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Exploring gamification approach in hazard identification training for Malaysian construction industry

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ABSTRACT

In recent years gaming products have increasingly been used to enhance learning and training development in academic and commercial sectors. Games have become more pervasive; they have been adopted for use in many industries and sectors such as defense, medicine, architecture, education, and city planning and government as tools for workers development. In Malaysia, it has been reported that the construction industry holds the third highest record of occurrences of accidents at work. Therefore, safety training is inevitable to reduce the alarming rate of accidents on construction sites. However, currently, available safety training approaches are still lacking in terms of delivering hands-on training and are more theoretical-instead of being more practical-based. This is due to the nature of the construction environment itself in which safety training involving certain hazards that cannot be implemented hands-on as it may bring harm to trainers, trainees and the environment. Gaming is an approach that applies technology to provide an almost real experience with interactive field training, and also supporting the theory of learning by doing with real case scenario. The purpose of this paper is to seek and explore the differences in existing gamification genres such as simulation game, role-playing, action game, strategy game and etc. Data were collected through available literature. The findings of the study show that serious game is a suitable genre to be adopted as an approach in hazard identification training for the construction industry in Malaysia.

1. Introduction

Construction industry is known as the 4D industries: Dirty, Dangerous, Dark and Death (Bakri et al. 2006). According to the Department of Occupational Safety and Health Malaysia (DOSH), the construction industry in Malaysia has recorded the third highest accident rate after manufacturing and agriculture. Due to this concern, Construction Industrial Development Board (CIDB), National Institute of Occupational Safety and Health (NIOSH) and other related agencies through government initiatives provide trainings to increase awareness and enhance knowledge on safety among key players in the construction industry. Various types of training have been carried out such as induction, on-job training, competency, seminar, and forum (Mohd & Ali 2014; Mansur & Peng 2009). However, the approach taken to deliver these training sessions remain the same for years i.e. lectures, video demonstrations and hands-on. Apart from competency training, other types of training allocate less attention on hands-on approach. Undoubtedly, safety trainings require more hands-on or practical-based approach, but the nature of hazards itself restricts the implementation of practical-based approach in real-life situation.

According to Goetsch (1993) one of the fundamental principles for learning is "learning by doing", emphasizing on adequate hands-on learning opportunities for learners. As a result, some researchers have explored other methods to improve the delivery the safety training especially on the usefulness of technology to create safety training modules (Xie et al. 2006; Ho & Dzeng 2010). By using technology, training has become more flexible in terms of time management, cost and experience (Qin et al. 2016). However, advanced technology such as Virtual Reality (VR) requires some high-end hardware and software which can be costly and limited to researchers who have access to this technology because of the availability of funding for their research (Ebersole 1997). Hence, as highlighted by Filigenzi et al. (2000), there is a need for affordable technology. Affordable technology is a technology that can be developed using a simple software but is able to give the same experience offered by other more advanced and expensive applications such as web-based training, learning via CD-ROM and games (Charsky 2010)

Simulation using gaming approach is more productive and its advantages have been proven in terms of cost and retention of knowledge compared to conventional classroom teaching (Kirriemuir & McFarlane 2004). This is because by actively participating in the learning process, learners take charge of their own learning by observing and "doing". Learners are more likely to retain the knowledge by at least 30% and the percentage may even reach 90% (Goetsch 1993). Gaming is an approach that applies technology to provide a near real experience with interactive field training, and also supporting the theory of learning by doing with real case scenario (Assfalg et al. 2002). For example, in New Zealand transportation department used affordable technology to develop a simulation of driving to measure the awareness and decision making among those new drivers in identifying hazards (Isler & Isler 2011). At the Department of Construction Management, the University of Washington, students were introduced and exposed to a 3D-video game system developed for safety education (Teizer et al. 2013). In Ireland, a simulation game known as MERIT (abbreviated from

Management, Enterprise, Risk, Innovation and Teamwork), originally developed by Loughborough University in the UK, was integrated into the blended learning module to accommodate the needs for Continuing Professional Development (CPD) among construction professionals (Wall & Ahmed 2008). In Malaysia, Virtual Simulated Traffics for Road Safety Education (ViSTREET) has been designed by three researchers from Universiti Malaysia Sarawak for use in teaching and learning of road safety curriculum to schoolchildren aged 12 to 14 (Chuah et al. 2009). However, safety training in construction within the Malaysian context has yet to adopt a game-based VR approach.

