same vibration,
2) Vibration was not changing,
3) Vibration differences were not noticeable, and
4) Whatever the vibration differences they did not affect the experience.

The combined mean was 2.123, suggesting that the participants were reluctant in admitting a positive impact of the adaptable vibration during the VR experience. This can be explained by the fact that adaptable vibration was only felt in the case of wrong interactions which was not frequent especially in the case of the "identification task" which was the low cognition level task. It could be suggested as a future research study to utilize adaptable vibrations to be triggered even in the case of successful interactions or more complex tasks were the participants will make more mistakes. The reliability of this result is supported by the Cronbach's Alpha value calculated at the acceptable score of 0.743.

Figure 7 illustrates these results.

B. Reflections on the VRE experience

The reflections from the VRE experience included three different constructs to be discussed in this section. First, the construct "Positive effect of the VRE", referred to the general feeling of joy, happiness, content, etc. felt by the participants. It was measured by the following questions:

1) I felt content,

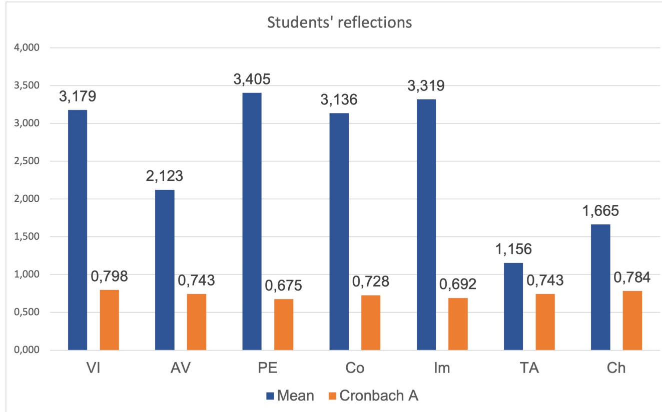

Fig. 7. Students reflections of the VRE (Means and Cronbach Alpha). VI: Vibration impact, AV: Adaptable vibration, Re: Reflections on the VRE, Co: Competence, Im: Immersion, TA: Tension/Annoyance, and Ch: Challenges.

2) I thought it was fun,
3) I felt happy,
4) I felt good, and
5) I enjoyed it

The combined mean score was 3.405, indicating a generally positive reflection on the VRE experience. Reliability was marginally acceptable (α = 0.675) and it is explained as a relatively minor reluctance among the participants to admit they were happy about the whole experience. Indeed, some of them found it nice but a few found it indifferent especially among the AvEng participants.

The second construct "feeling of competence in using the VR equipment", referred to the participants' feeling of having enough skills and being comfortable in using the VR equipment in the VRE experiment and it was measured by the following questions:

1) I felt skillful,
2) I felt competent,
3) I was good at it,
4) I felt successful, and
5) I was fast at reaching the experiment's targets

The mean of 3.136, suggests the participants felt competent in using VR technology for the VR experiment. The reliability was acceptable (α = 0.728). It must be noted that this result includes both those with the prior VR experience and those without. This indicates that a short two to five minutes tutorial is enough to make even those without prior experience to feel comfortable of the use of them.

The third construct, "feeling of immersiveness", referred to participants feeling of being immersed in the VRE and considering it a pleasant, impressive, and rich experience. It was measured by the following questions:

1) I was interested in the experiment,
2) It was aesthetically pleasing,
3) I felt imaginative,
4) I felt that I could explore things,
5) I found it impressive, and

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6) I felt like a rich experience.

The mean of 3.319 indicates the participants were highly concentrated during the experiment but not entirely immersed. The reliability of the result was marginally acceptable (α = 0.692) explained by the disagreement between the participants whether they were fully immersed and impressed or just interested and happy from the experience. (See Figure 7)

C. Challenges during the experiment

The study attempted to reveal negative feelings of the participants during the experiment, i.e., possible feelings of tension or problems they faced. The construct ”feeling of tension/annoyance”, referred to the feelings of annoyance disturbance and it was measured by the following questions:

1) I felt annoyed,
2) I felt irritable, and
3) I felt frustrated.

