Original Article

Construction Personnel's Perception of Gamified Safety Training

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ABSTRACT: *Construction workers consistently face various occupational hazards of varying complexity across different projects. Consequently, there is a pressing demand for training modules that equip them with knowledge and skills to ensure occupational and environmental safety on construction sites. However, existing safety training methods predominantly rely on theoretical content and lack practical, hands-on approaches. This limitation stems from the inherent challenges of applying hands-on techniques in specific hazardous scenarios within the construction industry. Integrating technology into training has proven to be a potent tool for enhancing learning, catering to both children and adults. One promising avenue is the adoption of gamified approaches, which have gained traction in educational contexts and across diverse sectors such as the military, mining, transportation, oil and gas, and the construction industry. Therefore, this study assesses construction workers' perceptions of using gaming as a training tool. To this end, a customised questionnaire was designed and descriptive statistics were employed to analyse the questionnaire responses. The findings underscored construction workers' strong interest in leveraging gaming to provide hands-on training in a safer environment. The participants also expressed confidence in the potential of game-based training modules to create cost-effective, interactive, and engaging training experiences for the industry. This research contributes to better understanding the safety training requirements within the construction sector, advocating for an approach that is both safer and more engaging while being cost-effective.*

Keywords: *Gamification, Safety Training.*

1.0 INTRODUCTION

The construction industry is known as the 4D industry: dirty, dangerous, dark, and deathly (Misnan et al., 2014). According to the Department of Occupational Safety and Health Malaysia (DOSH), Malaysia's construction industry recorded the third highest accident rate after manufacturing and agriculture. Owing to this concern, through government initiatives, the Construction Industrial Development Board (CIDB), National Institute of Occupational Safety and Health (NIOSH), and other related agencies have started to provide training to increase awareness and enhance knowledge of safety among key players in the construction industry. Various types of training have been conducted, including induction, on-the-job training, competency training, seminars, and forums (Mansur & Peng, 2009; Jason et al., 2020). However, the approach to delivering these training sessions has remained the same for years, that is, in the form of lectures, video demonstrations, and hands-on applications. Apart from competency training, other training types pay less attention to hands-on approaches. However, safety training requires hands-on and practical approaches. However, the nature of the hazards restricts the implementation of practical approaches in real-life situations. According to Goetsch (1993), one of the fundamental principles for learning is 'learning by doing' thus, emphasising adequate hands-on learning opportunities for learners (Al-Sahar, 2021). Consequently, researchers have explored other methods to improve safety training delivery, particularly the usefulness of technology in creating safety training modules (Assfalg et al., 2002; Mohd et al., 2019). By using technology, training has become more flexible in terms of time, cost, and experience (Mohd et al., 2019; Mohd, Liyana, et al., 2020).

2.0 GAMES AS TRAINING TOOLS

Many authors have interpreted the definition of games differently. Felix and Johnson (1993) described games by listing their structural components, such as dynamic visuals, interaction, rules, and goals (Moya et al., 2016), whereas Gredler (1996) described games according to their essentials, such as the stated task, player roles, multiple tasks to the goal, and degree of player control (Utoyo, 2021). Meanwhile, Hays (2005) defined games as *"an artificially constructed, competitive activity with a specific goal, a set of rules and constraints that is located in a specific contact"* (p. 15).

Electronic games can create a more exciting and interactive approach for delivering complex or tedious learning content (Prensky, 2014; Supriana, 2017). As Whitton and Moseley (2012) noted, games can also enhance the learning process in terms of playfulness, practice, and engagement. This statement was supported by Gee (2005), who believes that games should be designed in a way that triggers deep motivation for learning. Most electronic games provide a highly structured environment, with tutorials for new players. Such games often break down complex tasks into smaller, more manageable ones, catering to each player's pace and providing immediate and continuous feedback (Gee, 2005; Hilliard & Kargbo, 2017). Moreover, electronic games often require players to formulate content, evaluate hypotheses, and experiment with the outcome–a cycle of activities closely related to the learning process, defined as 'experiential learning' (Kolb, Boyatzis, & Mainemelis, 2001; Lehane, 2020).

