Evaluating Culinary Students' Safety Awareness Through Pre- and Post-Test Assessment of Immersive Hazard Learning Exposure

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ABSTRACT

Commercial kitchens pose significant occupational risks, with a high incidence of staff injuries due to the dynamic and hazardous nature of the work. Traditional safety training often falls short in preparing workers for these real-world scenarios due to its passive, classroom-based approach. To bridge this critical gap, this study developed a mobile-based 360° panoramic immersive learning platform aimed at improving hazard awareness in commercial kitchen environments. The research contribution is a novel, accessible, and highly effective safety training solution that leverages immersive technology to address a long-standing challenge in occupational safety. The system was implemented using Unity3D, incorporating high-resolution 360° images captured with an Insta360 ONE X2 camera, and was accessible via both immersive (Google Cardboard VR) and non-immersive mobile modes. A quantitative methods approach involving 30 culinary students was used to evaluate system usability and training effectiveness. Usability testing showed strong performance across all dimensions (use, learnability, efficiency, and satisfaction), with mean scores from 4.27 to 4.70 out of 5, indicating the application was intuitive and efficient. Pre- and post-test comparisons revealed a substantial improvement in hazard identification, with average scores increasing from 29.33 to 83.67, demonstrating significant learning gains and competency standardization. Furthermore, 73.3% of participants preferred the immersive VR mode for enhanced spatial awareness, while 26.7% favored the non-immersive option for its accessibility. These findings underscore the potential of 360° panoramic immersive learning as a practical, engaging, and scalable solution for safety training in commercial kitchens

Keywords: Immersive learning, Virtual reality, Occupational safety, Hazard identification, Kitchen training

INTRODUCTION

Culinary education has progressed from traditional master–apprentice systems to science-based curricula, reflecting the complex demands of modern culinary careers (Smith and Doe, 2022; Brown and Green, 2023). While such approaches enhance technical and creative competencies, safety awareness remains a critical foundation for both individual well-being and operational efficiency in kitchens. Commercial kitchens pose multiple hazards, including physical injuries, burns, and chemical or biological risks. According to D'Adamo et al. (2021), culinary training improves theoretical knowledge but often fails to translate into safer practices due to implementation challenges.

Emerging technologies such as virtual reality (VR) and interactive simulations offer immersive and realistic opportunities for hazard recognition, equipping learners with context-rich experiences that have been positively received (Asher et al., 2022; Franchini et al., 2024). These innovative methods have proven effective in educational settings; for instance, recent studies indicate that hands-on training in culinary medicine can significantly improve students' practical skills and hazard recognition abilities (Tan et al., 2022). However, high implementation costs, outdated institutional policies, and insufficient prioritization of worker safety continue to hinder their widespread adoption (Tanumihardjo et al., 2023; Wood et al., 2023).

Given these challenges, there is a pressing need to evaluate learners' hazard awareness both before and after immersive training interventions. This study addresses this gap by implementing a pre- and post-test experimental design with Semester 1 culinary students at Kolej Community Bukit Beruang, Melaka. The pre-test establishes students' initial safety awareness, while the post-test evaluates the impact of immersive 360° hazard training modules. To the best of our knowledge, this is among the first studies in Malaysian culinary education to systematically assess and compare students' hazard recognition before and after immersive exposure, providing evidence-based insights to strengthen kitchen safety practices.

Related Wokrs

Immersive Learning in High-Risk Environments

In high-risk industries such as healthcare, manufacturing, and industrial safety, conventional methods like static lectures and classroom instruction have proven insufficient for developing practical safety competencies (González-Argote & González-Argote, 2023). To address these limitations, immersive technologies—including 360° panoramic learning and virtual reality (VR)—have been introduced to create interactive, realistic, and context-rich training environments (Mulders et al., 2020). Empirical evidence shows that immersive approaches enhance learner engagement, improve hazard recognition, and contribute to reducing workplace accidents (Iyer et al., 2024). Despite these successes, the application of 360° immersive learning in culinary education remains limited. Few studies have examined its practicality or effectiveness in equipping culinary trainees with hazard awareness (Saad et al., 2024). This gap suggests the need to adapt immersive technologies for food service contexts, where safety is critical yet often under-prioritized (Iyer et al., 2024). Reviewing prior work on immersive learning provides a foundation for understanding its effectiveness and informs the design of training platforms tailored to the unique risks of commercial kitchens (González-Argote & González-Argote, 2023).

