

Engaging students in OH&S hazard identification through a game

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ABSTRACT

The Construction Industry has one of the highest rates of injury and fatality in Australia and across the world. To address this in Australia, everyone who intends to work on a construction site must complete a Construction Induction course. As Construction Students tend to be experiential learners, class room teaching is often not engaging for them. This paper describes a computer game that was developed as a classroom activity to motivate Construction Induction students to learn about hazards on construction sites and their management via application of OH&S controls. We used a test, a questionnaire and interviews to assess if contextualised game playing improved engagement supported learning and assisted with application to real world situations. Our preliminary results show that the students who played the game were engaged, and felt that through playing the game they increased their knowledge about hazards on construction sites and reinforced the learning of the material presented in the classroom. The data collected to date however does not show strong evidence that game playing made the students statistically better at recognising hazards in pictures depicting real world situations.

Keywords

Serious Games, Occupational Health and Safety, User Experience, Engagement, Learning and Teaching, Construction Industry, Hazard Identification.

INTRODUCTION

The construction industry is one of the largest employers worldwide; in Australia the construction industry represents 9% of the Australian workforce. However, it is one of the industries with the highest rate of fatalities and serious injury claims. Within the time frame of 2009 - 2011, 11% of all serious workers' compensation claims occurred in the construction industry. Despite the rate of serious claims in the industry reducing, the rate remains much higher than the rate for all industries (SWA 2012).

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In an attempt to reduce this impact, most jurisdictions in Australia now require manufacturers and designers to design for safety in construction and use of buildings and plant (SWA 2012). However, “it is almost impossible to identify all hazards before the start of construction” (Li, Chan, and Skitmore 2012). Thus, it is critical that construction personnel are trained to identify hazards on sites and to react appropriately to control those hazards.

The Australian National Occupational Health & Safety (OH&S) Strategy 2012-2022 (SWA 2012) suggests that in order to improve Work Health and Safety Capabilities, work health and safety skills development should be appropriately and effectively integrated into relevant education and training programs (SWA 2012). Since human lives depend upon the performance of trainees (Anderson, Aylor, and Leonard 2008), the need for effective training has been identified to prevent avoidable injuries in the future (Lauriola et al. 2000). A critical success factor that influences the effectiveness and appropriateness of training, is the engagement of learners (Prensky 2001; De La Harpe and Peterson 2009).

The construction industry and its regulator, the Office of the Australian Building and Construction Commissioner, have established compulsory Construction Induction training for everyone intending to engage in construction work. This training provides, *inter alia*, guidance about the common hazards on construction sites and their management, and corresponds with the learning requirements of the Australian Certificate I in “Work safely in the construction industry” (CPSISC 2011).

There are a number of ways by which the Construction Induction training material is presented to students. Many organisations offer the training face to face, consisting of a mix of lecture presentation, videos and text based materials with pictures. Anecdotal evidence, however, indicated that students were often disengaged in the course, which raised questions about the engagement with the course content and the student’s learning (Greuter et al. 2011).

Occupational Health and Safety training is also offered online. While online training provides the learner with the flexibility to progress through the content at a speed that best suits the learner, most online courses do very little to engage the learner. For example, a study into work-related fleet safety found that 91% of staff failed to complete online safety training (Rowland, Watson, and Wishart 2006). The drivers interviewed indicated that a major problem was a lack of engagement, with one person bluntly stating “it was so f***ing boring, I didn’t finish it...I just told my supervisor I did” (p.8).

In this project we developed an electronic game called 'Trouble Tower' in consultation with experts in Electronic Games, OH&S and Construction. Through user testing we are assessing whether contextualised game playing improves the motivation of students to engage with the OH&S content and if the game playing supports the learning of required knowledge and skills. The project also aimed to assess the student's ability to transfer the knowledge and skills learned in the game, to real world situations. User testing is still ongoing. This paper reports the preliminary findings.

LITERATURE REVIEW

Learning is often defined as a modification of behaviour by experience (Encyclopædia Britannica Online 2013). Constructivism is a theory of learning which explains that people create meaning of the world around them through a series of individual constructs.