2.1 Game vs. Hazard Identification Training

Hazard identification training is part of the *Hazard Identification Risk Assessment and Risk Control* (HIRARC) training module of the NIOSH (NIOSH, 2017). This training proceeds as follows: 1) train construction workers to identify unsafe acts and conditions in the working environment, 2) train their actions toward hazards, and 3) train decision-making skills in handling hazards wisely. This training should be performed visually and hands-on, so that the consequences of the decisions can be seen and remain accessible. These consequences make trainees more cautious when performing tasks. However, hazard can occur. Therefore, applying a hands-on approach in training is sometimes almost impossible in real life because it exposes trainees, trainers, and the environment to risks. Therefore, the gaming approach is a practical solution.

Games that offer visual training in an objective-based scenario allow construction workers to train and apply their knowledge without causing unnecessary harm. Because of the nature of the construction industry, simulated training with real people and hazards for training purposes is unlikely. This is where games can become the missing link between knowledge and hands-on training. Games enable users to practice their skills using a "*trial and error*" approach based on their existing knowledge and experience (Hess & Gunter, 2013; Kasemsap, 2017). By using games, users can observe the consequences of their actions and decisions without causing harm or injury (Backlund & Engstrom, 2007; Engelbrecht et al., 2019). The game environment is also safe for training workers who can practice their skills in a realistic environment and minimise the human errors that construction workers make in the real world (K.-Y. Lin, Son, & Rojas, 2011; Feng et al., 2022).

Pedagogical elements make learning more effective in training decision-making and problem-solving skills allow to handle hazards. These elements will also be used as guidelines in designing games to appeal to users and trigger their minds by following the user's nature of learning (Harteveld & Guimarães, 2007; Hauge et al., 2022). In this case, the game module applies experiential learning theory. Hazard training has become more flexible in terms of time, cost, and health, using a serious game approach. Table 1 shows the compatibility between games and hazard training.

Table 1: Compatibility between the natures of hazard identification training vs. games

Criteria of Game \ Nature of hazard training	Harmful	Need to experience	Hands-on training	Problems solving	Decision making
Visual (Abt, 1968; Mohd, Ariffin, et al., 2020)	X	X	X		
Immersive (Susi, Johannesson, & Backlund, 2007; Ren et al., 2022)		X	X		
Scenario-based (K.-Y. Lin, Son, & Rojas, 2011)		X	X	X	X
Safe environment (K.-Y. Lin, Son, & Rojas, 2011)	X	X	X		
Re-usable/Re-play (Backlund & Engstrom, 2007; Ren et al., 2022)		X	X		
Pedagogy (Harteveld & Guimarães, 2007; Ren et al., 2022)				X	X
Decision making (Hulst & Ruijsendaal, 2012)				X	X

3.0 METHODOLOGY

This pilot study aimed to evaluate the perspectives of individuals within the construction industry at various hierarchical levels. The data collection method employed was a survey complemented by a specific questionnaire. The questionnaire was structured into three distinct sections: 1) user characteristics, 2) user needs analysis, and 3) user perspectives on training utilising serious games, which form the focus of this study. Specifically, special attention was paid to the third section, which comprises two components: 1) the familiarity of users with games and 2) respondents' perspectives on using games as a training tool. Thirteen items adapted from previous studies investigating students' perceptions of the advantages of incorporating games into the learning process (Bourgonjon et al., 2010), were employed to measure respondents' perceptions. The data collection process involved the distribution of identical questionnaires among the participants to an occupational safety and hazard (OSH) training course, conducted both in-person and online. Although a minimum sample size of 30 respondents was sufficient for a pilot study (Bujang et al., 2024), we successfully gathered responses from 50 participants. Descriptive statistics were used to analyse the gathered data.

4.0 RESULTS AND DISCUSSION

Among the complete cohort of 50 respondents, an equitable distribution was maintained, with precisely half of the participants emanating from the occupational safety and hazard (OSH) training course and the remainder participating in an online survey. This ensured a balanced representation of perspectives from the in-person OSH training setting and virtual environment, enhancing the comprehensiveness and diversity of the data collected.

