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Valid Virtual Reality Applications for Commercial Kitchen Safety Training

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Abstract
The rise in the number of workers in gastronomy tourism has coincided with an increase in workplace accidents. New workers lack hazard identification abilities and fail to recognize dangerous events in the workplace. Thus, a two-fold goal has been established: (1) design and develop VR applications for spotting risks in the kitchen workplace, and (2) validate the VR application's effectiveness. The invention involved the 360-degree camera and VR software, and it was validated by multiple experts who had long working experience. The VR technology was found noteworthy as it received positive acceptance in the hospitality business.

Keywords: Virtual Reality, Workplace Safety, Food Service Safety, Employee Safety

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1.0 Introduction

Nomenclature 9 AN	
A	radius of
B	position of
C	further nomenclature continues down the page inside the text box

1.1 Foodservice Safety

In foodservice, the aim is to create wonderful experiences for guests, but the industry struggles to improve workplace safety. When reviewing the industry's safety records, the most prevalent injuries have been muscle strains, tears, and pulls, followed by cuts, puncture wounds, burns and bruises (Lippert et al., 2020). The main causes of injuries in the foodservice industry are slips and falls, being hit by an object, and overexertion. These appear consistent, with accidents occurring if a worker tries to move too quickly. It is easy for someone to slip on a floor when they are in a hurry or to strain a muscle when lifting too much weight. Even burns, punctures, and cuts are more likely to occur when someone is rushing. These situations may also occur more frequently with new employees trying hard to impress others (Breslin & Smith, 2006). Studies have reported that most accidents that occur in restaurants involve less experienced employees (Jeong & Shin, 2016; Lippert et al., 2020).

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During the COVID-19 pandemic, many restaurants in Malaysia were temporarily closed or operated at a reduced capacity. With the advent of new vaccines, the Malaysian economy will soon likely be back to normal (World Bank Group, 2020). This return to normal operations could increase workplace accidents as many employees return after a long period away. These workers may take time to regain their former proficiency. Before the pandemic, the restaurant industry in Malaysia was an important economic segment, with more than 167,000 establishments employing over 1 million workers (Statista, 2021). With employees potentially returning to this hazardous environment, the industry managers must understand all the tools they have at their disposal to prevent workplace accidents.

According to the International Standard ISO 45001, occupational safety and health (OSH) refer to providing safe and healthy working conditions for employees to reduce or prevent work-related injuries or illnesses regardless of an organization's activities, size, or structure (Campailla et al., 2019). Workplace safety is an issue for industries worldwide, with over 340 million occupational accidents occurring annually and 2.3 million work-related fatalities a year (ILO, 2015).

New hires must understand that faster is not always better. Aside from over-eagerness, new employees may not be familiar with particular kitchen movements or regulations (Breslin & Smith, 2006). Similarly, individuals who have been out of the industry for a long time may face similar challenges. Due to the pandemic's recent impact in Malaysia, the government was forced to impose regulations that significantly impacted the foodservice industry (World Bank Group, 2020). Restaurants were asked to either close or limit their operating hours. As a result, a significant number of foodservice employees were temporarily laid-off. With a return to normal business after the pandemic, these workers will likely be returning to their jobs. They could face a higher risk of workplace accidents as reduced familiarity can increase the likelihood of accidents (Picchio & Van Ours, 2017).

1.2 Potential Hazards in Kitchen

Kitchen risks include wet and slippery surfaces during floor cleaning, fire from an unattended gas burner, and knife cuts and lacerations. Job (2021) suggested that high shelves be balanced and the footings are securely planted on the ground to avoid falling. He warned that germs and bacteria, such as salmonella spp. and norovirus can also be harmful. The kitchen may also have insufficient power lines and outlets, meaning that outlets can become overloaded, resulting in a higher risk of fire. Cross-contamination can occur due to oil and moisture beneath the cooktops and improper food storage. Furthermore, synthetic clothing material can melt in the event of a fire and contribute to high-temperature burns. Additionally, heavy lifting can result in muscle sprains and strains.

A hazard is defined as "a source, situation, or act with a potential for harm in terms of human injury or ill health and damage to property" (DOSH, 2008). Although industry kitchens have become more professionalized, the environment is still hazardous. One strategy to reduce the risk may be to incorporate technology. Karakhan et al. (2019) discussed integrating technology into the control hierarchy. The hierarchy represents a safety management system that approaches safety using a sequential approach. The study proposed using VR technology to reduce or eliminate hazards proactively to eliminate hazards before an accident may occur.

Having a safe and conducive workplace is crucial for hospitality workers' quality of life. The primary purpose of this study is to promote and improve the wellness of both employees and employers, health, and safety by introducing safety training tools using virtual reality (VR). Employees can operate this technology remotely to safely identify risks before entering a more dangerous physical environment (Sandra, 2019). Hence, the two-fold goal established for this study is: (1) to design and develop VR applications for spotting risks in the kitchen workplace, and (2) to validate the VR application's effectiveness.

