Penerbit Akademia Baru

Journal of Advanced Research in Technology and Innovation Management

Journal homepage:
http://www.akademiabaru.com/submit/index.php/artim/index
ISSN: 2811 - 4744

Investigation of Using Gamification as A Technology-Based Tool for Teaching and Learning of Process Safety

Brandon Ying Liang Choo[1], Jully Tan[1,*], Mimi Haryani Hassim[2], Kathleen B. Aviso[3], Chia Pao Liew[4]

[1] School of Engineering, Monash University Malaysia, Jalan Lagoon Selatan, 47500 Bandar Sunway, Selangor, Malaysia
[2] School of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia
[3] Center for Engineering and Sustainable Development Research, De La Salle University, 2401 Taft Avenue, 1004 Manila, Philippines
[4] Faculty of Engineering, Technology & Built Environment, UCSI University, UCSI Heights, 56000 Cheras, Kuala Lumpur, Malaysia

ABSTRACT

Industrial accidents continue to rise, demanding more process safety experts. Process safety education, particularly at the university, has become critical in nurturing process safety experts. Process safety education has become crucial in nurturing process safety experts, particularly at the university. Technology advancements have created various resources for university instructors and students to employ as teaching and learning aids. This study investigates the usage of gamification as a technology-based tool in the teaching and learning process; hence, a game was created. The gamification in process safety was then evaluated to determine its ability to raise the interest and perceived competence of chemical engineering undergraduate students in process safety, besides promoting independent learning. The correlation between students' learning interest in process safety and perceived competence was also investigated. Twenty-one students partook in the game and the pre- and post-game survey. It was found that the more interested students are, the higher their perceived competency is. In conclusion, the application of gamification in learning process safety can help students become more independent learners and increase their perceived competency.

Keywords:
Gamification; Teaching; Learning; Safety

Received: 29 Dec. 2022 **Revised: 27 Jan. 2023** **Accepted: 19 Feb. 2023** **Published: 8 Mar. 2023**

1. Introduction

The increasing demand for chemical-related products has caused an increase in the number and scale of chemical processing industries [1]. Therefore, continuous operation is required to meet the high demand [2], but this could impact the performance of the industries and cause industrial accidents if not carefully handled. Process safety experts are one of the means to prevent accidents, such as the Bhopal disaster in 1984 [3], the Optima Chemical explosion in 2020 [4], and the recent Beirut ammonium nitrate explosion [5]. The occurrence of such accidents would put millions of lives, property, and the environment at risk. These industrial catastrophes highlighted the necessity of process safety education in developing individuals capable of managing process safety in the

* *Corresponding author.*
E-mail address: tan.jully@monash.edu

workplace. A systematic learning approach on safety principles and operating disciplines is known as process safety education. It can be delivered via different routes: university-based, government regulatory agencies training, and professional routes [1]. University-based is the most basic yet indispensable route [6].

Instructors and lecturers at universities are actively looking for novel technology tools to incorporate into their classes since these technologies can boost students' interest in learning [7]. As a result of digitalisation, a more comprehensive range of technology tools is available for instructors. These technology tools can include but were not limited to computer modelling, video [8], virtual reality (VR) and augmented reality (AR) [9], and game-based learning, or known as gamification [10].

Generation Z students have spent more time (about eight hours) using electronic devices than former generations' users in this digital era. [11]. The study showed that they often have a shorter attention span, which is eight seconds [11]. Thus, they favoured active learning methods, such as carrying out hands-on practice and observing various phenomena, over traditional teaching methods [12], preferred technology over books and storytelling over reading [13]. The above-mentioned characteristics of Generation Z students prepared the way for the use of technology-based tools in the classroom, which in this case is gamification. Several gamification education tools have been developed, such as Kahoot, ClassDojo, Classcraft, etc. Tracey's investigation revealed a correlation between interest and a student's competence [14]. Rottinghaus *et al.,* [15] found that using technology-based tools increases learners' interest. However, the relationship between interest and competence in the process safety aspect was unknown because Tracey's study was limited to youth aged 11 to 14, and Rottinghaus *et al.,* [15] focused on the arts, mathematics, and science components only.

Concurrently, the experts' guidance in the process safety education is vital. Nonetheless, the topic of process safety is too broad [16], so a thoroughgoing reliance on lecturers and instructors is not practicable. Independent learning (i.e., self-study) is an essential skill that a student must acquire to ensure the students take time to revise the studied program. Students can investigate the studied subject more deeply, critically analyse the strengths, shortcomings, and chances for improvement, and ensure that the learning outcomes have been appropriately accomplished through self-study or independent learning [17,18]. A proper revision leads the student to become fully competent in process safety. However, there has been a dearth of innovative technology tools for students outside of the classroom to self-study process safety.

Due to the lack of research papers on gamification of process safety in undergraduate chemical engineering education, this study investigates the feasibility of gamification of process safety lessons in chemical engineering undergraduates. A refined search of "process safety" returns 213 articles in Scopus, but only 21 are related to chemical engineering. In a further refined search with "undergraduate," only three papers were found that discussed game-based learning or gamification of process safety in undergraduates. As a result, the outcomes of this study will help educators better understand how to use gamification to boost learning and teaching engagement.