2. Why gamification approach?

The definition of the games is interpreted differently by many authors. Wilson et al. (2009) described game by listing their structural components such as dynamic visuals, interaction, rules, and goals while Charsky (2010) described game according to the essentials of the game such as stated task, the player roles, the multiple tasks to the goal, and the degree of player control. 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 better interactive approach in context of delivering complex or boring learning content (Prensky 2005). As noted by Whitton & Moseley (2012), game can also enhance the process of learning in terms of playfulness, practice and engagement. This statement has been supported by Gee (2005) who holds the belief that games are designed in a way that triggers a deep motivation for learning. The vast majority of electronic games provide a highly structured environment with tutorials for players who are new to the game. Such games often break down complex tasks into smaller and more manageable tasks, which cater for the individual pace of each player and give immediate and continuous feedback along the way (Gee, 2005). Moreover, electronic games often require players to formulate the content and evaluate hypotheses, experiment with the outcome, which is a cycle of activities that are closely related to the learning process defined as 'experiential learning' (Perryer et al. 2016).

3. Methodology

A deductive approach is based on an earlier theory or model and therefore it moves from the general to the specific (Wilson et al. 2009). It only can be carried out when the structure of analysis is operationalized on the basis of previous knowledge (Wilson et al. 2009). For this study, the content components that need to be analysed consist of phrases, concepts, theories and the characteristic which fall under objectivity outcome. This outcome only pursues the basic of context, which the results obtained will remain the same from each document or message (Wilson et al. 2009). Pre-determine coding to extract the findings.

Hence, for this study the deductive content analysis study was carried out to distinguish the type of gamification genres. The keywords and the benefit from both generated to analyse the content of the study. Besides that, attributes of the serious game are ascertained through the review from previous studies. However, these attributes need to be incorporated into the nature of construction safety training. Then, it is important to conduct the content analysis as an approach for the researcher to make an observation about the implicit messages that are conveyed. Therefore, the analysis was conducted based on the five steps of deductive content analysis (Figure 1).

The Web of Science and SCOPUS database were used to search the relevant research article articles consist of the report, journals and proceedings from 1994 to 2018. The identified articles were sorted

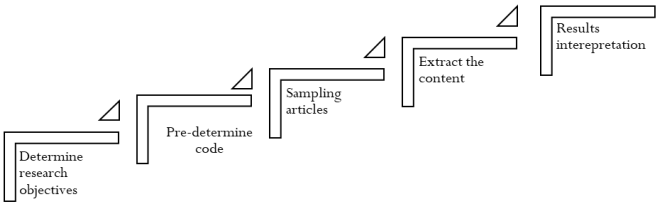

Figure 1 *Step model of deductive category application*

through three phases searching for example types of gamification genre, purpose, training or learning and application in industry. Hence, the after reading, the relevant article is brought together according to the following topic [1] Types of game genre (15 articles), and [2] Types of Serious game (10 articles). Even though, the sampling is small, according to Uribe & Manzur (2012) the sampling size range between 6 to 12 enough to carry out content analysis study.

4. Findings

4.1 Types of game

Gaming approach provides a competitive environment for players to achieve their goal (C Girard et al. 2013). It also emphasizes first, learning what to do, then how to do it. Using gaming approach can allow individuals to discover what they have to do in the game, not what they should do, by experiencing themselves (Kirriemuir & McFarlane 2004). This approach will guide the discovery method of training that empowers individuals to solve the problems that arise in the game, which become a part of the training process. However, to identify gaming approach that is suitable to be adopted as a training tool is quite complicated. Table 1 below shows the types of games genre approaches that are available in the game industry.

Even though there are various types of game genre, in this paper, only related genre which are suitable for training and expected to be adopted in hazard identification training module will be discussed. Based on all attributes on simulation games shown in Table 1, it is viewed that simulation game, adventure game and serious game are suitable to be adopted in hazard identification training module. Simulation games attempt to mimic the environment that presents reality as a method of learning. They can be defined as representations of some real-world environment or imitation of a system and process that also have aspects of reality for the participants (Ranchhod et al. 2014). On the other hand, adventure games can be described as story-based games that usually rely on puzzle-solving to move on along the action in a continuum as players proceed from one level to the next (Michael & Chen 2006).

