The Use of Gamification in Safety Training for Construction Workers: Evidence from Lagos State, Nigeria.

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Abstract

Gamification has a long-term effect on safety training for workers based on the lasting impact on memory and retention through simulation and inclusiveness in training activities to check of safety measures on-site. While the knowledge and application of gamification continually expands as a training measure in the construction industry, its application in Nigeria is still largely understudied. Therefore, this study investigates its use in safety training measure amongst construction experts within the context in Lagos State Nigeria. The study revealed that the application of gamification in the construction industry is beneficial for employees in the construction field as it enhances efficiency in operations and task delivery. The design method of research adopted is the quantitative methodology which considers the positivist method to ensure that the numerical data in research in general is scientific and analyzed with scientific tools and approaches. 0.839 Cronbach's Alpha score reliability test was applied to data and 0.839 score was achieved which shows high level of data reliability. The study found that the knowledge on gamification in the construction industry is Nigeria is higher among the high-ranking experts involved in training activities who are responsible for encouraging firms to adopt this approach as an effective training tool. Although the lower ranking experts who are more exposed to accident hazards are knowledgeable in theoretical safety training, hence, the call for gamification to be included as training tool for all employees due to its associated benefits in enhancing efficiency since gamification is seen to be an effective addition to safety training in construction. The implication of this study is the revealed opportunities to tailor gamified training to specific roles and associated hazard on project sites which could further influence safety regulations and training requirement in the construction industry.

Keywords

Construction Workers, Gamification, Safety Training, Virtual Reality.

1. Introduction

Construction sites remain among the hazardous workplaces with high rates of injuries and fatalities in globally of which Nigeria is not excluded. Falls from height, injuries from machine handling, inhalation of fumes and dust, exposure to hard chemical substances amongst others are various risk hazards in construction activities on sites Willians et al., (2018). As such, various training courses are regularly provided to enhance the safety of workers (Jatau, 2022). However, there is a failure in the traditional training methods often fail to fully engage workers or translate into consistent safe behaviors on the job, as such the consideration for gamification (Bes and Strzalkowski, 2024).

The incorporation of gaming into safety instruction for construction workers, known as gamification, is gaining attention for its potential to enhance training effectiveness. This study explores the integration of gamification into safety training for construction workers in Lagos State, Nigeria. Drawing on perspectives from scholars such as van Wyk and de Villiers (2019), and Radianti et al. (2020), whose research investigates how gamification, particularly through virtual reality (VR), can improve safety awareness and adherence to protocols. Gamification involves listing the key elements that govern the morality of games, such as visuals, established norms, and manners with the inclusion of strategic objectives to attain a productive as well as an enjoyable process of gaming while learning about safety among workers in the construction or building industry (Wilson 2009).

Although the traditional theoretical workshops and other training processes have been the norm for construction workers (Jatau et al 2023 and Mohd et al., 2019), as such, the integration of gaming will be an added advantage to enhance participation and retention. The study of van Wyk and de Villiers (2019), asserts that gamification also considers the use of Virtual Reality (VR), and the study further identified three types of gamifications which are the non-immersive which is based on the use of desktop, semi-immersive which involves gaming with mobile devices, and general immersive which cut across all devices. To present a Virtual Reality Environment (VRE), desktop is used to show reality of a process virtually on a standard monitor, while the use of speakers and mouse is to aid audio and communication (van Wyk and de Villiers, 2019). Hence, virtual reality (VR) is a vital component and instrument in the construction industry and, when VR is applied properly in safety instruction, is ascribed to gamification (Radianti et al., 2020). Similarly, Feng, et al., (2022) also specified that gamification should include visualization of gaming elements, and the design approach should be strategic to allow different activities to be developed within games so to make learning more inclusive. Concerning the effectiveness and importance of gamification in training, Bes and Strzalkowski (2024) analyzed various training instruments in construction, mining and the energy industry, their findings placed gamification at topmost ranking as amongst the most effective safety training approach within the construction, engineering and architectural sectors. Thus, gamification as an information technology measure can be utilized in the construction sector, especially to educate construction workers about understanding safety measures. Overall, gamification in safety training research is receiving great attention because of the benefits it brings in presenting hazards in an almost real-life environment and scenarios which entwines with memory and retention among trainees through participation in gaming activities which enhances inclusiveness in training sessions (Jatau et al., 2023: Bes and Strzalkowski, 2024).