2. Literature Review

Recently, the demand for chemical-related products increased because of globalisation and the increase of the human population [1]. As the most fundamental matter in our needs in life, Chemicals exist everywhere in this world, such as food, shelter, health, and products essential to the high technology world of telecommunications, computing, and biotechnology [19]. The chemical processing industry (CPI) must operate continuously to adapt to the increasing demands of chemical-related products in the market [2]. Nonetheless, continuous operation is responsible for increasing

the risk of industrial accidents. Seventy-five fatal accident cases were reported in Malaysia in 2020 [20]. Chong and Low's analysis also said that 42,775 accidents had occurred in Malaysia from 2000-2009 [21]. Even though understanding the causes of accidents has improved throughout time, industrial accidents still occur. Let us closely examine the lessons acquired from these accidents. We will undoubtedly discover that the vast majority of them could have been evaded by an adequate knowledge of the core science and engineering underpinning the process, as well as the application of process safety management [22].

Process safety is constantly being studied to reduce risk and address the emergency in preventing industrial accidents. The definition of Process Safety is a disciplined framework that utilises engineering, designing principles, and practices in operation to govern the integrity of processes and operating systems in managing hazardous materials, to control and prevent incidents that may release hazardous materials or energy [23]. These incidents can yield fire, explosion, or toxic effects, resulting in severe injuries, lost production, property damage, and environmental impacts [23].

Employee participation, process safety information, process hazard analysis, operating procedures, training, contractors, pre-start-up safety review, mechanical integrity, hot work permit, management of change, incident investigation, emergency planning and response, compliance audits, and trade secret are among the 14 elements of process safety management defined by the United States Occupational Safety and Health Administration (OSHA) [24]. Simultaneously, the Malaysian Department of Occupational Safety and Health (DOSH) released a guideline on the Occupational Safety and Health (OSH) system, covering the five OSH aspects of policy, organising, planning and execution, assessment, and improvement action. Although there are differences in the elements, all guidelines exist to ensure safety, minimise the risks, and, if possible, prevent accidents.

University-process safety subjects are typically taught in a bachelor's degree program [25]. The process safety subjects in the bachelor's degree program are generally fundamental concepts and basic process safety principles that seek to introduce to the undergraduates [1]. On the other hand, professional training performed within the industry could also be acquainted with process safety. For example, on-the-job training (OJT) is a form of initial training, retraining, and mentoring programs obtained from professional work execution [26]. Subsequently, continuous professional development (CPD) can be acquired from professional licensures, such as a Chartered Engineer and Professional Engineer [27,28]. Other than that, innovative experimental research in the industry could also be considered one way to process safety education, as long as sufficient scientific observations are available to support the research [1].

Generation Z has been gaining popularity in recent years as they represent the new characteristics and behaviour of the current generation. Generation Z has grown up in a digital world that includes cellphones, the internet, social media, and online commerce. Generation Z has become a true digital native due to their living environment [11]. Because of Generation Z's changing needs and expectations, Instructors or lecturers must acclimate to the swift change of technology to overcome the challenge of teaching the students [29].

Engineering instructors had used many technology tools as their teaching aids. Gillett divided the teaching aid into four different categories — first, remote teaching, for example, videos and sound recording; second, models such as computerised models and laboratory experiments; third, dramatisations (e.g., films), role-playing, novels; fourth, automatic teaching systems (e.g., programmed learning and computerised teaching machines). Adapting these teaching aids can help students learn more and improve the classroom environment [8]. By adopting visual aids in the teaching and learning activities, the students could develop a more profound comprehension and understanding of the scientific principles [30].

Virtual Reality (VR) technology, which allows users to engage with a virtual computer-generated environment in total immersion, is another tool that educators can use to teach. One of the challenges faced by the educational institution in adapting VR technology into education was the unbearably high cost [31]. Fortunately, with the rapid development in computer hardware and software, VR technology has become more attainable in integrating into the teaching strategy. Researchers deduced that VR technology is a promising teaching strategy for engineering education and training [31,32]. Halabi also determined that VR technology can be used as an enjoyable learning tool for students and can be deployed without prior knowledge of the technology [33].

On top of that, the educational institution can also implement Augmented Reality (AR) technology in education. AR is another variation of VR [34] that allows users to interact with a "different" actual world improved by computer-generated perceptual data [35]. Thus, unlike VR that substitutes reality entirely, AR complements reality [7]. Gutierrez & Fernandez developed an AR tool to aid the mechanical engineering students in gaining knowledge of sketching, designation, and normalising standard mechanical elements [7].

Furthermore, instructors can gamify the learning material to make it a more exciting teaching aid, called gamification. Generation Z is being raised in an electronic world that recognises and embraces gaming [36]. Gamification can be a helpful teaching tool because it requires users (students) to choose, determine, and solve challenges that need mental and physical stimulation [36]. Students can quickly learn the outcomes of every choice they make, whether right or wrong, because they can get immediate feedback from the game. The feedback will serve an educational purpose when the game merges theory and practice into it [37,38]. Giving immediate feedback also enables the user to review their understanding independently. By attracting the students' focus, gamification can help them to concentrate on the given task [39,40] and then initiate their inner desire to learn [41]. Operant conditioning could be the reason why gamification is able to raise the students' interest [42]; If the player makes the correct decision, they will be rewarded, and if they make the wrong decision, they will be punished. Monash University Malaysia has used Kahoot to integrate game-based learning during the tutorial session [43] to encourage the participation of students in the classroom and promote active learning.