2.0 Literature Review

2.1 Underlying Theories

Filiaggi and Courtney (2003) mentioned that workplace injuries were common in the kitchen due to the fast pace of this guest-centric environment, and these accidents could be costly. Based on iceberg theory, workplace accidents can lead to lost productivity, higher insurance rates, legal issues, and trauma (Mbuvi et al., 2015). The idea of VR in this study is represented by the socio-technical theory, which explains the harmonious man-machine interaction in a designated practice to transform inputs into outputs for the companies' performance; in this case, it is the awareness of hazardous environments at the workplace. Hodge and Anthony (1988) pioneered using a socio-technical method to investigate how tools and equipment can be made more human-friendly. The socio-technical theory includes the organizational and management aspects so that a cooperative system of man-machine interactions achieves the best safety practices and eliminates probable mishaps.

2.2 The Need for a New Tool for Kitchen Safety

In 1991, the establishment of the National Institute of Occupational Safety and Health (NIOSH) was approved, and a national workshop on OSH information strategy development was organized to determine a system of best practices. The 1994 Occupational Safety and Health Act was passed, covering 90% of the nation's workforce. This law requires employers to provide safe working conditions and report accidents or dangerous occurrences (Department of Occupational Safety and Health, n.d.). This law is a significant step in allowing Malaysian employees to feel confident that they are protected in the workplace. With the advent of the 1994 OSH Act and its legal implications, businesses must now take reasonable precautions to eliminate OSH risk factors. This makes it imperative for organizations to fully explore new technical advances and the consequent impact on OSH in the workplace.

Revolution 4.0 has introduced a virtual system to significantly reduce the risk of personnel injury or machinery damage while reducing waste and inconsistency in educational sessions. Tichon et al. (2019) found that when training was conducted using PowerPoint slides as compared to VR, the VR group was 15-20% better at identifying hazards. In the 1960s, Morton Heilig and Ivan Sutherland developed the

first systems capable of creating the illusion of three-dimensionality, paving the way for the first VR experience (Ambrosio & Fidalgo, 2020). Marzouk et al. (2019) asserted that VR applications were easy to use because the content was consistent and informative.

Training based on theory is common regarding kitchen safety (McFarland et al., 2019). This training aims to increase knowledge, but unfortunately, it does not enhance behavior since it is often conducted quickly, with little reinforcement and without providing an opportunity to implement best practices physically. A food safety training program can only teach you the information and not the skill (Yeargin et al., 2021). Yeargin et al. (2021) noted that food handlers obtained information following training but typically struggled to use this knowledge when they returned to the workplace. One explanation is that the training environment and the implementation contexts differ, leaving the newly trained workers with contextual issues that make applying what they have learned difficult. Has et al. (2018) highlighted that there was no significant difference in food safety attitude scores before and after training. However, there were statistically significant differences in food handler knowledge and practice scores before and after food hygiene training. Only the food handlers' food safety knowledge and behavior improved, not their attitude.

Japan Airlines (JAL) is using VR technology as a training tool to improve the skills of their mechanics. VR training simulations are set up for the mechanics and engineers to familiarise them with the engine run-up procedures via the VR environment (VRARSAI, 2021). Kim et al. (2020) mentioned that VR technology was one of the methods to gain an authentic experience. The findings have highlighted that VR highly and significantly impacts the consumers' authentic experience in terms of their cognitive and affective responses to the activities because it involves the enjoyment and emotion of the users. To date, VR applications can expand the users' ability in other aspects such as safety. VR safety training focuses on virtual hazards recognition on the road, oncoming traffic, and debris from concrete saws (Feguson, 2020), and hazard recognition training and fire watch for hot work, confined spaces, scaffolding, and hydrogen sulfide (West, 2019).

3.0 Methodology

3.1 Research Approach and Instruments

This study used triangulation methods, combining experimental and quantitative nature to gauge the potential of applying VR technology in safety training. VR uses a three-dimensional (3D) system with a combination of visual, kinetic, and audio elements so that a tourist can experience the real object (Hobson & Williams, 1994). For the VR designing purpose, we used a smartphone, 360-camera, VR headset, and 1.4m tripod. For the second objective of this study, a questionnaire survey was designed to obtain demographic information and validity information. The question items of the questionnaire survey were adopted and adapted from Alsalamah et al. (2017), Kawaguchi et al. (2014), and Compton (2020).

3.2 Data Collection

The data collection process began with taking photos in the kitchen of one of the hotels located in Shah Alam, Selangor, Malaysia. At first, a GoPro Fusion 360-camera on a 1.4m height tripod was set up to take 20 photos at 20 different spots to ensure the full coverage of the kitchen. A 360-camera was used because it could capture 360° degrees of angle, which was compatible with VR function. This study chose the tripod with a maximum height of 1.4m to emulate a person's height at eyesight.

