Jestr

Journal of Engineering Science and Technology Review 15 (5) (2022) 9 - 12

JOURNAL OF
Engineering Science and Technology Review

Innovation Article

www.jestr.org

The Contribution of Virtual Reality in Awareness and Preparedness of Oil and Gas Professionals

Nikolaos C. Kokkinos*, Athanassios Ch. Mitropoulos and Michail Chalaris

Department of Chemistry, School of Science, International Hellenic University, Ag. Loukas, 654 04 Kavala, Greece

Received 24 August 2022; Accepted 11 November 2022

Abstract

Human factor played a dominant role in the majority of the past technological accidents. Ignorance, carelessness or even worse negligence by operators were only some reasons of those accidents. Chemical industry keens on new techniques for optimizing human and environmental safety. The main scope of this study is to examine the contribution of virtual reality in awareness and preparedness of oil and gas industry professionals in emergencies. The methodology based on an in-situ threefold assessment process of the chemical industry staff on virtual reality high tech facilities at the Department of Chemistry of International Hellenic University. Firstly, the control room operations of the examinees were assessed in a state of the art Virtual Control Room environment. Then, participants' interaction with faults, incidents and accidents was examined in a Virtual Reality Oilfield using wearable technology. Finally, examinees' skills in crisis management were evaluated in a Virtual Dispatch Center. Various emergency what-if scenarios were investigated that were not hypothetical or fiction products, but rather the result of long-term interviews with industry executives, field operators and control room operators; in order to reproduce accurately, efficiently and effectively near-misses, dangerous incidents and accidents. Useful results were drawn regarding the behavior of the participants during emergencies, their teamwork performance and their interaction with the virtual system.

Keywords: Virtual reality, emergency, crisis, control room operations, O&G staff

1. Introduction

The oil and gas (O&G) industry has confronted with many difficulties in recent years, such as the extreme price variability in short periods, the instability of global supply and demand, and the increasing competition in the energy sector with numerous alternatives forms of energy. It is essential for the O&G industry to discover ways to conduct business for achieving high levels of productivity at low cost, while at the same time remaining profitable and competitive. To achieve the aforementioned aim, it is important to turn on in the implementation of new technological solutions, such as immersive technologies at all stages of the industry.

The virtual reality (VR) was the first of the immersive technologies used. In 1962, a device called Sensorama was invented and was able to create virtual environment giving various senses to the users such as sound, wind, vibration [1]. However, the fact that the device was not interactive made scientists to develop different systems in the following years in order to improve the efficiency, the accessibility and the convenience of the virtual reality to audiences. According to Speicher, *et al.* [2], it is exceedingly difficult to define what exactly is virtual reality with only one definition that will effectively explain this notion. Thus, VR is a temporary definition and it is possible the VR notion to be very different in the near future. However, nowadays, virtual reality could be defined as a highly interactive, computer-based multimedia environment in which the user becomes the participant in a computer-generated world [3]. Specifically, VR is a three-dimensional interactive environment employing a special kind of graphical user interface generated by a computer, providing a full sense of immersion to the user [4].

The immersive technologies, and particularly VR, in the oil and gas industry improved the accessibility of information, enhanced personnel and team training, reduced maintenance time and contributed in operational awareness and preparedness during emergencies. Qi and Lei [5] developed a Digital Oilfield Emergency assistant system for making decisions on oil field emergencies, integrating virtual reality and workflow technologies. Moreover, Manca, *et al.* [6] discussed the immersive training of oil and gas operators, namely the use of plant simulators based on virtual reality. These dynamic simulators enabled to reproduce real accidents and thus, training dispatchers and field operators to avoid operational errors. Similar plant simulators for training operators were also mentioned by Colombo, *et al.* [7] and Colombo, *et al.* [8]. Then, Hou, *et al.* [9] wrote about developing a virtual reality-based training program for construction operations in the oil and gas and chemical industries. A year later, Hou, *et al.* [10] proposed a framework for training and qualification improvement with the use of virtual reality, which helped project managers to develop or improve skills in the operation and maintenance of oil and gas facilities. During the same year, Koo, *et al.* [11] developed a training simulator for training fire incidents on an offshore platform, which was based on virtual reality technology. In 2020, Wan, *et al.* [12] proposed a system based on virtual reality for safety inspection of oil depots and training in emergencies; Abdul Aziz, *et al.* [13] also considered introducing virtual reality for training oil and gas industry personnel, before they perform real tasks in a real workplace.