These constructs are created based on the person's own individual perspective of the world and is dependent on prior experiences and pre-existing schemata that are constantly revised and re-structured in an active process based on the situation (Bruner 1966). John Dewey (1972), who articulated many of the key ideas of constructivism emphasised that learners should be active participants in their learning environment and highlighted the "unique and individual nature of interaction in the learning experience". Learners therefore need to be engaged in active and interactive learning activities to better construct their own knowledge and understanding, rather than being passive 'receivers' of information (Prensky 2001; De La Harpe and Peterson 2009).

Games are well known for their engaging interactive experiences. Gee (2012) states that games are about "doing, making decisions, solving problems and interacting" and that the content often only facilitates "acting, deciding, problem solving, and interaction". To engage in this kind of interaction, players need to formulate hypotheses, experiment with the content and evaluate the outcome, which is a cycle of activities that is closely related to the learning process defined as 'experiential learning' (Kolb 1984) and linked with better learning outcomes (Gee 2005; Whitton 2010).

From an educational point of view, Prensky (2001) suggests that electronic games are useful in situations where learning may be perceived as complex. The vast majority of electronic games provide a highly structured environment with tutorials for players that are new to the game. Such games often break down complex tasks into smaller more manageable tasks that cater for the individual pace of the player and give immediate and continuous feedback along the way (Gee 2005). Gee (2012) similarly states that games constantly assess players and that game designers have found a mechanism to make learning and constant assessments fun for people, which is why games may be useful in situations where learning may be perceived as boring (Prensky 2001).

Mihaly Csikszentmihalyi's concept of Flow is a very popular model to explain the experiences that are often associated with fun in games. Csikszentmihalyi (1990) defines 'flow' as an experience in which players become so immersed and engaged in the game that time and place become unimportant. This state is achieved through a balance of skill and challenge that focusses the player's attention, engagement and motivation into an experience of fluid gameplay that is intrinsically psychologically rewarding for the player. Flow in games has been used in explanations for why learning games have the potential to be effective (Murphy 2011).

Initial studies show promise that games may be used to improve safety training (Power 2009; van Wyk 2006). For instance, Van Wyk (2006) discusses the design and implementation of an Immersive Learning Simulation for miners' safety training in South Africa. However, the design, development and evaluation of 3D Learning Simulations are at a primary stage of evolution (Whitton 2010). These immersive learning simulations are often highly specialized to a particular training need, require experts to calibrate the equipment and specialised facilities that are not easily accessible with a large number of students.

Dalgarno and Davies (2009) report that learners perceived Serious Games to have an advantage over real investigation, particularly for fire safety training. The learners commented that they were able to explore multiple outcomes for particular actions as opposed to being forced to choose only one action. This approach provides learners with choices to create their own learning pathways, providing cognitive flexibility (Spiro et al.

1992) and a more adaptive approach to learning (Wolf 2007). This finding also aligns with situated learning theory (Spiro et al. 1992), which highlights the need for learning environments to create authentic and contextualised experiences for the learner.

In a study based on 164 students in New Zealand, who were enrolled in a variety of courses leading to careers in the construction industry, students tended to be surface learners with a lack of motivation to complete a course of study, and with limited individual responsibility for their learning. These same students preferred activity-based classroom teaching in a peer learning environment with a high degree of instructor monitoring to check on their progress. The students also prefer structured course content and assignments that are presented graphically with little text (Harfield et al. 2007). These were the students for whom we developed this game.

METHOD

The aim of Trouble Tower was to provide a mechanism to increase the student's engagement with the OH&S course content in the Construction Induction (CI) course and to assist players to recognise hazards on construction sites. To determine if this aim was achieved, the game was tested with students attending the CI course at RMIT.

The CI training was delivered in an interactive lecture format supplemented by multimedia. The unit about the hazard identification also made use of a cartoon style drawing where students identified hazards as part of a classroom activity.

Participants

The user testing to date was conducted on students from the Property and Construction Management TAFE program who attended the Construction Induction course at RMIT University. The sample so far comprised more male (90) than female (7) students. The participants to date ranged in age between 18 and 30, although the vast majority (~87%) of participants were in the 18-22 year age range. All students who participated in the game test were male.