After obtaining the photos needed, the website app.CloudPano.com was used to align and adjust the positioning of each photo for the VR tour project. The VR tour project (version 1) was duplicated for version 2 to create two VR tours but with two different layouts. The first version consisted of instruction text and the second version consisted of instruction text, a pinpoint of each hazard location, and the hazard description.

Then, the face and content validity took place in July and August 2020 with three (3) groups consisting of 10 experts from Information Technology (IT), OSH, and culinary background. IT executives determine the validity of the uses of technology related to VR. The participants measured the validity statements using a 5-point Likert scale by marking the point that the participants felt most appropriate, with "5" being "strongly disagree" and "1" being "strongly agree."

4.0 Findings

The VR's design development took about two months to be completed. The trial-and-error processes were conducted five times to search for potential VR editing applications. This study ultimately found that the VR simulation of CloudPano.com was very user-friendly. At the designing stage, a sample 360-degree view of the kitchen was required to create a simulation in the program. It was obtained by taking a 360-degree panoramic photo using a 360-degree camera. These 360-degrees photos then were stitched together by matching similar points in each photo to create an environment simulation. Later, it was accessed by placing a smartphone into a VR headset slider holder, as shown in Fig. 1. After rendering the simulations, they were uploaded to the cloud storage of cloudpano.com. The simulations then were accessed from an Apple operating system (IOS)-based smartphone. The simulations were displayed using a smartphone in VR mode. The smartphone was finally merged with the VR headsets to give an overall VR experience. The design process consumed most of the time; a part of the process required people with skill and certain equipment like 360-camera. Fig. 2 provides a simulation view from the VR applications with guiding aids (instruction).

Figure 1: Placing a smartphone into the VR slider slot

Figure 2: VR simulation view with guiding aids (instruction)

The validation process was done by ten (10) experts from Malaysia who had work experience of more than two years. They included eight males who were the IT and safety officers and two female culinary lecturers. Sixty percent of the experts were experienced in occasionally conducting hazard identification in their workplace. The face validity median score showed that the experts' rating ranged between 2 (agree) to 1 (most agree). The experts mostly agreed on eight statements. Four statements (statements 2, 5, 7, and 8) were strongly agreed and relevant to simulators for the actual hazard identification training, the realistic appearance of kitchen hazards, and the simulator's overall use as training and testing tools. Two statements (statements 1 and 6) scored 1.5, which were "VR simulator was easy to use" and "the overall graphic quality of the simulator was realistic." Lastly, the statements that were rated as 'agree' were statements 3 and 4: "Realism of the simulator to simulate a kitchen surrounding," and "realism of angle view movement from an individual perspective." Based on the result, the experts confirmed and strongly agreed upon the face validity. Table 1 shows the details.

Table 1: Face validity statements

	Median score (range)
Face validity statements	Experts
1. VR simulator was easy to use	1.5 (1-3)
2. Relevant to simulators for the actual hazard identification training	1 (1-3)
3. Realisms of the simulator to stimulate a kitchen surrounding	2 (1-3)
4. Realisms of angle view movement from an individual perspective	2 (1-4)
5. Realistic appearance of kitchen hazards	1 (1-3)

6. Overall graphic quality of simulator was realistic	1.5 (1-3)
7. Stimulator's overall use as training and testing tools	1 (1-3)
8. Overall value of the simulator as a testing tool	1 (1-2)

Note. "1" is "strongly agreed and "5" is "strongly disagreed"

For the content validity, the experts' median score ranged between 2 (agree) to 1 (most agree) (Table 2). Most statements were strongly agreed (statements 1, 2, 4, 5, and 6) in aspects of usefulness, ability, overall relevance as practice format, and appeal in simulator experience. Only one statement was not strongly agreed, but was still agreed upon by the experts, which was the realism of the simulator statement: "Realism of the simulator to provide hazard measurements." Overall, the contents were strongly agreed upon by the experts.

Table 2: Content validity statements

	Median score (range)
Content validity statements	Experts
1. Useful for teaching kitchen SOP	1 (1-2)
2. Useful for teaching kitchen hazards.	1 (1-2)
3. Realism of the simulator to provide hazard measurements	2 (1-3)
4. Ability to test hazard identification skills	1 (1-2)
5. Overall relevance as a practice format	1 (1-2)
6. The simulator experience was interesting	1 (1-2)

Note. "1" is "strongly agreed and "5" is "strongly disagreed"

5.0 Discussion

In line with 1994 OSH Act requirements which require "so far as practicable", this study supported the advent of best practises from the system-based and new technological advances that have been part of NIOSH initiatives. This VR safety training is one of the answers to the "so far as practicable" training in Section 15 2(c) of OSH Act 1994, which mentioned that it is a general duty of employers and self-employed persons to provide the "so far as is practicable" training to ensure the employees' health at work. The invention of this safety VR application corroborated the findings by Sandra (2019), who reported that kitchen employees could learn about the available risks before they worked in the kitchen. To create positive behavior in the kitchen workplace, the invention of VR focusing on safety should solve the food safety attitude; it was conducted through food hygiene training since it was based on the knowledge, and not on the behavior of the employees (Has et al., 2018; Yeargin et al., 2021).