In conclusion, the use of technology tools as a teaching and learning aid can boost students' motivation towards the lessons, and as a result, they had had a better academic performance.

3. Methods

This study is divided into two main parts: the game's development and the study on the students' perception of gamification in learning process safety. Each part's methodology will be explained in detail in this section.

3.1 Game Development

PSQG (Process Safety Quiz Game) is a computer game created with Unity v2020.3.9f1 (a game development engine by Unity Technologies) [44]. Unity Technologies provided a free license for the usage of students. Figure 1 shows the interface of the software Unity.

The computer game is based on the original Nintendo game Pokémon, in which the player must roam the map region (Figure 2) and battle with various Pokémon and trainers to complete the task. Graphics, player controller, non-player character (NPC), process safety quizzes, and battle system logic are all needed to make this game. The adventurous nature of the Pokémon games and the turn-based combat battle system are inherited by this game. It lets participants plan their moves for each

turn of a conflict. Nevertheless, it is not appropriate for students to use a pure Pokémon-like game to learn process safety outside the classroom. Hence, quizzes were integrated into the game to add education functionality. The battle will start if the player encounters an enemy or talks to specific NPCs (trainer NPCs).

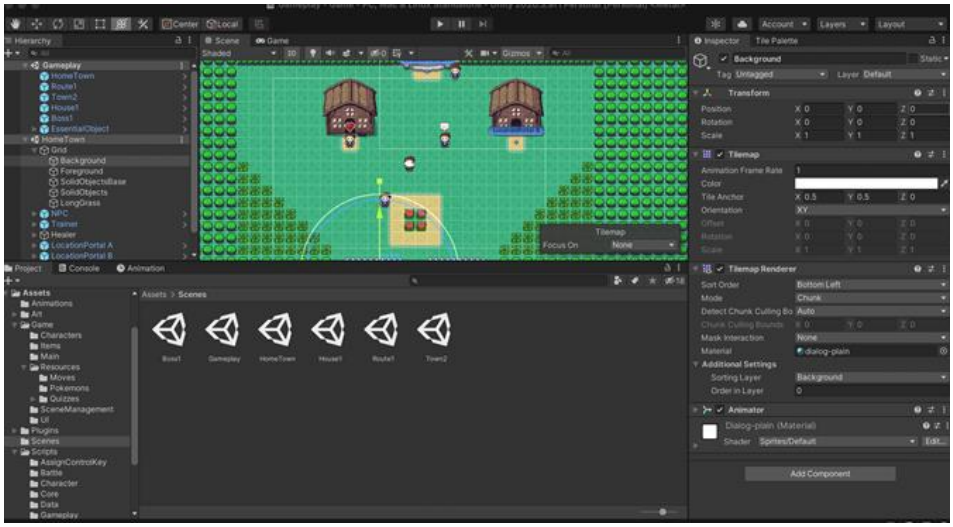


Fig. 1. Interface of Unity engine

This mechanism provides immediate feedback and rewards the player when a quiz is answered correctly. Likewise, there will be a punishment when answered incorrectly, following the operant conditioning principle. After defeating an NPC called The Boss, the game is completed (see Figure 2). The player can use the arrow keys to select an action and then confirm it by pressing the "Z" button. Otherwise, the player can hit the "X" button to cancel their current choice. If the player chooses "Fight," a quiz must be completed before dealing damage to the enemy. The reward to correctly answering the quiz is dealing extra damage to the enemy. The higher the correct streaks, the greater the damage dealt.

On the other hand, a wrong answer will result in dealing a zero-value damage. Other features in PSQG resemble those seen in Pokémon games, such as levelling up and collecting more Pokémon to keep the game from being purely a quiz game. The quiz questions were obtained from online sources and literature [45,46]. The expert then verified the compiled quizzes to ensure they were free of errors and that the game's content was suitable for distribution to the study's participants (students). The quizzes chose only to cover the basics of process safety management and major industrial accidents because the game was designed to be completed in half an hour.