Prior literature has considered various aspects of gamification, from understanding the concepts, feasibility of adoption, application approach, user friendliness and designs. Typical is the study by Mohd et al., (2019) in which the study sort to understand the gamification process through review of related literature and applied deductive approach to determine the simulation games that is most suitable for hazard identification on construction sites in Malaysia. Studies on the design approach tried to consider models that are necessary to be within gaming tools, frameworks to navigate the game and user friendliness (Feng et al., 2022; Leite et al, 2022: Ren at al., 2022). While most studies of gamification training are geographically contextualized, this study sort to access the adoption of gamification in Nigeria and it discovered that prior study on the topic in Nigeria only considered gamification in productivity enhancement and employee engagement. This study by Oke et al., (2023) further sort to know the aspect of construction gamification is most needed in Nigeria construction industry and Safety was top listed. Therefore, this study is motivated by the need to consider how gamification can be employed in safety training of construction workers. Although the study by Jatau et al (2022), mentioned that most training workshops in Nigeria are mostly dominated by verbal instructions which could be hindering effectiveness as site accidents continues to grow on construction projects. Therefore, to achieve the aim of this study, the following questions were considered (1) What game design is most effective for safety training that will enhance effectiveness of training in improving

safety on site (2) what are the benefits and opportunities in the application of gamification in safety training? The implication of this study is, the knowing the most applicable game to enhance safety training will reveal opportunities to tailor gamified training to specific roles and associated hazard on project sites which could further influence safety regulations and training requirement in the construction industry.

Overview of the Application of Gamification in the Safety Training in the Construction Industry.

The construction industry is generally at an infant stage in the adoption of gamification in safety training, albeit at a slower pace compared to other sectors. However, certain key aspects have been identified, some of which are virtual reality (VR) simulations which allow workers to experience hazardous situations in a safe, controlled environment. This immersive approach helps in improving hazard recognition and decision-making skills (van Wyk and de Villiers, 2019). Mobile apps and serious games are interactive, scenario-based training that workers can access onsite or during downtime and they often include quizzes, challenges and rewards to reinforce safety concepts (Gao et al 2019). Augmented Reality for onsite training overlays safety information into real world environments, providing context-specific training and reminders (Li et al 2018). Pillay (2022) further added that the "Safe Work Method Statements(SWMS) is another game that helps construction employees to perform specific tasks securely; and this type of game gives hints on how hazards can be managed and, if the hazards is physical lifting. The SWMS game comprises the steps that are needed to correctly lift a heavy load and through this, the SWMS game explains the necessary real-world approach to finish an activity. Leatherboards and competitions are implemented systems where workers or teams can earn points for safe behaviors, creating a friendly competition to promote safety awareness. Gee (2015) stated that another efficient game design concept for construction workers' safety training is the electronic games structure with leader board outcome that are seen to be very useful because they are perceived to be more advantageous than an actual exam for training in fire safety. Deductively, these electronic games allow construction workers to experiment on what they have learnt and evaluate the outcome of the experiment, and this is thereby seen as a sequence of tasks that are directly connected to the learning process. This type of effective game design is known as experimental learning, and it has been related to a better learning outcome (Whitton, 2016). Adoption challenges outlines are Initial cost, resistance to change in traditional industry, ensuring relevance to specific construction contexts and measuring and providing effectiveness

Early studies suggest that gamified safety training can improve knowledge retention, risk awareness, and worker engagement (Bitrain et al., 2016). However, the long-term impact on accident rates and safety culture is still being evaluated. It is worth nothing that while adoption is growing, it's not universal across the industry. Larger companies and more technology-oriented firms tend to be early adopters, while smaller contractors may lag due to resources constraints (Agyekun,, 2018: Oke et al 2023) , Hence the need for continuous study to investigate this position in Lagos state Nigeria.