In the current study, a threefold methodology was proposed for training and assessment of oil and gas professionals as well as chemical industry staff in a virtual reality high tech environment.

*E-mail address: nck@chem.ihu.gr
ISSN: 1791-2377 © 2022 School of Science, IHU. All rights reserved.
doi:10.25103/jestr.155.02

2. Methodology

The methodology based on an in-situ threefold training and assessment process of the O&G industry staff on virtual reality high tech facilities at the Department of Chemistry of the International Hellenic University (IHU). Various emergency what-if scenarios were investigated which were not hypothetical or fiction products, but rather the result of long-term interviews with industry executives, field operators and control room operators in order to reproduce accurately, efficiently and effectively near-misses, dangerous incidents and accidents of the chemical and energy industry. This is particularly beneficial to the oil and gas professionals (trainees) for getting well acquainted with what-if fact-scenarios of a developed comprehensive database, and coping with difficult circumstances, often more difficult than they actually were. To that end, trainees had the opportunity to test and understand their limits in a highly secure environment; and on the other hand the industrial executives to be informed about the suitability, awareness and readiness of their staff.

The oil and gas professionals (trainees) trained themselves and cooperated as a team in three different environments-facilities: i) Virtual Control Room (VCR) environment, ii) Virtual Reality Oilfield (VRO) environment and iii) Virtual Dispatch Center (VDC) environment.

3. Virtual Control Room (VCR) Environment

Firstly, the control room operations of the examinees were assessed in a state of the art Virtual Control Room (VCR) environment. The VCR established at IHU is one of the most complete and modern VCR all over Europe. It specializes in the fundamental and advanced training of students and professionals on control room operations and emergency responses during technological or natech accidents. The VCR comprises a pair of rooms that is set up as a Trainer/Trainee system.

3.1 Trainee Room

The trainee room is an emulated industrial control room environment (Figure 1) that allows both training and competency assessment of procedures and emergency response situations, with audio-visual recording and printed monitoring of the operators' performance. The trainee room of the VCR is equipped with real interfaces from crucial infrastructures from the whole value chain of Oil and Gas Industry (onshore and offshore).

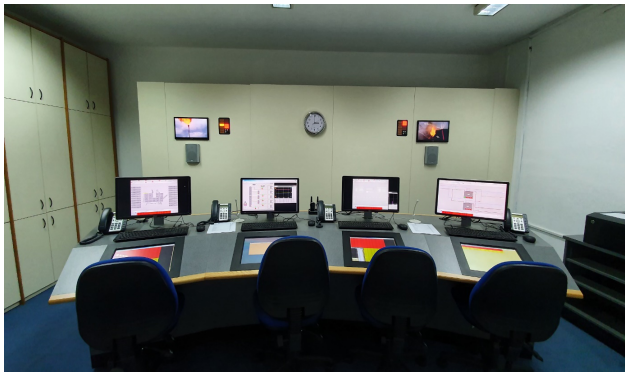

Fig. 1. The VCR trainee room.

It consists of the following components:

- Four (4) console-workstations each equipped with process monitors, touch screen displays handling alarms, telephone, and radio communication.
- Two (2) wall-mounted illuminated alarm panels with lamp test and audible warning.
- Two (2) wall-mounted flat screen TV showing pre-recorded videos associating with complicated scenarios.
- Closed circuit television (CCTV) camera system.
- Voice over IP (VOIP) telephone system.
- Audio-visual recording system.