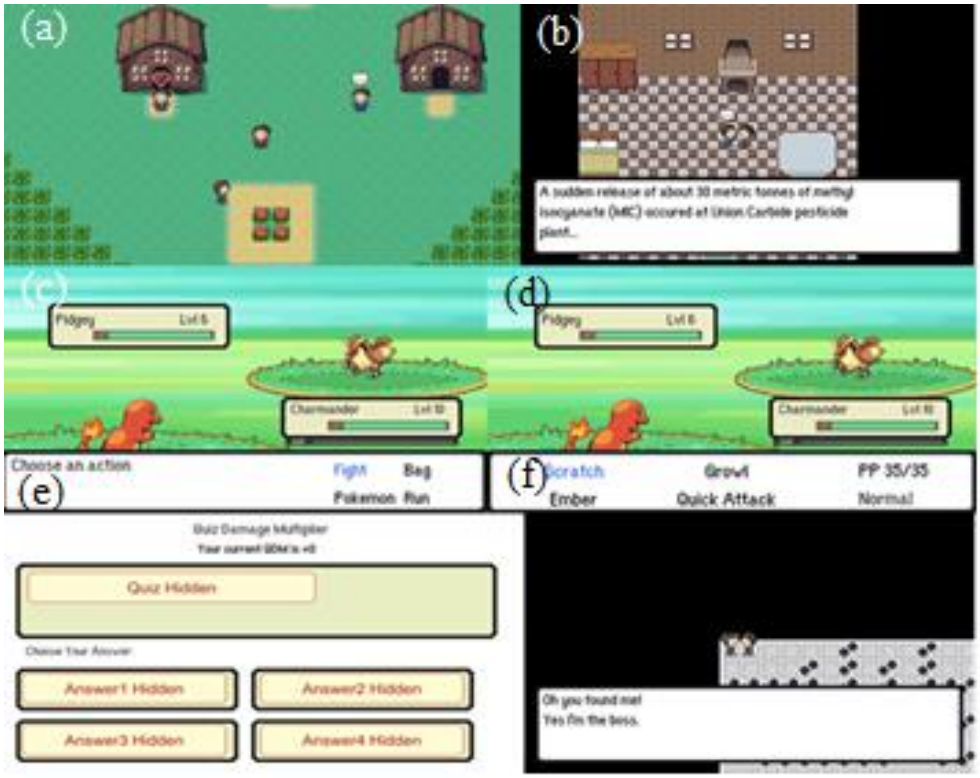


Fig. 2 (a) The interface of the map area (b) NPC is narrating the Bhopal incident (c) Action that a player can choose to perform (d) The game's interface if the player chooses "Fight" (e) The quiz's interface after the player picked a move. Answering the quiz is compulsory. No cancellation is allowed (f) The location of The Boss in the castle

3.2 Survey on Student's Perception (Questionnaires)

The students' information was gathered using questionnaires. Two questionnaires were created with direct replication from de Carvalho [36] and Gonzalez Rogado *et al.,* [47] for the participating students to fill out, one for pre-game and the other for post-game, to examine the influence of gamification on students in learning process safety. The questions were taken verbatim from the literature because the study's goal and theory are identical to the literature. Both the pre- and post-game surveys use a five-point Likert scale.

The pre-game survey consisted of 15 questions designed to learn about the students' interest in process safety, their perceived competency in process safety, and their motivation to play games.

Meanwhile, the 32-question post-game survey was designed to collect information on the following dimensions:

i. Interest in gamification of process safety
ii. Perceived competence
iii. Relevance to process safety
iv. Personal work methodology of the participant
v. Perception of the methodology used
vi. Risk prevention perception in the future work field

The personal work methodology dimension determines whether the participant comprehended the objective, found the game challenging, and agreed that its content is valuable for their future career [47].

3.3 Survey on Student's Perception (Competency Test)

This study solely relied on the students enrolled into unit CHE4161 – Engineer in Society. This study did not consider different levels of students' capability, gender, race, and ethnicity. This particular group of students was chosen for this study because they are currently learning process safety through a traditional method. The lecturers manage and govern the flow of information and knowledge. Similarly, these students study and revise through a textbook, lecture slides, and lecture recordings.

However, note that participation is voluntary. Hence, the signed-up participants could already be interested in gamification. Furthermore, because no knowledge assessments (pre-test and post-test) are included, this study only evaluates the students' perceived competency rather than their actual competency.

3.4 Survey on Student's Perception (Interest in Learning)

Participants were advised that their participation was entirely voluntary. The Monash University Human Research Ethics Committee provided formal ethical approval (MUHREC). All of the information provided by the responders was kept confidential.

4. Results and Discussion

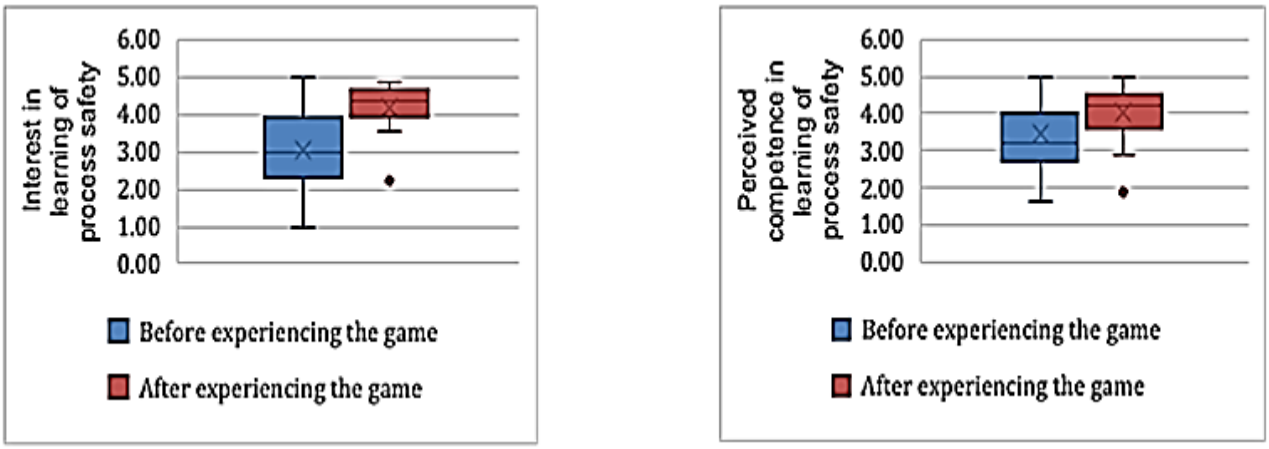
This study included 21 students who volunteered to participate and provided feedback on learning process safety via gamification. The responses provided by the students were organised into two classifications: "Perceived competence" and "Interest in the learning of process safety".