2. Research Method

The quantitative research methodology was adopted in this research to enable this study to produce results that are generalizable (Hasan, 2024). Quantitative research methodology is a systematic approach employed to investigate a phenomenon through measurable variables and numerical data (Mohajan, 2020; Hasan, 2024). As stated in Saunder et al (2019), the quantitative method employed in this study adopted a single data collection method which is survey with the use of close ended questions structured within the questionnaire, and the non-probability sampling techniques using purposive sampling was employed in this research. Although a probability stratified sample technique would have been considered due to its importance of reaching a broader group of respondents across various skill trade hence minimizing sampling bias error, the purposive sampling was rather employed to ensure that those contacted have a background knowledge of gamification, are computer literate to be able to identify various gamification options, and that respondents are workers in the construction industry involved in health and safety training of employees. Since gamification is a relatively new technology still developing, archival and secondary data were not considered because such data is still unavailable in Nigeria. Limited by time, geographical location and resources, this study adopted the Stutely's (2014) rule of thumb smallest number of cases cited in Saunders et al (2019) to ascertain the suitability of sample size. As such, a total of 25 respondents self-completed the questionnaire out of the 45 contacted. Content validity of the questionnaire was tested through discussion with supervisory team

and referenced with literature before it was sent out to respondents and the Cronbach Alpha was used to identify the reliability and consistency of the data.

In analyzing the data, the descriptive analysis was adopted using frequency distribution approach and the use of percentages. This according to Manikandan (2011) and Peck et al., (2015) provides a basis for comparison, allows room for further statistical analysis and employs the use of the Likert scale. However, the limitation in the choice of this analysis is that conclusions cannot be extended beyond the data presented neither can it be used beyond the feasible inferences present in the data.

3. Results

This section discusses the results from the analysis from the questionnaire and groups the Likert scale based on the objective of the study under the effective gaming option selected and the level of effectiveness, and the opportunities and benefits in gamification. However below is the demographic representation of the respondents.

Table 1: Demographic representation of the respondents.

Age Category	**Frequency**	**Percentage**
25 – 34	16	64.0
35 – 44	8	32.0
45 – 54	1	4.0
Total	**25**	**100.0**
Minimum Age= 25; Maximum age= 49; Mean Age= 34 Years; Std. Age=3.8		
Highest Educational Qualification	**Frequency**	**Percentage**
HND/First Degree	15	60.0
Masters	10	40
Total	**25**	**100.0**
Position in Organization	**Frequency**	**Percentage**
Senior-General Manager	2	8.0
Associate & Manager	3	12.0
Engineer-Project Manager	16	64.0
Architect	1	4.0
Health and safety workers	3	12.0
Total	**25**	**100.0**
Duration Working in Organization	**Frequency**	**Percentage**
2-3 yrs	6	24.0
4-5 yrs	7	28.0
6-7 yrs	12	48.0
Total	**25**	**100.0**

Table 1 above shows the mix of workers category in construction industry who are knowledgeable in gamification application in safety in the construction industry. Unfortunately, the category of workers who are most prone to site accidents and are likely to attend toolbox meetings are not knowledgeable in gamification in safety training. However, with the involvement of top managers is a plus as company adaptation of gamification can be promoted by this category of experts.

3.1 Effective Game Design Element for Safety Training

In this section, the analysis focuses on the effectiveness of designing game elements for safety training in the construction industry. Several questions were posed regarding the efficacy of different game design elements, including leaderboards, virtual reality (VR), choices, challenges, and feedback within the gamification system.

Responses were collected using a Likert scale ranging from "strongly disagree" to "strongly agree." The data illustrates the frequency distribution of responses for each game design element.