4.1 Exploration of Respondents' Acquaintance with the Gaming Approach

Most participants were 21–30 years old, constituting 64% of the sample (32 respondents). Subsequently, respondents aged 41 years and above comprised 22% of the cohort (11 respondents), and those aged 30-40 constituted 12% (6 respondents). Individuals aged 20 years accounted for 2% (1 respondent). Regarding professional experience, nearly half of the participants reported having one to three years of work experience (48%, 24 participants). This was followed by respondents with more than 10 years of industry experience (20%, 10 respondents), those with 5–10 years of experience (14%, 7 respondents), and individuals with 3–5 years of experience (12%, 6 respondents). A minority, constituting 6% (3 respondents), reported having less than one year of working experience.

Notably, all respondents were actively engaged in the construction industry during the pilot study. More than half (74%, 37 respondents) were already acquainted with gaming approaches. The results in Fig.1, which depicts the first part of the questionnaire's third section, illustrate users' familiarity with games categorised by age group. Notably, the 21–30 years old group exhibited the highest number of respondents who played video games, with 46% of participants (23 respondents), followed unexpectedly by the group aged 41 years and above, constituting 16% (8 respondents). This intriguing finding underscores that age did not emerge as a significant determinant of the engagement in gaming activities.

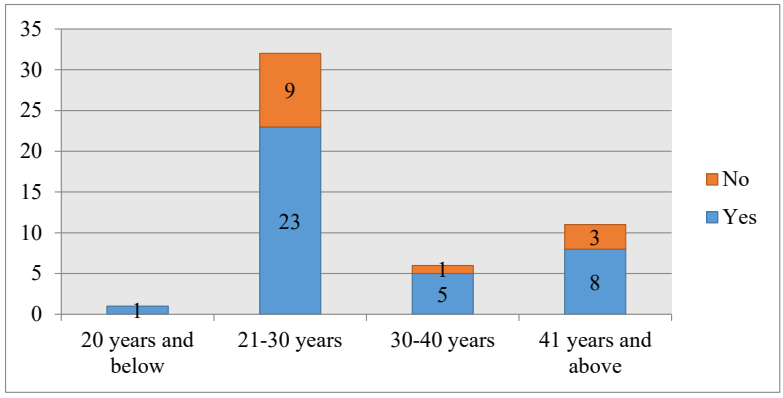
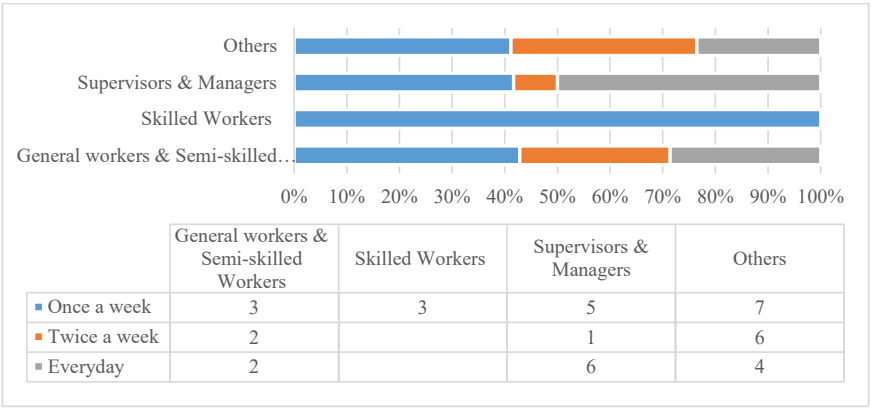


Figure 1: Numbers of respondents who played games according by age group

Fig. 2 provides a detailed breakdown of the descriptive statistics of respondents' familiarity with the game approach. The data outlined in this table reveal that the highest frequency of weekly playtime occurred once a week, constituting 36% of the respondents (18 individuals). This was closely followed by those who engaged in daily gaming activities (24%, 12 respondents) twice a week (18%, 9 respondents). Examining workers' weekly playtime ascertained the frequency with which they could allocate time for playing games. Notably, the findings indicated that respondents within the construction workforce could dedicate time to training at least once per week.