Meanwhile, serious games have several terms that describe the approach used, for example, game-based learning and or game-based training. This approach has been used and discussed for over four decades. Many authors have their own perceptions to define the meaning of serious games. For instance, Michael & Chen (2006) in his book entitled, "Serious Game" concluded serious games as ones that had an explicit and carefully thought-out educational purpose but not intended to be played primarily for amusement. Girard et al. 2013) defined serious games as "digital games, simulations, virtual environments and mixed reality/ media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning" (p.210). Based on the definitions given, it shows that the only difference between these gaming approaches lies on their intents and purposes. Thus, in order to distinguish between simulation, adventure game and serious game, a review of related literature was conducted. Evaluation was made based on the purpose and the

Table 1 *Summary of Distinguishing between types of games approaches*

Genres	Attributes				
	Purpose	**Focus**	**Design**	**Essence**	**Example**
Adventures Game (Prensky 2001)	Problem-solving	Command	Large, complex world, interesting character and good story	Story, Puzzles, Interface & Exploration	King's Quest Monkey Island
Action Game (Garris et al. 2002)	To keep player moving and create an adrenaline rush	Quick tactical thinking on fly	First-person game Third person games	Weapon Engine	Tomb Raider Deus Ex
Role-Playing game (Etienne 2003)	To polish skills and get an immersive experience	Character attributes and skills		Story Character Combat	Unreak2: XMP
Strategy Game (Michael & Chen 2006)	To manage limited resources to achieve goal	Balancing		Resources, Teams Weapons, Artificial Intelligence (AI) & Mission	Command & Conquer
Simulations Game (Crookall 2010)	To fulfil layer's fantasy that cannot be done in real life.	Rich experience		Interface	NASCAR Racing 3
Sports Game (ASEP 2013)	To fulfil player's fantasy to become	Emulating an athlete's action	Animation Original rules of the sport	Motion Interface	Sydney 2000
Fight Game (Michael & Chen 2006)	To create quick bursts of swift and intense action	Simple, direct and very engaging	great graphics, Graphic effect Sound effects Easy move	Character Weapon	Mortal Kombat Deception
Casual Game (Michael & Chen 2006)	Easy to learn but not difficult to master	Strategic decision and enhanced level of skills	Simple Uncluttered interface	Rules	Who wants to be a millionaire Hear, Solitaire, Poker
God Game (Michael & Chen 2006)	To push player to choose his own path.	Decision making	Simple interface	Compelling activities Variety of choice	Sim City
Educational Game (Schrader & Bastiaens 2012)	To teach a specific body of knowledge	Transferring knowledge	Simple interface Engage emotion Interactivity	Goal Target group Reward	Reader Rabbit Oregon Trail
Serious Game (Gomes et al. 2013)	To learn by doing and transferring knowledge	Rich experience and on problem-solving		Story, art, software & pedagogy	Military
Puzzles Game (Michael & Chen 2006)	To allow players to challenge himself	Creative thinking	Simple interface	Problems Hints to solution Fun	Heaven & Earth Law & Order
Online Game (Derryberry 2007)	Depend on the type of game	Depend on the type of game	Long-term commitment Character	Internet	Declaring the right of the avatar Counterstrike

elements of each game.

4.2 Element of game and game purpose

As mentioned in the previous section, classification of games in gaming environment can be categorized according to their intents and purposes. Simulation game, adventure game and serious game have been applied in a gaming environment for education and training purposes. Simulation game has the potential to be applied in vocational training. As such, it has been adopted in many industries for CPD and training. It provides the appropriate learning environments that mimic reality and is often designed to engage the learners in situations that would be too costly, difficult or hazardous to be implemented in the real world (Gredler 1996). One of the advantages of simulation is that it can promote strategic thinking by using repetitive learning methods (Bonk & Dennen 2005).

Conversely, for adventure game, its purpose is problem-solving which focuses on giving commands or instructions. This kind of game genre will train player to give commands or instructions to solve arising problems. Commands or instructions can be given in textual or graphical forms and can be communicated from either a first-person, second-person or third-person perspective (Michael & Chen 2006). In general, adventure game is not played in real time, unless it is an action-adventure hybrid game in which a player usually takes as much time as he wants between turns, and nothing happens in the game environment until he enters a command. More modern adventures are points-and click, in which a player indicates what he wants to do by moving the cursor using the mouse around the screen. Players generally expect adventure games to have large, complex world to explore along with interesting characters and a good storyline. This is a mental contest game that follows certain rules and sometimes rules can be broken for amusement, recreation, or winning a stake (Ulicsak & Wright 2010).