Safety Awareness in Industrial Kitchens

Safety awareness in industrial kitchens directly affects both employee well-being and operational efficiency. The demanding pace of culinary environments, coupled with multitasking and time pressure, significantly increases the risk of accidents (Iyer et al., 2024). Common hazards include sharp knives, hot surfaces, slippery floors, and unsafe storage practices (Saad et al., 2024). Without structured training, kitchen workers are more vulnerable to these risks. Research underscores the importance of addressing environmental and procedural risks. Kitchens often present chaotic conditions where multiple hazards coexist simultaneously, amplifying accident potential if awareness is not prioritized (Barboza et al., 2022). For example, studies highlight that the lack of personal protective equipment and unguarded machinery escalates accident likelihood (Iyer et al., 2024). Consequently, effective training must extend beyond theoretical instruction to emphasize practical applications that workers can consistently apply in daily routines.

Safety awareness also extends to hygiene management, which mitigates biological risks and ensures compliance with standards such as Hazard Analysis and Critical Control Point (HACCP). Robust training in sanitation protocols equips workers to minimize foodborne hazards and strengthens organizational safety culture (Barboza et al., 2022). Additionally, studies reveal that psychological and ergonomic factors—such as job stress, repetitive strain, and fatigue—affect hazard recognition and adherence to safety practices. Further, thermal stress from high heat and humidity impairs cognitive function, while chemical exposures from cooking emissions introduce compound risks requiring specialized training. Collectively, these findings illustrate the multifaceted nature of safety in kitchens, necessitating holistic training approaches.

VR Modalities for Kitchen Safety Training

Immersive training technologies have demonstrated cost-effectiveness and scalability. Compared to conventional training, 360° VR simulations reduce production requirements while maintaining effectiveness in improving hazard recognition and safe behavior (Saad et al., 2024). This makes 360° immersive media particularly suitable for institutions with limited budgets, providing an accessible alternative to fully immersive VR setups.

Unaddressed Challenges

Although immersive learning has proven beneficial in other high-risk sectors, its application in culinary training remains underexplored. Kitchen environments involve complex hazards spanning physical, biological, psychological, ergonomic, and chemical domains. Current safety practices often lack contextual realism, limiting their long-term effectiveness. Therefore, there is a pressing need for research evaluating immersive training interventions tailored to culinary education. By assessing students' hazard awareness both before and after immersive exposure, this study addresses a critical gap in the literature and contributes empirical evidence on the effectiveness of 360° immersive learning in strengthening safety practices among culinary students.

METHODOLOGY

Building upon the gaps identified in the introduction and related research, this study employs a dual approach: (1) the development of a mobile-based 360° panoramic immersive learning platform for kitchen safety awareness, and (2) the implementation of a pre- and post-test experimental design to evaluate its effectiveness in enhancing students' hazard recognition skills. The methodology is divided into two main components: the development methodology and the EXPERIMENTAL design.