The Game

The Trouble Tower game was designed as an activity for the construction induction training course and addresses some of the elements and performance criteria outlined in the competency unit "CPCCOHS1001A Work safely in the construction industry" (CPSISC 2011) including:

- Identify construction hazards and control measures
- Identify OHS communication and reporting processes

The game was designed for 30 minutes of casual puzzle gameplay. Every level in the game depicts a segment of a multi-story tower that is constructed as the player progresses through the game. Figure 1 shows a screenshot of the actual game. Autonomously animated game character workers try to accomplish tasks on the construction site, but are hindered by hazards that prevent them from doing their work. However, the workers in the game are not able to manage the hazards by themselves and are injured if they come in contact with the hazard. To avoid injury to the workers, the player needs to resolve the hazard by applying OH&S controls shown in a menu at the bottom of the screen.

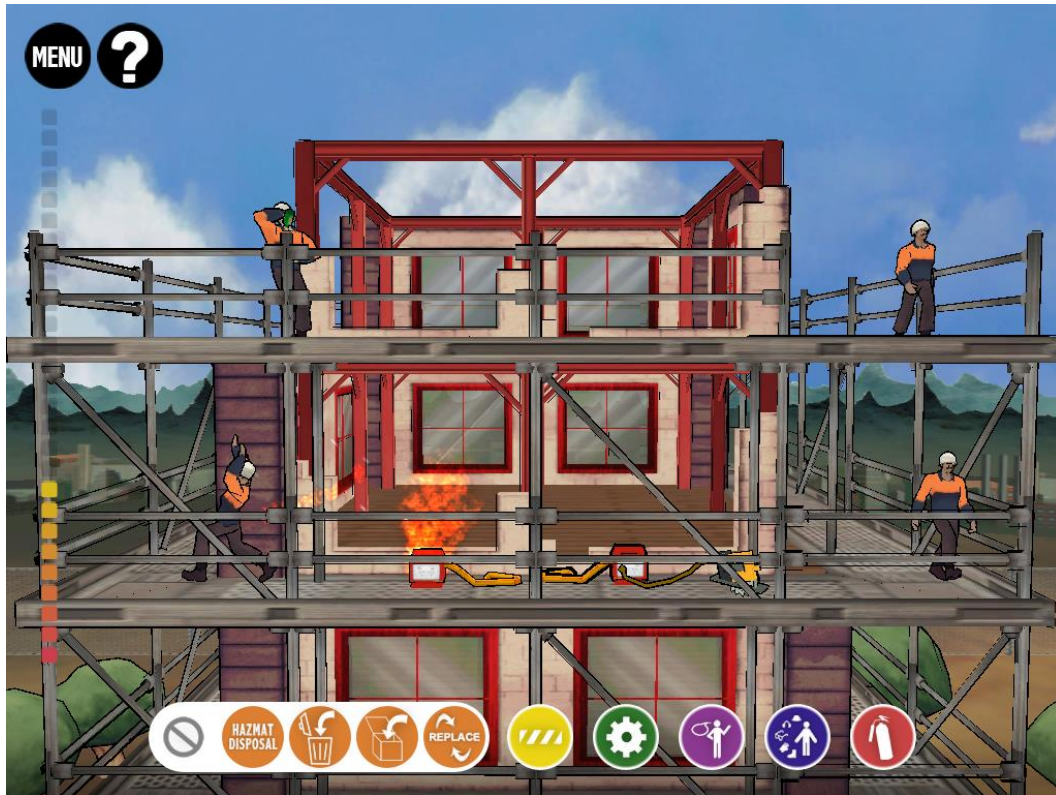


Figure 1: Screenshot of the game “Trouble Tower”

The controls menu at the bottom of the screen consists of 22 OH&S controls. Each control becomes available when the control hierarchy icon is selected. To support learning, the player can trigger information about the hierarchy or the individual controls by continued pressing by their finger on the respective button. Control buttons show an enlarged icon of the control object itself, so that the player can recognise the control measure in the real world. The control information also contains a text box that provides essential information in textual form.

The game allows the player to experiment with what happens when they attempt to use a control to resolve the hazards on the site. Replicating the real world, the suitability of a control depends on the situation and can trigger a number of different outcomes. In certain situations, a control results in the effective management of the hazard. In other cases, the same control can have negative consequences for the worker. For example, the water based fire extinguisher can be used to control a paper fire, but the same water based fire extinguisher used on an electrical fire causes the electrocution of the worker. When the fire extinguisher is given to the worker about to fall into a hole, the extinguisher leaves a cloud of mist as the worker disappears into the open hole. The game addresses over 30 of the most common hazards encountered on construction sites (SWA 2011).