Serious games tend to be linear; the issues, problems and situations are always similar. The focus of these games is to train players on planning and decision-making strategies (Yee Leng et al. 2010). They also tend to be more complex because of their nature being more immersive and focused on strategizing. However serious games are more structured and well designed to allow learners to experience and practice their knowledge that are likely impossible to be done in the real world because of safety concerns as well as cost and time constraints (C Girard et al. 2013). As pointed out by Mitchell & Savill-Smith (2004), well designed computer games can enhance a wide range of skills from psychomotor and spatial to analytical and strategic, and gain insights into learning and recollection capabilities, as well as increase visual selective attention.

For simulation, the design criteria must have some focus, specific and systematic steps. It is an immersive and complex approach that allows players to relate and apply their existing real-life knowledge in the simulation. For adventure game, the structure is also complex and heavy design because it wants to entertain, amuse and get the attention from gamers who want to challenge themselves by moving on to the more difficult levels and ultimately win. On the other hand, serious games are designed to give a real experience and hands-on training based on the real situation, so that the players can have a positive impact and further developed their skills.

Serious games are referred to as the type of games when the focus of

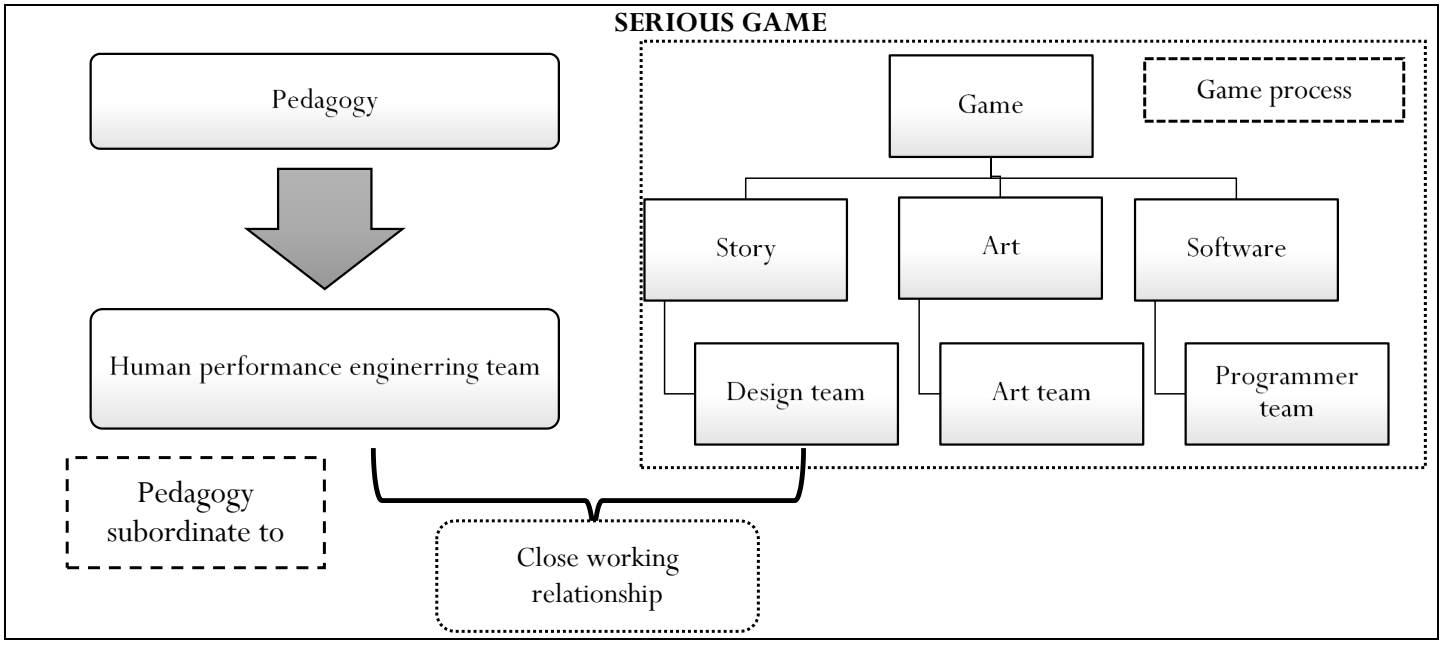

Figure 2 *Concept changes from game to serious game taken from (Zyda 2005)*

such games is for training, advertising, simulation or education. This is because when comparing serious games with other computer or video games, serious games are not only about the story, art and software, but they are beyond that. They have the addition of pedagogy which means that in serious games, there are activities related to education from which players gain knowledge and skills (Zyda 2005). However, pedagogy element must be supported by other elements i.e. art, story and entertainment. Figure 2 shows how serious game works. For the video game to change to a serious game, it needs to include pedagogy to infuse instruction into the gameplay experience.