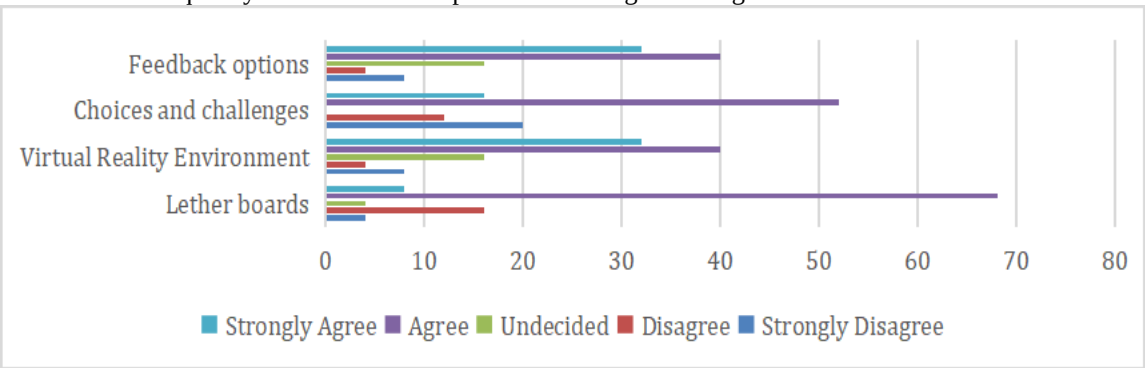

Figure 1: Shows distribution of responses for effective gaming design element

Figure 1 above shows that for leaderboards, 4.0% of respondents strongly disagreed, while 16.0% disagreed, and 68.0% agreed that they are effective in safety training for construction workers. Additionally, 8.0% strongly agreed with this statement while the remaining 4.0% are undecided

Regarding the effectiveness of VR in construction safety training, 8.0% strongly disagreed, 4.0% disagreed, 16.0% were undecided, while 40.0% agreed, and 32.0% strongly agreed. For the use of choices and challenges within the gamification system, 20.0% strongly disagreed, 12.0% disagreed, 52.0% agreed, and 16.0% strongly agreed that they are effective in safety training for construction workers. Finally, concerning the importance of feedback in gamification for workers learning safety measures, 8.0% strongly disagreed, 4.0% disagreed, 16.0% were undecided, while 40.0% predominantly agreed, and 32.0% strongly agreed. The analysis underscores varying perspectives on the effectiveness of different game design elements in safety training for construction workers, with a majority acknowledging the significance of leaderboards and feedback, while opinions on VR and the use of choices and challenges are more divided.

3.2 The Effect of Game Design for Safety Training on Performance

The section discusses the distribution of frequency regarding the long-term effects of designing games for safety training in the construction industry. Questions regarding the importance of gamification in improving safety performance, informing workers about managing work processes safely, and enhancing worker performance were posed.

Figure 2: The effect of game designs for safety training on safety performance

Data analysis from figure 2 above revealed varying degrees of agreement among respondents. For instance, regarding the importance of gamification in improving safety performance, 8.0% strongly disagreed, 8.0% disagreed, 4.0% were undecided, while 52.0% agreed, and 28.0% strongly agreed. Similarly, regarding whether gamification effectively informs workers about managing work processes safely, 4.0% strongly disagreed, 12.0% disagreed, 12.0% were undecided, while 56.0% agreed, and 16.0% strongly agreed. Moreover, concerning the impact of gamification on worker performance, 8.0% strongly disagreed, 4.0% disagreed, 16.0% were undecided,

while 56.0% agreed, and 16.0% strongly agreed. Finally, on whether gamification has been integrated into construction worker training for safety measures, 4.0% strongly disagreed, 12.0% disagreed, 16.0% were undecided, while 52.0% agreed, and 16.0% strongly agreed. These findings provide insights into the perceived effectiveness of gamification in safety training within the construction industry, highlighting areas of consensus and dissent among respondents.

3.3 Factors Influencing Game Design for Safety Training On Performance Effectiveness

The section delves into factors influencing the design of safety training games for construction workers. Data from respondents reveal insights into the impact of hiring new employees, the implementation of gamification training due to technological advancements, the introduction of gamification training in response to new employees, and the effectiveness of gamification in addressing poor safety measures among construction workers.