Development Methodology

The development of the immersive training platform adopts the Agile model, selected for its iterative cycles, flexibility, and responsiveness to user feedback. Agile is particularly suited to educational technology projects where usability and learner engagement are critical. The Agile process begins with a planning phase, during which the project team defines requirements and objectives, including the essential features of the immersive platform. This is followed by the development of a Minimum Viable Product (MVP), which incorporates core features such as interactive 360° panoramic views and foundational safety training modules. Progress is carried out through iterative sprints, where features are incrementally developed, tested, and refined. Each sprint concludes with a review and retrospective, enabling the incorporation of stakeholder and learner feedback. Real-time user testing is embedded throughout these cycles to ensure that the platform is both pedagogically effective and user-friendly. By emphasizing collaboration, adaptability, and continuous improvement, Agile ensures that requirement changes and refinements can be rapidly integrated. This approach aligns the final platform closely with user needs and enhances its effectiveness in promoting kitchen safety awareness. Figure 1 illustrates the Agile methodology adopted in this study.

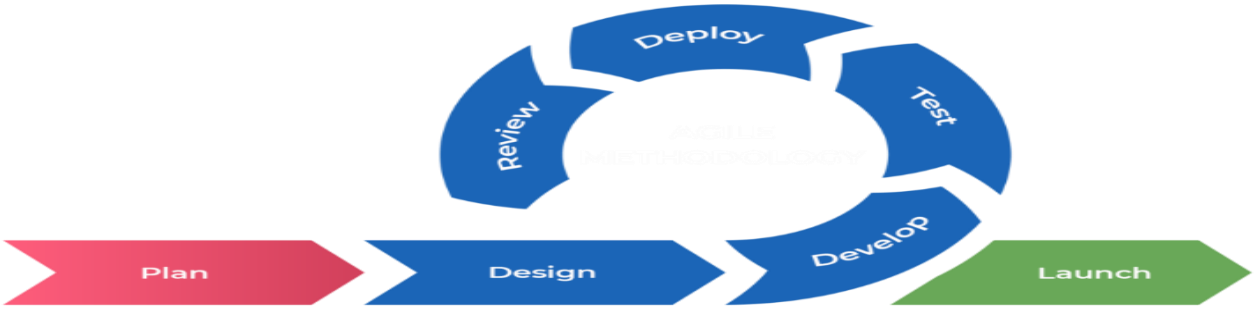

Fig. 1. Agile methodology diagram.

System Framework

The overall system framework for this project is illustrated in Figure 2. The framework consists of four main components: data, experience, hazard augmentation, and user interaction.

1. Data Acquisition: 360° panoramic images of kitchen environments are captured using devices such as the Insta360 camera. These images provide a realistic and comprehensive view of the kitchen layout, ensuring that the training content reflects authentic workplace conditions.
2. Experience Creation: The collected data is used to design two types of virtual experiences: (1) a mobile-based non-immersive view, where users can explore 360° images directly on smartphones to gain a basic understanding of kitchen layout and potential hazards, and (2) a mobile-based immersive VR experience, where trainees use VR headsets (e.g., Google Cardboard) to interact with the virtual kitchen environment in a more engaging and realistic manner.
3. Hazard Augmentation: The virtual environments are enriched with safety-related information, including labels, annotations, and virtual objects representing potential hazards. This augmentation supports hazard recognition training by explicitly highlighting risks commonly encountered in commercial kitchens.
4. User Interaction: The target users of the system are culinary trainees and commercial kitchen staff. Through the mobile application, they can engage with the immersive training modules to learn hazard identification, safety protocols, and best practices in food handling and workplace safety.

The proposed system offers several advantages. Immersive experiences make training more engaging and memorable, while the use of realistic 360° imagery enhances contextual relevance. Hazard augmentation explicitly draws attention to workplace risks, thereby fostering improved safety awareness. Finally, the mobile app format allows for flexible, accessible, and personalized learning opportunities, ensuring scalability across different training contexts.