The mean of 1.156 suggests clearly very minor negative feeling of annoyance, irritation or frustration for any reason. The reliability of the results was calculated at α = 0.743 in full support of the above result. This is a very promising result especially considering the prototype nature of the VRE and not a fully featured commercial application.

Finally, the construct ”negative challenges during the VRE”, attempted to reveal any challenges, problems or issues faced during the VRE. It was measured by the following questions:

1) It gave me a bad mood,
2) I thought about other things, and
3) I found it tiresome.

The mean of 1.665 is, once again, very positive and promising indicating largely the absence of such problems. The reliability calculated at α = 0.784 is also in full support of the result. The easy interpretation is that the participants did not face any particular negative challenges during the VRE. (See Figure 7).

D. Participant preferences

One of the most interested parts of the survey was the question about the participants' preferences for a VRE in their learning over a physical lab. Notably, they were presented with four options: a. ”Yes,” b. ”No,” c. ”Both,” and d. ”No preference.” These options are interpreted as follows:

1) ”Yes”: The participant prefers a VRE over a physical lab,
2) ”No”: The participant does not prefer a VRE over a physical lab,
3) ”Both”: The participant would prefer both environments during training,
4) ”No preference”: The participant has no preference of one option over the other.

Figure 8 illustrates the participants responses.

The results are clear, suggestive, and rather simple to interpret. There were only 7 out of 81 (8.64 %) participants who did not prefer the VRE over the physical lab or had no preference. The majority 55.56 % (45 of 81 participants) prefer

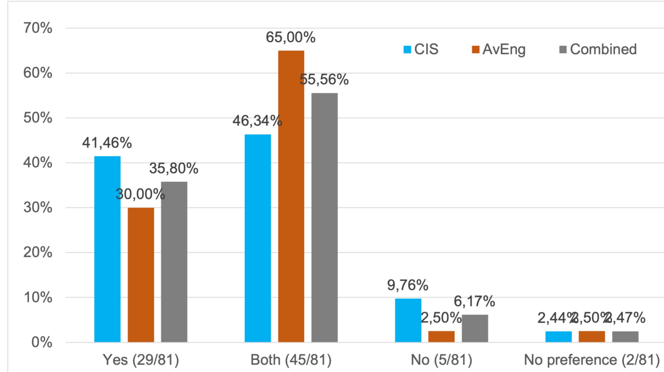

Fig. 8. Participants' preferences of VREs over physical labs

utilization of both environments and a very large 35.8 % (29 of 81 participants) prefer the shift toward the VRE. These results indicate that there is still way to go if the goal is to replace the physical labs with VREs but the trainees are ready to have both environments for their training.

VI. Conclusion and Future research

The main aim of this research was to explore the reflections of trainees in training center institutions on the use of VREs during their training process. It also attempted to identify possible feelings of discomfort or other frustrations in a VRE experience. Finally, it aimed to unveil the participants' feelings of preference for VR over physical labs and classrooms. The results were positive and promising, although it is clear there is still room to fill if the ultimate goal is to replace physical labs with VREs.

Indeed, firstly, the participants largely accepted the experience with feelings of contentment, joy, and competence. These results were supported through a survey, providing acceptable levels of reliability for the participants' responses. Secondly, the participants admitted that vibration plays a positive role in developing an immersive experience, but more research needs to be done to understand how adaptable vibration can contribute. Finally, the participants suggested a mix of both VREs and physical labs would be ideal for their training, rejecting the idea of solely utilizing VREs and replacing physical labs.

There were a few limitations in this research that suggest further studies. First, adaptable haptic feedback vibration was applied only in the case of wrong interactions between the participants and the 3D objects in the VRE. Given that many did not make mistakes, it is doubtful whether adaptable vibration indeed plays a role or not. It is suggested to extend the research to apply adaptable vibration, somehow, in more complicated interactions to study its impact more deeply. Second, the study involved single users interacting in the VRE. It would be very interesting to study the same or similar questions in a collaborative mode and see how this enhances the training experience. Finally, there were no technical issues during the experiment in a single-user mode; however, it would be of particular value to extend the experiment to multi-users in collaboration to see how the scalability of such an experiment can be affected in a real-life scenario. The present study has already been extended to the collaboration mode.

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