3.2 Trainer Room

All the control room operators' (trainees) responses are fully monitored from a separate room (Figure 2) where the instructors control the training process and assess competence. The Trainer Room views the Trainee Room through one-way window. The trainers may use the process simulation system to inject faults or to emulate operating sequences.

The Trainer Room includes:

- Two (2) instructor workstations with simulation software, allowing complete "failure mode" exchange.
- CCTV with HDD recording and playback facilities.
- Instructor control of Control Room Alarm Panels.
- Instructor software for full selection, control, recording and scenario creation.

Fig. 2. The VCR trainer room.

4. Virtual Reality Oilfield (VRO) Environment

Participants' interaction with faults, incidents and accidents was also examined in a Virtual Reality Oilfield (VRO) using wearable technology (Figure 3). In this stage of training-assessment, the trainees played the role of the field operators. They collaborated with the control room operators of the VCR through radio communication in order to shut down, startup, bypass or repair equipment. The trainees used wearables for this purpose such as VR headsets, controllers, glasses and gloves.

5. Virtual Dispatch Center (VDC) Environment

Examinees' skills in crisis management were evaluated in a Virtual Dispatch Center (VDC), too. In the VDC environment, the oil and gas professionals are trained in the proper use of telecommunication equipment along with the coordination and management of a complicated scenarios of a crisis, due to a technological accident. The VDC (Figure 4)

is equipped with VOIP telephone system connected with all the internal departments, shops and the control room of the industry; as well as with external boards, such as fire brigade, nearby hospitals, coast guard, police and other public services. The VDC users can also communicate through radio communication with the first responders of the examining crisis.

Fig. 3. The VCR trainer room.

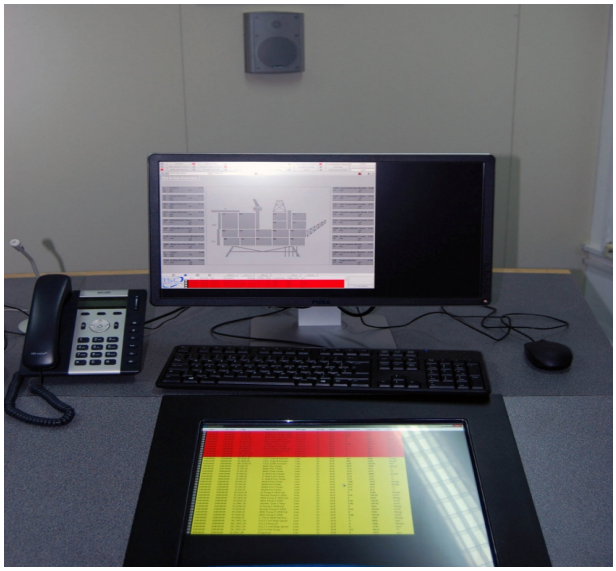

Fig. 4. A VDC workstation.

6. Observations and Conclusions

Useful results were drawn regarding the behavior of the participants during emergencies, their teamwork performance and their interaction with the virtual system:

- Even oil and gas professionals with many years of experience were really stressed and felt the pressure of scenarios during the assessment process. They stated that in most of the cases the VR environment was too close to reality.
- Although it took less time for oil and gas professionals to familiarize with the VR environment than students did; few elder O&G professionals found it difficult to acquaint themselves with immersive technologies.
- Testing industrial facilities and infrastructure under extreme conditions was reported as a dominant highlight of the training process.
- The communication among the teams of the three environments revealed the need of following proper protocols and lists-to-do, especially, during emergencies.
- The communication between the control room operators of the industry with the dispatch center was satisfactory.
- A very good level of communication, understanding and collaboration was shown among control room operators in the same room. However, the communication among control room operators and oilfield operators revealed significant and crucial issues that leaded in emergency shut down or even in evacuation alarms.
- Human factor played a dominant role in the final outcome of the majority of the scenarios. Ignorance, carelessness or even worse negligence by operators were some reasons of the undesirable upshot and ultimate negative evaluation.
- The response time of the participants on emergencies was severely improved after two iterations of the scenario.
- The VR training process revealed common operational and communication problems among operators and contributed in finding suitable solutions preparing them for future events.