	General workers & Semi-skilled Workers	Skilled Workers	Supervisors & Managers	Others
Once a week	3	3	5	7
Twice a week	2		1	6
Everyday	2		6	4

Figure 2: Respondents' weekly game playtime

Beyond merely assessing the hours spent playing a game, the survey delved into workers' preferred game genres (Fig. 3). It is essential to note that only workers who actively engaged in gaming activities responded to this particular item. The respondents preferred puzzles (18%) and action games (16%). Other genres, such as arcades, sports, and role-playing games, garnered 10% of the responses. In comparison, simulation games received 6% and strategy games 2%. The nuanced distinction between puzzle and action games was imperative for gaining insights into the types of video games that respondents typically played during their leisure time.

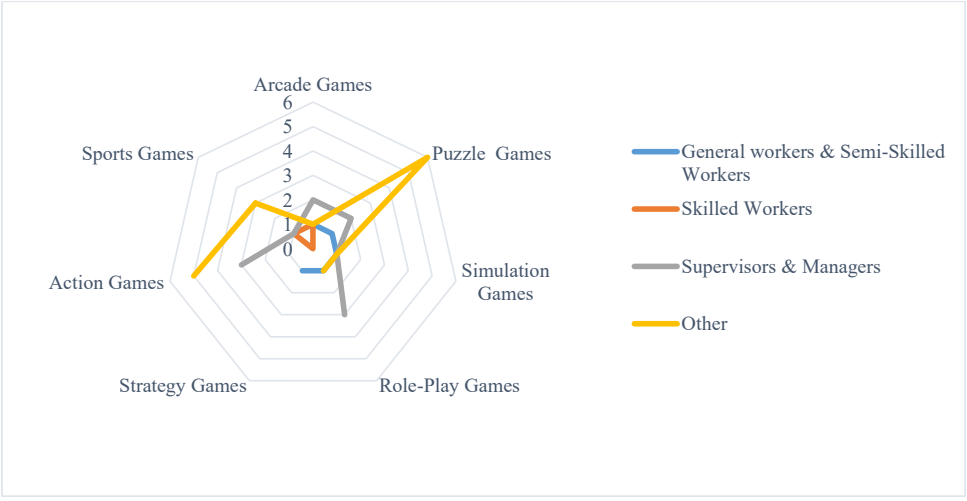


Figure 3: Respondent's preferred game genre

4.2 Respondents' Attitudes Regarding the Utilisation of Games as Training Tools

Table 2 and Fig. 4 show respondents' perspectives regarding the incorporation of the game approach into training, as elucidated by Girard et al. (2013). This perspective signifies one of the advantages offered by the game approach for individuals employed in the construction sector. The results revealed that three out of five distinct groups (other supervisors, managers, and skilled workers) displayed heightened expectations concerning the efficacy of the game approach in augmenting their knowledge and skills in alignment with prevailing market requirements. Notably, the mean scores for these groups were 3.74, 3.67, and 3.60, respectively, which were the highest scores among all categories. These findings suggest a pronounced willingness among construction workers' respondents to embrace the game approach as part of their occupational safety and hazard (OSH) training for continuous learning.

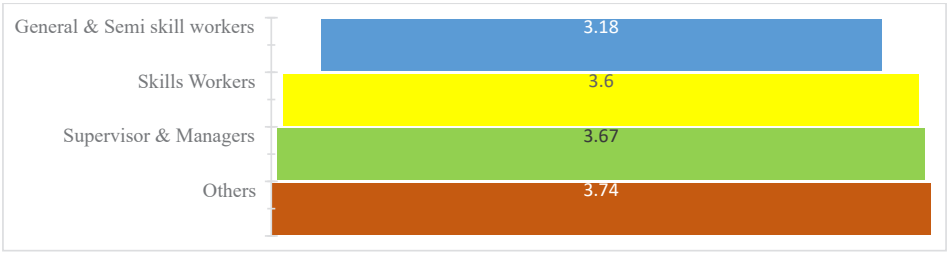


Figure 4: Construction workers' attitudes toward games as training tools

Moreover, unanimous agreement was observed among all respondents regarding the perceived benefits of employing the game approach in training. Specifically, they concurred that practising with a game approach could yield time and cost savings in addition to offering a safer methodology for training, mainly when dealing with on-site hazards. The gaming training paradigm is also known to provide a flexible schedule. This flexibility enables construction workers to conveniently engage in training sessions without compromising their daily routines.