The pre- and post-game questionnaires' results were analysed to examine if there was a difference in students' interest in learning process safety and perceived competency before and after gamification. As shown in Table 1, participants' interest (N=21; Avg=3.01; SD=0.99) is considerably below value 5, showing that they neither like nor dislike process safety, but rather have a moderate attitude toward it. Participants' perceived competence was also poor (N=21; Avg=3.44; SD=0.91), reflecting low process safety self-efficacy.

Table 1
Descriptive statistic and inferential test for the contrast in interest and perceived competency before and after the game

Classifications	Average (Avg)	Standard Deviation (SD)	t-test (p value)	Wilcoxon test statistic (W)
Interest in learning of process safety (*before game*)	3.01	0.99	6.9×10^{-5}	11
Interest in learning of process safety (*after game*)	4.20	0.61		
Perceived competence in process safety (*before game*)	3.44	0.91	0.034	52
Perceived competence in process safety (*after game*)	4.02	0.74		

After the students partook in gamification and completed it, their interest and perceived competence greatly enhanced, as shown in Table 1 and Figure 3. This result is backed by the t-test p-value, which is lower than the significance level (α=0.05) and Wilcoxon test, W lower than its critical value (T = 58) [48], which showed that the result is significant.



(a) (b)

Fig. 3. The results of (a) participants' interest in process safety before and after partaking in gamification (b) perceived competence of the participants in process safety before and after partaking in gamification

Interest is believed to correlate with competence [14]. The outcomes of an investigation into the relationship between participants' interest in learning process safety and perceived competence were provided in this section. It's worth noting that this study only included 21 people and focused solely on their perceived competence. Figure 4 depicts how participants' perceived competence rises in proportion to their interest in learning process safety. This finding is consistent with Tracey and Kamp *et al.,* who found that students' achievement is positively influenced by their interest [14,49]. The pre- and post-game results show a link between process safety interest and perceived competence. All the p-values in Table 2 are less than the significance level (0.05), indicating that this result is significant. Furthermore, it is reasonable to establish that interest has a moderate to strong correlation with perceived competence depending on the Spearman coefficient [50]. This finding is in line with those of Rottinghaus *et al.,* [15]. Hence, the conclusion is that motivating the students' interest can increase their perceived competence in process safety.

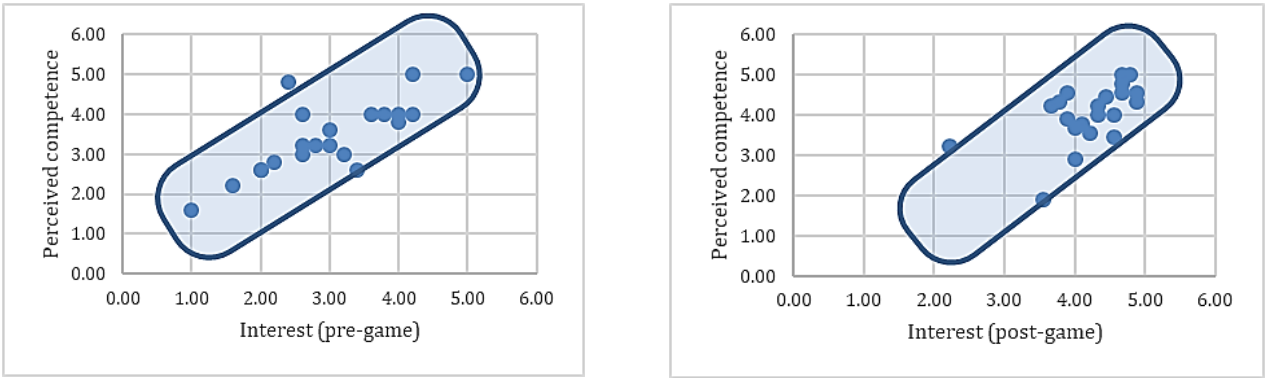


Fig. 4. Correlation of interest in learning of process safety and perceived competence of the participants

Table 2
Result for the correlation of interest and perceived competency evaluated through Spearman Rank test and Pearson test

	Pre-game	Post-game
N	21	21
Spearman ρ coefficient	0.73	0.61
$p_{Spearman}$ value	0.0002	0.003
Pearson r coefficient	0.77	0.56
$p_{Pearson}$ value	0.00004	0.009

Questions 15 and 17 investigated the game's relevance to process safety by analysing the results of post-game. According to participant's response, the content is accurate and suitable for engineering audiences to study process safety (Avg=4.62; SD=0.5). Learning process safety through gamification is also engaging, as per the participants' feedback (Avg=4.62; SD=0.5). As a result of this finding, gamification can be an interactive tool for learning process safety.