Acknowledgments

This research has received funding from the European Union´s UCPM-2020-KN-AG under grant agreement No 101017819 (RESISTANT Project) that is gratefully acknowledged.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License.

References

1. Dinh, H.Q.; Walker, N.; Hodges, L.F.; Song, C.; Kobayashi, A. Evaluating the importance of multi-sensory input on memory and the sense of presence in virtual environments. In *Virtual Reality Annual International Symposium*, 1999; pp 222-228.
2. Speicher, M.; Hall, B.D.; Nebeling, M. What is mixed reality? In *Conference on Human Factors in Computing Systems*, 2019; pp 1 - 15.
3. Kim, J.H.; Park, S.T.; Lee, H.; Yuk, K.C.; Lee, H. Virtual reality simulations in physics education. *Interactive Multimedia Electronic Journal of Computer - Enhanced Learning* 2001, 3.
4. Brey, P.; Søraker, J.H. Philosophy of computing and information technology. In *Philosophy of technology and engineering sciences*, 2009; pp 1341-1407.
5. Qi, Z.; Lei, C. The design and construction of decision-making command system for digital oilfield emergency drill. In *2nd International Conference on Challenges in Environmental Science and Computer Engineering*, Procedia Environmental Sciences: Haikou, China, 2011; Vol. 11, pp 32-36.
6. Manca, D.; Colombo, S.; Nazir, S. A plant simulator to enhance the process safety of industrial operators. In *SPE European HSE Conference and Exhibition 2013: Health, Safety, Environment and Social Responsibility in the Oil and Gas Exploration and Production Industry*, 2013; pp 394-404.
7. Colombo, S.; Nazir, S.; Manca, D. Virtual reality as effective tool for training and decision-making: Preliminary results of experiments performed with a plant simulator. In *SPE European HSE Conference and Exhibition 2013: Health, Safety, Environment and Social Responsibility in the Oil and Gas Exploration and Production Industry*, 2013; pp 405-416.
8. Colombo, S.; Nazir, S.; Manca, D. Immersive virtual reality for

training and decision making: Preliminary results of experiments performed with a plant simulator. *SPE Economics and Management* **2**014, *6*, 165-172.

9. Hou, L.; Chi, H.L.; Utiome, E.; Wang, X. *Cooperative and immersive coaching to facilitate skill development in construction tasks*. 2016; Vol. 9929 LNCS, p 371 - 377.
10. Hou, L.; Chi, H.L.; Tarng, W.; Chai, J.; Panuwatwanich, K.; Wang, X. A framework of innovative learning for skill development in complex operational tasks. *Automation in Construction* 2017, *83*, 29-40.
11. Koo, M.W.; Ha, S.; Cha, J.H.; Cho, D.Y. Fire incident training for offshore worker using virtual reality. In *International Offshore and Polar Engineering Conference*, 2017; pp 886-890.
12. Wan, J.; Zheng, Y.; Li, Y.; Mei, H.; Lin, L.; Kuang, L. Oil depot safety inspection and emergency training system based on virtual reality technology. In *IOP Conf. Ser.: Mater. Sci. Eng.*, 2020; Vol. 782; pp 1-9.
13. Abdul Aziz, F.; Alsaeed, A.S.M.A.; Sulaiman, S.; Ariffin, M.K.A.M.; Al-Arhabi, A.R.Y. *Virtual reality training platform in onshore pipeline*. 2020; p 207-216.