The positive attitude and perceptions of construction workers toward games as training tools signify a paradigm shift in learning methodologies within the construction industry. Traditionally, training has been conducted using conventional methods in this field. However, the emergence of games as a tool for skill development has garnered enthusiasm among construction workers. This positive response is rooted in the recognition that game-based training provides a dynamic and engaging learning environment. Construction workers appreciate the interactive nature of games, which allows them to simulate real-world scenarios and apply their theoretical knowledge to practical situations. A gamified approach fosters a sense of immersion, making the learning process enjoyable and impactful.

Further, the adaptability and flexibility of game-based training resonate well with the demands of the construction workforce. Specifically, workers appreciated the convenience of accessing training materials at their own pace and schedule, which enhanced the overall effectiveness of the learning process. Construction workers perceived games as practical tools for honing their decision-making skills, hazard identification, and overall job preparedness. The gamification of training enhances their understanding of theoretical concepts and provides a safe space for hands-on practice. Construction workers' positive attitudes and perceptions of games as training tools underscore the industry's openness to innovative approaches, ultimately contributing to a more dynamic, engaging, and effective learning environment.

Table 2: Mean scores of respondents' perceptions of different types of workers

Items	Mean Analysis			
	General and semi-skilled workers	Skills Workers	Supervisor & Managers	Others
Keenness to experiment with the most recent computer applications.	3.00	2.60	3.79	3.50
Quick learner	3.43	3.00	3.71	3.63
I was assured of the simulation application's proficiency, which can facilitate training in decision-making processes.	3.43	3.60	3.64	3.79
Comfortable with the digital-based training environment	3.29	3.20	3.57	3.71
A digital learning environment enables me to conduct training anywhere and anytime.	3.29	4.00	3.86	3.88
Training-based skills will be more effective with the help of games.	2.86	3.40	3.64	3.63
Incorporating games will be appealing and contribute to a pleasurable training atmosphere.	3.29	4.20	3.93	3.83
Integrating gaming into training can offer an alternative method of delivering training.	3.43	4.00	3.71	3.88
Utilising game applications makes it easier to conduct experiential training for hazard identification.	3.14	3.80	3.64	3.83
I am enthusiastic about participating in training sessions that involve game-based methods.	3.00	4.20	3.86	3.75
I am confident that the assistance of games will enhance my comprehension of theories and knowledge.	3.14	4.00	3.36	3.75
Playing a game allows me to practice and develop my decision-making skills.	2.50	3.40	3.43	3.63
Utilising simulations is anticipated to enhance my readiness for the work environment on construction sites.	3.50	3.40	3.57	3.79
Means:	3.18	3.60	3.67	3.74

5.0 CONCLUSIONS

This study evaluates construction workers' perspectives on the use of games as a training tool, focusing on the safety training domain. The findings revealed a noteworthy degree of openness and a positive reception among diverse groups of construction workers. The anticipated significance lies in the potential integration of a blended training module that combines traditional methods with game-based approaches. This is particularly important for addressing the safety concerns prevalent in the construction industry, including occupational hazards. The incorporation of games as a training tool presents a novel and effective avenue for construction workers to enhance their decision-making skills in hazard management. The virtual environments simulated in these games closely mirror real workplace scenarios, providing workers with practical experience and insights. This enhances their ability to navigate and respond to potential hazards, and contributes to a more profound understanding of safety protocols and procedures.

Adopting games as training tools has several advantages. In addition to their demonstrable safety and cost-effectiveness, these tools offer high interactivity and entertainment value. This aspect is crucial for engaging construction workers, making learning more enjoyable and conducive to knowledge retention. Furthermore, the flexibility in accessing these training modules at any time and location aligns with the dynamic and often unpredictable schedules of construction workers, ensuring that training is accessible and adaptable to their individual needs. In conclusion, the positive outlook of construction workers toward game-based training tools signals a potential transformative shift in safety training methodologies within the construction industry, aligning with the evolving needs and preferences of the workforce.

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