In terms of the participants' personal work methodology (no. 18 to 20), the plurality of participants comprehended the game's objective (Avg=4.71; SD=0.56) and agreed on the game's effectiveness in their future profession (Avg=4.38; SD=0.86). Although most participants stated the game was simple to play, just around a quarter of them said the content was complex (Avg=2.67; SD=1.20), highlighting that the game's complexity was moderate. More tough quizzes and real-life situational-based missions should be introduced to strengthen the educational functionality of the game.

When questioned about the participants' opinions of the methodology used, they stated that they could learn process safety on their own through gamification (Avg=4.52; SD=0.68) (No. 21 to 30). Because of the nature of the game, which can provide instantaneous feedback [37, 38] to participants and help them to determine if their decision was accurate (i.e., answered the quiz correctly), gamification has the potential to promote independent learning, in addition to incorporating learning materials within the NPC dialogue. More than 95% of participants (Avg=4.52; SD=0.93) claimed they liked this approach as a learning tool. This finding validates gamification's ability to promote independent learning of process safety outside of the classroom. Furthermore, a significant number of participants stated that gamification drew them in to continue playing and learning more about process safety (Avg=4.10; SD=1.22), which is consistent with the previous finding. Most participants also agreed that gamification helps them understand process safety better (Avg=4.24; SD=1.04). Table 3 shows some of the participants' qualitative feedback on the gamification of learning process safety. Most participants would favour gamification as a learning aid during self-study sessions.

Table 3
Qualitative feedback from the participants

Against	Support
• It is not practical since it takes time, but it is fun and may be used in self-study. • It gives only a smidgeon of motivation for non-gamers, but it is a game-changer for those who enjoy playing games.	• Capable of encouraging students to study in new ways. • It is an exciting strategy that increases time concentration and attention span. • Able to motivate learners creatively. • It is helpful because it grabs students' attention, piques their interest, and leaves a lasting imprint on what they have learned. • Add extra fun to the learning process with this excellent self-learning application that allows learners to learn at their speed. • Gamification is beneficial since it motivates students to learn because it is fun. • Gamification is beneficial since it engages students in learning and reduces distractions while playing the game.

5. Conclusion

A quiz-based game was made using Unity v2020.3.9f1 to increase students' interest in learning process safety and study outside the classroom. Simultaneously, the researchers utilised this game to see if gamification may improve students' interest in process safety and foster independent process safety learning outside of the classroom. It is also used to determine the correlation between students' interest in learning about process safety and their perceived competence in process safety. The t-test and Wilcoxon Signed Rank test results show that gamification can improve student interest. As students' interest increases, so do their perceived process safety knowledge. As indicated by Spearman's Rank Correlation and Pearson Correlation tests, students' interest in studying process safety appears to be connected to their perceived ability.

Students can study process safety independently at any time and from any location, thanks to the nature of a game that delivers immediate feedback. According to the post-game survey and participant comments, the majority of participants find the game an excellent self-study aid since it is entertaining, convenient, and straightforward to use. While some participants disliked gamification as a learning tool, they gave positive feedback on its application. Process safety was better understood by the participants in this study, allowing them to envision its implementation in their future job fields.

The study would require a larger sample size to validate the findings and produce a more accurate result. Apart from that, the research can be carried out with two groups of students, one as a control group and the other as an experiment group. University professors should teach the experiment group completely game-based learning with gamification. The game should cover all topics as in a conventional lecture in this situation. In addition, the game can combine more difficult quizzes with real-life scenario-based missions to teach students how to respond in an emergency. On the other side, rather than examining the students' perceived competency, the actual competency of the students might be investigated. During the evaluation of true competency, a pre-test and a post-test will be necessary to evaluate the competency of both groups of students.

Acknowledgement
Authors would like to thank Ir. Balaram (Monash University Malaysia), Mr. Athul (Game Dev Experiments) and Mr. Geigle (OSHAcademy) for providing their expertise and support in this study. The authors also would also like to express their deepest gratitude towards Monash University Malaysia for funding the study under the School of Engineering Final Year Research Project Fund.