The above concept has been supported by Martens et al. (2008). They believe that serious games require a game, simulation and learning aspect in almost equal measure. According to them, it is argued that without combining pedagogy or learning goals, the game only becomes a simulation and a game without simulation becomes a simple one with a simple format like an edutainment game (Martens et al., 2008). If gameplay and mechanics are omitted, this will result in a training simulation. Figure 3 shows how the pedagogical elements interplay with computer sciences and games.

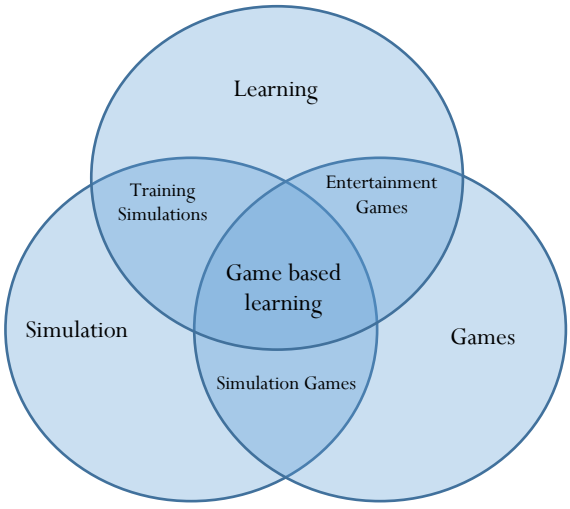

Figure 3 *Interplay of learning, simulation and games (taken from Martens et al., (2008), p.174)*

Table 2 *Summary of distinguishing between the types of game genres*

TYPE OF GAME	CRITERIA		
	Purpose	**Focus**	**Elements**
Simulation game	Training skills	Rich experience	Story, art, software
Education game	Problem-solving	Command	Story, art, software
Serious game	Learning by doing and transferring knowledge	Rich experience and on problem-solving	Story, art, software & pedagogy

Hence, to distinguish between adventure games and serious games, the elements of pedagogy must be added together with three main elements of computer games which are story, art and software (Zyda, 2005). Table 2 shows that the summary of different types of games approaches which were discussed earlier.

As a result of the earlier discussion, it can be concluded that serious games offer various approaches and benefits as a training tool. With the elements of pedagogy, serious games provide the users with an objective that they want to achieve. The relevant objectives that relate to their business or situation will encourage them to achieve the objectives. Besides that, a serious game also presents information as nested problems through the story elements which can be designed according to the needs of the user. This will give the user motivation to complete the objective. In spite of this, the user has to actively get involved in the scenario to work out how to achieve the objective. Serious games can also utilize interesting characters and reward loops to keep user pushing forward, which will lead the user to immersive into the scenario and become emotionally invested in seeing it through.

4.3 Serious game

Serious game "is all about leveraging the power of computer games to captive and engage end-users for a specific purpose, such as to develop new knowledge and skills" (Corti (2006), p.1), which highlights the usefulness of technology in delivering knowledge and skills. Serious games can enrich learning and development in both commercial and academic sectors. Besides that, Backlund & Engstrom (2007) argue that by training using serious games, the learners will have an advantage over a real investigation for example in fire safety training, because learners are able to explore multiple outcomes for particular actions as