The effectiveness of deterrent-based regulations and policies to improve workplace safety has been much debated. Some dispute its overall effectiveness, citing a penchant for creating a stratification of businesses based on resources. Others have found the laws to be an effective deterrent if violators face significant fines (Tombs & Whyte, 2013). Although the current statistics in Malaysia showed that restaurant fatalities and injuries were significantly lower than many other industries during 2020, it is crucial to consider that many restaurants were operating at a reduced capacity due to the COVID-19 pandemic (World Bank Group Bank, 2020). Furthermore, when we reviewed other nations with similar OSH regulations like the United States and Canada, we observed that the food and beverage industry has consistently poor performance concerning workplace safety (Lippert et al., 2020; Yu & Hon, 2020). It appears that the current regulations alone cannot ensure worker safety in Malaysian restaurants, but the VR safety training could further improve public health conditions of kitchen workers as they are alerted in advance to the visualized hazards before they start their work.

Organizations that wish to improve workers' confidence and reduce the expenses related to OSH should endeavour to find new and innovative ways to create a safer work environment. VR represents an effective method to train employees regarding workplace safety, particularly because it keeps workers isolated from hazards during training (Norris et al., 2019). This ability to reduce worker exposure while allowing employees to simulate real-world actions makes this technology invaluable. With the number of employees returning from layoffs related to the pandemic, and the seasonal nature of the restaurant industry, VR technology may provide a cost-effective and safe way to improve safety training and reduce accidents.

VR simulations are worthy as a one-time investment that can continue to provide benefits long after from a financial aspect. Some in-person trainings are too expensive to be implemented in many situations. According to the Ministry of Health Malaysia (2019), the international standard food safety training programs ranged from RM580 to RM2,000 per person. These can potentially be reduced by undergoing training virtually as work experience cannot truly be obtained through studying. This reduced cost could also be advantageous

for inexperienced workers' training, especially for small-medium businesses. Inexperienced workers are more likely to be involved in workplace accidents than experienced workers (Mark, 2016). CoreMark Insurance Service, stated in its blog, that workers with less than five-year experience accounted for 43% of the reported workplace injuries. Using VR applications in hazard identification training could be an alternative to more costly training programs.

6.0 Conclusion & Recommendations

A safe work environment is essential for all employees to maintain a high quality of life. The goal is to promote and improve employee and employer wellness and health and safety. In this study, VR as a safety training tool met both study goals: (1) design and develop VR applications for spotting risks in the kitchen workplace, and (2) validate the VR application's effectiveness. The invention of the safety training tool in this study has proven its ability to allow kitchen practitioners to spot risks. The current study managed to invent the safety training tool by using an intermediate software (cloudpano.com) that required a simple process of uploading, linking between the pictures, and editing texts and navigation points; and it is accessible by URL links. With a better budget (monthly maintenance fees) and better providers, the invention could reach a top tier of VR applications. Future researchers or inventors can enhance the current inventions for more interactive applications. Using the intermediate provider, this VR application for safety faced difficulties displaying and generating visuals in all mediums. We could only use the links provided during the development once we downloaded them on the personal computer to get the viewer's perspective. The VR application was limited in the realism of the dynamics and interaction since the VR could only display the graphics (Kamińska et al., 2019). This could break the immersion because it was a challenge to maximize the appearance of reality when realistic and authentic content is crucial, particularly to visualize a hazardous situation in a kitchen.

In conclusion, as theorized by socio-technical theory, the VR application provides opportunities to design a safety training tool to detect hazards at the kitchen workplace at an affordable cost. The result of this study is significant to show that hazard identification can be done by using VR. VR-based training can also ease financial burdens for small to medium-size enterprises. Thus, this could be the best approach to satisfy IR 4.0 while reducing costs for employers. This study recommends future research to expand VR applications on safety training tools that experts have validated. The development could use advanced software, such as pano2vr, krpano, and 3dvista to improve the quality. Moreover, the development can be expanded by having more experienced kitchen practitioners share their points of view through a qualitative approach.

Paper Contributed to Related Field of Study

This paper has contributed to the occupational safety field of study by proposing the technological option for minimizing accidents and incidents in the kitchen workplace when giving training to new workers.

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