References

[1] Mkpat, Effiong, Genserik Reniers, and Valerio Cozzani. "Process safety education: A literature review." *Journal of Loss Prevention in the Process Industries* 54 (2018): 18-27. https://doi.org/10.1016/j.jlp.2018.02.003
[2] Meyers, Robert A. "Encyclopedia of physical sciences and technology." *San Diego: Academic Press* (1992). https://doi.org/10.1016/B0-12-227410-5/00654-2
[3] Jasanoff, Sheila. "The Bhopal disaster and the right to know." *Social Science & Medicine* 27, no. 10 (1988): 1113-1123. https://doi.org/10.1016/0277-9536(88)90306-1
[4] Trager R. Fatal explosion at US chemical plant (Royal Society of Chemistry Report). 2020.
[5] El Sayed, Mazen J. "Beirut ammonium nitrate explosion: a man-made disaster in times of the COVID-19 pandemic." *Disaster medicine and public health preparedness* 16, no. 3 (2022): 1203-1207. https://doi.org/10.1017/dmp.2020.451
[6] Lim, Kok Hwa, and Chong Seng Teng. "University engagement to improve safety education." *Process Safety Progress* 40, no. 3 (2021): 12-17. https://doi.org/10.1002/prs.12241

[7] Gutiérrez, Jorge Martín, and María Dolores Meneses Fernández. "Applying augmented reality in engineering education to improve academic performance & student motivation." *The International journal of engineering education* 30, no. 3 (2014): 625-635.
[8] Gillett, John E. "Chemical engineering education in the next century." *Chemical Engineering & Technology: Industrial Chemistry-Plant Equipment-Process Engineering-Biotechnology* 24, no. 6 (2001): 561-570. https://doi.org/10.1002/1521-4125(200106)24:6%3C561::AID-CEAT561%3E3.0.CO;2-X
[9] Huang, Ta-Ko, Chi-Hsun Yang, Yu-Hsin Hsieh, Jen-Chyan Wang, and Chun-Cheng Hung. "Augmented reality (AR) and virtual reality (VR) applied in dentistry." *The Kaohsiung journal of medical sciences* 34, no. 4 (2018): 243-248. https://doi.org/10.1016/j.kjms.2018.01.009
[10] Hartt, Maxwell, Hadi Hosseini, and Mehrnaz Mostafapour. "Game on: Exploring the effectiveness of game-based learning." *Planning Practice & Research* 35, no. 5 (2020): 589-604. https://doi.org/10.1080/02697459.2020.1778859
[11] Vizcaya-Moreno, M. Flores, and Rosa M. Pérez-Cañaveras. "Social media used and teaching methods preferred by generation z students in the nursing clinical learning environment: A cross-sectional research study." *International journal of environmental research and public health* 17, no. 21 (2020): 8267. https://doi.org/10.3390/ijerph17218267
[12] Shatto, Bobbi, and Kelly Erwin. "Moving on from millennials: Preparing for generation Z." *The Journal of Continuing Education in Nursing* 47, no. 6 (2016): 253-254. https://doi.org/10.3928/00220124-20160518-05
[13] Williams, Cheryl A. "Nurse educators meet your new students: Generation Z." *Nurse Educator* 44, no. 2 (2019): 59-60. https://doi.org/10.1097/NNE.0000000000000637
[14] Tracey, Terence JG. "Development of interests and competency beliefs: A 1-year longitudinal study of fifth-to eighth-grade students using the ICA-R and structural equation modeling." *Journal of counseling psychology* 49, no. 2 (2002): 148. https://doi.org/10.1037//0022-0167.49.2.148
[15] Rottinghaus, Patrick J., Lisa M. Larson, and Fred H. Borgen. "The relation of self-efficacy and interests: A meta-analysis of 60 samples." *Journal of Vocational behavior* 62, no. 2 (2003): 221-236. https://doi.org/10.1016/S0001-8791(02)00039-8
[16] Crowl, Daniel A., and Joseph F. Louvar. *Chemical process safety: fundamentals with applications*. Pearson Education, 2001.
[17] Robbins, Jessica B., and David Sarkany. "Self-study: practical tips for a successful and rewarding experience." *Academic radiology* 24, no. 6 (2017): 721-724. https://doi.org/10.1016/j.acra.2016.10.015
[18] Liew, Chia Pao, Marlia Puteh, Shahrin Mohammad, Abdul Aziz Omar, and Peck Loo Kiew. "Review of engineering programme outcome assessment models." *European Journal of Engineering Education* 46, no. 5 (2021): 834-848. https://doi.org/10.1080/03043797.2020.1852533
[19] Sanders, Roy E. *Chemical process safety: learning from case histories*. Butterworth-Heinemann, 2015.. https://doi.org/10.1016/B978-075067749-3/50002-2
[20] DOSH Fatal Accident Case (Department of Occupational Safety and Health Reports). 2021.
[21] Chong, Heap Yih, and Thuan Siang Low. "Accidents in Malaysian construction industry: statistical data and court cases." *International journal of occupational safety and ergonomics* 20, no. 3 (2014): 503-513.
[22] Mannan, M. Sam, Sonny Sachdeva, Hao Chen, Olga Reyes-Valdes, Yi Liu, and Delphine M. Laboureur. "Trends and challenges in process safety." *AIChE journal* 61, no. 11 (2015): 3558-3569. https://doi.org/10.1002/aic.15019
[23] AIChE, Process Safety FAQs (The Global Home of Chemicals Engineer).
[24] U.S. OSHA 2000 Process Safety Management (US Department of Labor Occupational Safety and Health Adminstration)
[25] Krause, Ulrich. "Process safety in engineering education-pro's and con's of different approaches." *Chem Eng Trans* 48 (2016).
[26] Young, Clyde W., and Keith J. Hodges. "Process safety management mentoring: Subjects to convey and the methods for conveying." *Process Safety Progress* 31, no. 4 (2012): 350-354. https://doi.org/10.1002/prs.11529
[27] Board of Engineers Malaysia. Professional Engineer (Board of Engineers Malaysia). 2021.