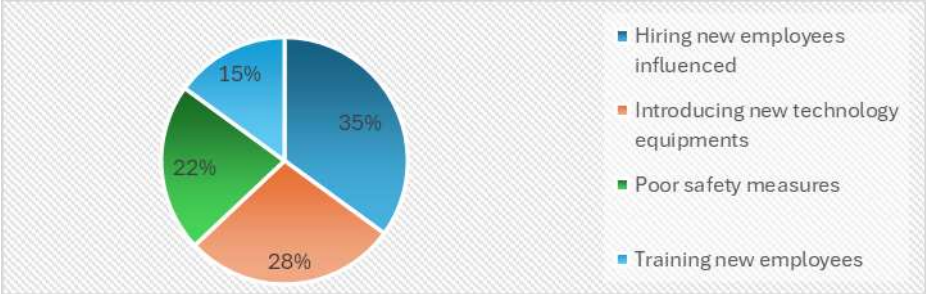

Figure 3: Factors influencing game design for safety training on performance effectiveness.

Results indicate varying opinions on these factors, with a significant 35% percentage agreeing that hiring new employees influences gamification training effectiveness and that technological developments have led to the implementation of such training. Additionally, opinions differ on whether gamification training was introduced due to new employee hires and its effectiveness in addressing poor safety practices among construction workers.

3.4 Benefits and Opportunities in Gamification Towards the Improvement of Safety Training for Construction Workers.

The Section focused on opportunities that are available in gamification to ensure improvement of safety training amongst construction workers,

Figure 4: Benefits and opportunities in gamification towards the improvement of safety training for construction workers

The data from figure 4 revealed that using gamification puts construction workers at an advantage as potential dangers are simulated in the gaming environment thereby providing consciousness in carrying out task with related perceived hazards. However, gamification could improve the effectiveness of task delivery since accidents can be prevented and measures are put in place to endure this effectiveness in job delivery. More so, the data revealed that gamification should be used to train construction workers as it will ensure their effectiveness on the job.

4. Discussion

Based on the objectives that guide the study, and in relation to the findings from the results on the most effective game design elements to be incorporated into safety training for construction workers, the findings are in line with

the literature of Oke et al., (2023) where leader board is identified as one effective design or elements in games that is crucial for efficiency in gamified challenges. Furthermore, on the long-term effects of gamification on safety training on workers safety performance, Priya et al., (2021) asserts that it will ensure that safety officers guarantee the construction workers' safety check always because of the need to implement gamification prior to every work process. Additionally, concerning the factors influencing effective gamification safety training for different construction worker type, the findings are in relation to the literature as the study of Sarkam et al., (2018) asserts that positive elements when integrated into gamification can be used to improve or promote safety training for workers in the construction industry and this is significant to the study.

More so, based on the opportunities in gamification towards improving safety training in construction workers, the analyzed data has revealed that gamification has opportunities that construction companies can investigate in order to ensure that safety is improved on project sites. Similarly, the study of Alsharef et al., (2020) attested to this as it revealed that gamification offers various opportunities such as education for safety in the construction industry. Lastly, in relation to the benefits and opportunities in the use of gamification towards improving safety training amongst construction workers, the study analyzed if the use of a gamified system can address some challenges in a construction job and the responses were majorly agreed and this is in line with the literature as Kawuwa et al., (2018) stated that through gamification, health and safety risks, ignorance, regulations violation, absence of training knowledge can all be addressed within gamified system, which is part of the opportunities or solutions of gamification.

5. Conclusions

This study focused on discovering the incorporation of gaming into construction workers' safety instruction, considering the perspective from construction experts in Lagos State Nigeria. Meanwhile, gamification has been shown to be a crucial supportive tool to construction workers as game design is important because it will include different safety tips and will ensure that construction workers can easily integrate their learning to the work process. More so, based on the objectives of the study found out that gamification is used to improve workers performance in construction sites and safety training. Also discovered is that gamification equips and prepares workers concerning safety measures on the job.

Additionally, the study revealed that some employees are properly informed with gamification safety training which helps them to manage their work process and maintain safety always. The implication of this study is, the knowing the most applicable game to enhance safety training will reveal opportunities to tailor gamified training to specific roles and associated hazard on project sites which could further influence safety regulations and training requirement in the construction industry.

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