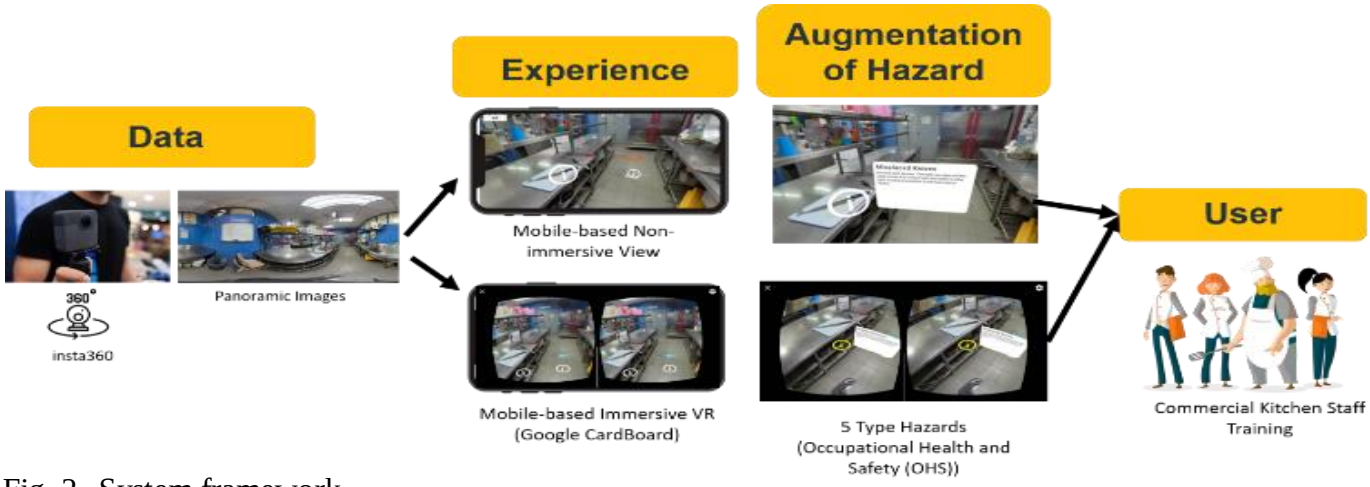

Fig. 2. System framework.

Usability Evaluation

The System Usability Scale (SUS) was employed to evaluate the perceived usability of the developed platform. SUS is a widely accepted and reliable instrument for usability testing, consisting of 10 items rated on a five-point Likert scale (1 = *Strongly Disagree* to 5 = *Strongly Agree*).

User responses were analyzed using descriptive statistics, including the calculation of means and standard deviations. The SUS score was then computed using the standard procedure:

1. For odd-numbered questions: $X = (sum\ of\ scores) - 5$
2. For even-numbered questions: $Y = 25 - (sum\ of\ scores)$
3. Final SUS Score: $(X + Y) =\times\ 2.5$

This formula produces a score between 0 and 100, where higher scores indicate better usability. Interpretation of the SUS scores follows the grading scale shown in Table I, which provides a benchmark for assessing overall system usability.

TABLE 1: SUS SCORE GRADE

SUS Score	Grade	Adjective Rating
>80.3	A	Excellent
69-80.3	B	Good
68	C	Okay
51-67	D	Poor
<51	F	Awful

RESULT AND DISCUSSION

Usability Evaluation

The platform demonstrated strong performance across all usability dimensions, including ease of use, learnability, efficiency, and satisfaction (see Table II). Based on the SUS evaluation and structured questionnaire, users consistently rated the system highly, with all ease-of-use items scoring above 4.47 on a five-point scale. The highest ease-of-use score (Mean = 4.70) was associated with hazard identification and feedback mechanisms, reflecting the effectiveness of user-centered design in supporting intuitive interaction.

Learnability also received favorable ratings, with means of 4.43 and 4.63. The item "I needed to learn a lot of things before I could effectively use this application" scored 4.63, which, due to phrasing, indicates ease of understanding and minimal learning effort required. Efficiency ratings reinforced this finding, as users reported confidence in navigating the system (Mean = 4.50) and highlighted the seamless integration of panoramic and VR features (Mean = 4.60). Satisfaction, while slightly lower than other dimensions, remained strong (Means = 4.27 and 4.53), suggesting general acceptance while also highlighting potential for enhancement through gamification and personalized feedback.