Table 3 *Summary of types of serious game (Sawyer & Smith, 2008)*

Types of serious game	Purpose	Example of game
Advergames	To increase recruitment	*Army Game*
Edutainment	Entertainment game to be educational	*Oregon Trail* and *Math Blasters* - teach kids history and math
Game-based Learning	to retain and apply said subject matter to the real world	*Historia* – learning history
Training and Simulation Games	to teach effective behaviour in the context of simulated conditions have or situations	*Microsoft Flight* - Simulator developed as a comprehensive simulation of civil aviation.
News games	to convey some kind of interactive news or editorial content	*Darfur is Dying* - An online game by mtvU That simulates life in a Darfur refugee camp
Persuasive Games	to change attitudes or behaviours of the users through persuasion	*Colorfall* -Created with Humana Games for Health to Promote a healthy life.
Organizational-dynamic	For furthering personal development and character building	*Houthoff Buruma* developed by Dutch law firm Houthoff Buruma.
Games for Health	Educate people regarding health matter	*Funphysio*: This game helps patients in physical therapy treatments.
Edumarket	combine several aspects or goals	*Food Forces*: combines news, persuasive and edutainment goals

opposed to being forced to choose only one 'final' action. This approach has been linked to better learning outcomes (Gee, 2005).

Sawyer & Smith (2008) have identified nine types of serious games, classified according to their purposes: [1] Advergames, [2] Edutainment, [3] Game-based Learning, [4] News games , [5] Training and Simulation Games, [6] Persuasive Games , [7] Organizational- dynamic, [8] Game for Health and [9] Edumarket (educational games that are available in the market). Table 3 shows the summary of types of serious games.

Thus, for the purpose of this research, Edumarket game is proposed to be adopted in developing hazard identification training module. Combination between Advergame, Game-based Learning and Training and Simulation game will fulfil the requirements of the hazard identification training module which are to advertise, attract and transfer knowledge among construction workers.

5. Serious game for hazard identification training

Hazard identification training is a part of the Hazard Identification Risk Assessment and Risk Control (HIRARC) training module in NIOSH module of training (NIOSH 2017). The purposes of this training are 1) to train construction workers in identifying unsafe act and unsafe condition that exist in the working environment; 2) to train their action toward hazard; and, 3) to train decision-making skills in handling hazard wisely. This training should be done visually and hands-on so that the consequences of the decisions made can be seen and will remain accessible. Such consequences will make trainees become more cautious while carrying out their tasks. However, hazard itself is harmful. Therefore, to apply hands-on approach in training is sometimes almost impossible in real life because this will expose the trainees, trainers and the environment to risks. Therefore, serious game approach can be a practical solution.

The attributes of serious game which offer a visual training with a real based scenario allow construction workers to train and apply their knowledge without unnecessary harm. Due to the nature of the construction industry, a simulated training with the real people and hazard simply just for training purpose is very unlikely. This is where serious games can become the missing link between knowledge and hands-on training. Serious games enable users to practice their skills using "trial and error" approach with their own existing knowledge and experience (Hess & Gunter 2013) . By using serious games, users actually can see the consequences of their action and decision without getting harm or injured (Backlund & Engstrom 2007). The environment in serious games is also safe for training workers who will be able to practice their skills in a realistic environment and minimize human errors that construction workers will make in real world (Lin et al. 2011).

The pedagogy elements make learning more effective in training decision-making and problem-solving skills in handling hazard wisely. These elements also will be used as guidelines in designing a serious game to appeal to the users and trigger their minds by following the ways of user nature of learning (Harteveld & Guimarães 2007). In this case, the module will apply the experiential learning theory. By using serious game approach, hazard training becomes more flexible in terms of time, cost and health. Table 4 shows the compatibility between serious game and hazard training.

6. Conclusion

The nature of the construction environment requires a new approach to safety training to identify on-site occupational hazards. Serious games have the capability to achieve specific learning objectives by combining the gameplay, simulation and also learning theory. Serious games also offer a flexible approach that enables hands-on, active learning in a safe environment simulated to mimic a real-life situation at the workplace

Table 4 *Compatibility between the natures of hazard identification training vs. serious game*

Nature of hazard training / Criterion of serious game	Harmful	Need to experience	Hands-on training	Problems solving	Decision making
Visual (Abt 1968)	X	X	X		
Immersive (Susi et al. 2007)		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)		X	X		
Pedagogy (Harteveld & Guimarães 2007)				X	X
Decision making (Hulst & Ruijsendaal, 2012)				X	X

which is also cost-effectiveness for training purposes. It is anticipated that the development of such a blended training module will be of great significance to safety training among construction workers in handling occupational hazards. This is because by developing serious games to be used as a tool for training, these workers can be trained to make wise decisions in handling hazards in a virtual environment that is close to reality at the workplace. More importantly, this approach is not only safe and affordable but also very interactive and entertaining, which can be made available anytime and anywhere.

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