[28] IChemE. Chartered Member (The Institute of Chemical Engineers). 2021.
[29] Moore, Kevin, Carol Jones, and Robert Scott Frazier. "Engineering education for Generation Z." *American journal of engineering education* 8, no. 2 (2017): 111-126. https://doi.org/10.19030/ajee.v8i2.10067
[30] Yu, Lih Jiun, Nai Yeen Gavin Lai, Chia Pao Liew, Jully Tan, and Se Yong AL Eh Noum. "Using web-based visual aids and assignment in enhancing student's learning in materials engineering course." In *2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, pp. 606-609. IEEE, 2020. https://doi.org/10.1109/TALE48869.2020.9368376
[31] Abulrub, Abdul-Hadi G., Alex N. Attridge, and Mark A. Williams. "Virtual reality in engineering education: The future of creative learning." In *2011 IEEE global engineering education conference (EDUCON)*, pp. 751-757. IEEE, 2011. https://doi.org/10.3991/ijet.v6i4.1766
[32] Lai, Nai Yeen Gavin, Kok Hoong Wong, Lih Jiun Yu, and Hooi Siang Kang. "Virtual reality (VR) in engineering education and training: A bibliometric analysis." In *Proceedings of the 2nd World Symposium on Software Engineering*, pp. 161-165. 2020. https://doi.org/10.1145/3425329.3425360
[33] Halabi, Osama. "Immersive virtual reality to enforce teaching in engineering education." *Multimedia Tools and Applications* 79, no. 3 (2020): 2987-3004. https://doi.org/10.1007/s11042-019-08214-8
[34] Azuma, Ronald T. "A survey of augmented reality." *Presence: teleoperators & virtual environments* 6, no. 4 (1997): 355-385. https://doi.org/10.1162/pres.1997.6.4.355
[35] Hayes A. Augmented Reality (Investopedia). 2020.
[36] de Carvalho, Carlos Vaz. "Is game-based learning suitable for engineering education?." In *Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON)*, pp. 1-8. IEEE, 2012. https://doi.org/10.1109/EDUCON.2012.6201140
[37] Schmitz, Brenda D., Susan L. MacLean, and Helen M. Shidler. "An emergency pursuit game: A method for teaching emergency decision-making skills." *The Journal of Continuing Education in Nursing* 22, no. 4 (1991): 152-158. https://doi.org/10.3928/0022-0124-19910701-07
[38] Henry, Joan M. "Gaming: A teaching strategy to enhance adult learning." *The Journal of Continuing Education in Nursing* 28, no. 5 (1997): 231-234. https://doi.org/10.3928/0022-0124-19970901-10
[39] Heinich, Robert. "Instructional media and technologies for learning." *(No Title)* (1996).
[40] Coller, Brianno D., and Michael J. Scott. "Effectiveness of using a video game to teach a course in mechanical engineering." *Computers & Education* 53, no. 3 (2009): 900-912. https://doi.org/10.1016/j.compedu.2009.05.012
[41] Ryan, Richard M., and Edward L. Deci. "The darker and brighter sides of human existence: Basic psychological needs as a unifying concept." *Psychological inquiry* 11, no. 4 (2000): 319-338. https://doi.org/10.1037//0003-066X.55.1.68
[42] Sheth, Swapneel, Jonathan Bell, and Gail Kaiser. "Halo (highly addictive, socially optimized) software engineering." In *Proceedings of the 1st International Workshop on Games and Software Engineering*, pp. 29-32. 2011. https://doi.org/10.1145/1984674.1984685
[43] Monash University. Three online interactive tools, two workshops, one goal (Monash University Reports). 2016.
[44] Unity 2021 (Unity Student)
[45] OSHAcademy. OSHAcademy Course 736 Study Guide: Introduction to Process Safety Management, (Beaverton: Geigle Safety Group, Inc). 2020.
[46] NEBOSH. UNIT NGC1: Management of Health and Safety (NEBOSH). 2018.
[47] Rogado, Ana B. González, Ana María Vivar Quintana, and Laura Lavandero Mayo. "Evaluation of the use of technology to improve safety in the teaching laboratory." *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje* 12, no. 1 (2017): 17-23. https://doi.org/10.1109/RITA.2017.2655179
[48] Sani, Fabio, and John Todman. *Experimental design and statistics for psychology: a first course*. John Wiley & Sons, 2008. https://doi.org/10.1002/9780470776124
[49] Kamp, Rachelle JA, Diana HJM Dolmans, Henk JM van Berkel, and Henk G. Schmidt. "The relationship between students' small group activities, time spent on self-study, and achievement." *Higher Education* 64 (2012): 385-397. https://doi.org/10.1007/s10734-011-9500-5

[50] Akoglu, Haldun. "User's guide to correlation coefficients." *Turkish journal of emergency medicine* 18, no. 3 (2018): 91-93. https://doi.org/10.1016/j.tjem.2018.08.001