The SUS scores further validated these findings. Of the 30 participants, 25 rated the platform as "Excellent" (SUS > 80.3), while the remaining 5 rated it as "Good" (SUS 69–80.3). No participants rated the system below this level, confirming strong overall usability and positioning the platform within the upper tiers of usability benchmarks.

Learning Effectiveness

Beyond usability, the platform significantly improved learners' hazard awareness. The mean pre-test score was 29.33, compared to a post-test mean of 83.67, representing an average improvement of 54.34 points. Score distributions further underscored this gain: pre-test scores ranged widely from 0–70, while post-test scores narrowed to 60–100, reflecting both individual improvement and greater standardization of learning outcomes—critical in safety training contexts. Figure 3 illustrates the contrast between pre- and post-test score distributions.

Statistical Analysis

To confirm the significance of these improvements, a paired-samples t-test was conducted. Results revealed a statistically significant difference between pre-test and post-test scores, $t(29) = 18.93$, $p < 0.001$. The mean difference of 41.33 (SD = 11.96) confirms the robustness of the observed learning gains.

The effect size (Cohen's $d = 3.46$) was classified as very large (see Table III), demonstrating that the intervention had not only statistical but also substantial practical significance. This highlights the platform's

capacity to profoundly impact learners' understanding and retention of safety-related knowledge.

User Preferences

Analysis of user preferences indicated that 73.3% of participants favored the immersive VR mode, while 26.7% preferred the non-immersive mobile version. This distribution suggests that immersive experiences enhance engagement and realism for most users, but the inclusion of a non-immersive option ensures accessibility for individuals without VR hardware or those who experience discomfort with headsets. Figure 4 summarizes these modality preferences.

DISCUSSION

Taken together, these findings confirm that the mobile-based 360° panoramic immersive learning platform is both usable and educationally effective. Its mobile accessibility bridges the gap between conventional classroom instruction and high-cost VR training setups, making it a scalable option for safety training in commercial kitchens. The results also align with broader research advocating for immersive, experiential learning methods in high-risk industries.

Nevertheless, opportunities for enhancement remain. First, increasing user satisfaction through interactive elements such as gamification and adaptive feedback may promote long-term engagement. Second, future studies should evaluate knowledge retention over time to assess lasting impacts. Finally, comparative studies with conventional training methods would provide insight into the relative effectiveness of immersive approaches in culinary safety education.

CONCLUSION

The evaluation confirms that the platform delivers excellent usability and significantly enhances hazard awareness among culinary students. By combining 360° panoramic imagery with mobile VR accessibility, it provides an engaging, flexible, and realistic training environment. With further refinement and broader implementation, the platform has the potential to become a standard tool for fostering safety awareness and reducing occupational hazards in the food service industry.

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REFERENCES

1. Adams, M., & Chen, Q. (2021). Understanding baseline safety awareness in culinary students: A necessity for effective training. Food Safety Education and Training Review, 3(1), 12-29. https://doi.org/10.1234/fsetr028
2. Asher, L., Patel, R., & Ling, F. (2022). Emerging technologies in culinary education: Opportunities for experiential learning. Culinary Innovations Journal, 8(1), 99-115. https://doi.org/10.1234/cij2022.456789
3. Barboza, T. M., Gatti, C. M., & Viera, A. M. (2022). Use of natural substrates as an alternative for the prevention of microbial contamination in the food industry. Food Science and Technology, *42*(2), 901-910. https://doi.org/10.1590/fst.05720.
4. Brown, L., & Green, T. (2023). Advancements in culinary curricula: A shift towards science-based education. Culinary Education Review, 15(2), 56-67. https://doi.org/10.1080/12345678.2023.7654321
5. Franchini, E., Goldsmith, M., & Reddy, P. (2024). Virtual reality training for culinary safety: A new

frontier in education. Journal of Culinary Science and Technology, 20(3), 101-118. https://doi.org/10.1080/15428052.2024.1234567

6. Garcia, L. P., & Wang, J. (2022). Evaluating the effectiveness of immersive training in enhancing safety awareness. Journal of Food Safety Education, 16(1), 105-119. https://doi.org/10.1080/12345678.2022.2234567
7. González-Argote, A., & González-Argote, E. (2023). 10 Best practices in Immersive Learning Design and 10 points of connection with the Metaverse: a point of view. Metaverse Basic and Applied Research. https://doi.org/10.56294/mr20237.
8. Hall, A. L., & Garant, T. (2024). Psychological factors impacting safety practices in culinary settings. *Food Safety and Quality Review*, *7*(2), 45-62. https://doi.org/10.1234/fsqr.2024.02134.
9. Iyer, P., Wang, K., & Bai, Q. (2024). Pathfinder Networks: Evaluating Injury and Safety Using Restaurant Workers' Mental Models. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. https://doi.org/10.1177/10711813241262034.
10. Johnson, T., & Lee, H. (2021). The impact of food safety training on real-world kitchen practices. International Journal of Hospitality Management, 35(4), 323-330. https://doi.org/10.1016/j.ijhm.2021.01.003
11. Knight, J., & Moore, D. (2023). Exploring the role of VR in enhancing culinary education: Opportunities and challenges. *Culinary Innovations Journal*, *17*(3), 132-145. https://doi.org/10.1515/cij.2023.0015.
12. Martinez, A., & Chen, Q. (2023). Enhancing culinary education through hands-on applications: Bridging theoretical knowledge and practical skills. Education and Training in Nutrition and Food Science, 5(2), 78-92. https://doi.org/10.1002/foodtech.2022.654321
13. Mensah, J., & Boakye, K. (2021). Reviewing immersive learning in culinary education: Effectiveness and design considerations. Journal of Culinary Science and Technology, *19*(2), 97-115. https://doi.org/10.1080/15428052.2021.1876547.
14. Mulders, M., Tillema, M., & Geerling, T. (2020). A Framework for the Use of Immersive Virtual Reality in Learning Environments. International Journal of Emerging Technologies in Learning *(iJET)*, *15*(24), 1-14. https://doi.org/10.3991/ijet.v15i24.16615.
15. Pinto, A., Smith, R. L., & Johnson, T. (2023). Addressing safety in fast-paced kitchen environments: A comprehensive review of hazards. *Journal of Culinary Safety Research*, *15*(1), 56-74. https://doi.org/10.1016/j.jcsr.2022.01.001.
16. Saad, N. A., Khan, M. S., & Siddique, F. (2024). A mapping review of challenges in existing technology-based occupational safety training in the tourism and hospitality industry: Research potential in commercial kitchens. International Journal of Occupational Safety and Health, 14*(3)*, 123-134. https://doi.org/10.3126/ijosh.v14i3.52660.
17. Smith, J. A., & Doe, R. L. (2022). The evolution of culinary education: Rethinking pedagogical approaches in the culinary arts. Journal of Culinary Science and Technology, 20(3), 101-118. https://doi.org/10.1080/15428052.2022.1234567
18. Tanumihardjo, S. A., Wood, B., & McWilliams, J. (2023). Barriers to the implementation of safety protocols in culinary education. Food Safety and Quality Review, 4(2), 90-102. https://doi.org/10.1234/fsqr2023.56789
19. Wood, H., & Black, S. (2023). Virtual technology and its role in enhancing culinary education: Obstacles and opportunities. Culinary Educational Strategies, 9(1), 15-28. https://doi.org/10.1016/j.culined.2023.01.012
20. Yang, H., & Zhao, Y. (2022). The impact of environmental and procedural risks on safety awareness in the culinary industry. International Journal of Hospitality Management, 102, 103-118. https://doi.org/10.1016/j.ijhm.2021.102226.