When the player has managed all the hazards in a game level, the hazard must be reported before the player can proceed to the next level. As in the real world, if a construction worker encounters a hazard, the worker is encouraged to report the hazard via an incident report form. To reinforce the concept of reporting but to keep the game moving, a report button appears once the player has managed all the hazards in a given game level. The

reporting provides the player with a review of the hazard and feedback about the adequacy of the control that was used to resolve the hazard.

Safe Work Methods Statements (SWMS) and Material Safety Data Sheets (MSDS) are document types that are requirements for Australian work sites in the real world. We adapted these documents to be suitable for the game. The game SWMS contain hints on how to manage the hazards in the game context. For example, for a hazard related to manual lifting, the SWMS describe the effects of manual lifting and contain instructions to lift a heavy load correctly, paying particular attention to the solution expected in the game. Through this, the SWMS explain the real-world method required to complete actions depicted in the game. The MSDS provide summary information about the hazardous substances in the game level. The description comes with an image of the substance, so that it can be recognised in the game and in the real world.

The player performance is measured by the construction site work rate, depicted as a coloured bar graph on the left side of the screen. Every injury to a worker depletes the work rate. During the gameplay, the work rate indicator shows a bar with colours ranging from red to green. The green colour indicates a highly productive work site and red an unproductive work site. This reinforces the relationship between hazard control and productivity on real world work sites.

When the player completes the final floor of the building, the player has reached the end of the game, which culminates in an animation that shows workers on top floor celebrating the completion of the building.

To make the game accessible in lecture theatres, classrooms and computer labs, and also to students after the CI course, the game was designed with low hardware requirements such as iPads, laptops, netbooks and commodity computers. The game was specifically developed for the iPad. Although developed for the iPad, the game is also playable on PC and Mac computers with a mouse.

Testing Procedure

Students in the Construction Induction course were tested before and after the course for their ability to recognise hazards in photos of construction sites; this was construed as a test for transferability of learning to the real world. Students were randomly assigned to either the Training Group (control group) or the Training Plus Game Group (test group). The *pre-course testing* took about 15 minutes to complete and consisted of photos of actual construction sites and a list of hazards under each photo. Students were asked to indicate any hazards that were apparent in the photo.

In the *after-course testing*, the **Training Group** was given the same test as in the *pre-course testing*, effectively re-taking the test. These results were analysed for the change in test score as a result of attending the Construction Induction course, and were interpreted as the change in learning from attending the course (and from re-taking the test).

The **Training Plus Game Group** was asked in the *after-course testing* to play the Trouble Tower game, complete a user experience survey and have a personal interview related to aspects of the user experience survey. Finally, the students completed the same test as in the *pre-course testing*. The whole game playing, survey, interview and testing procedure for the Training Plus Game Group took about 1 hour.

The user experience survey and the interview provided us with information about the users' perceptions of the gameplay. The results of the hazard identification test were used to determine if the members of the group who played the game were able to spot hazards more accurately than the students in the group receiving the traditional training.

The testing protocol was approved by the RMIT Human Research Ethics Committee.

Transferability Testing

The primary aim of the Trouble Tower game is to assist student learning about hazards on construction sites, not about depictions of hazards in games. As such, we desired to determine if playing the Trouble Tower game assisted students in recognizing hazards in real world construction sites. Due to the logistic and ethical difficulties of taking students to real construction sites, we developed a test based on photographs of hazards in real construction scenes. The test consisted of 13 photographs of real construction sites with visible and assumed hazards, e.g. participants had to assume that a jack hammer is noisy. The participants taking the test were requested to examine the series of photographs for hazards and to select the hazards that they identified from a standardised list of hazards beneath each photograph. The list of hazards was derived from the topics that were to be addressed in the CI course (CPSISC 2011). The results were scored as for total number of hazards and percentage of right answers as deemed by construction safety experts (Construction safety experts looked at the photographs and indicated which hazards they saw. The hazards noted by all the experts were deemed to be the 'right' answer.) The test was administered on paper and the results were transferred to statistics software and subsequently analysed using ANOVA comparing game-playing and control groups.

User Experience Testing

The construction induction course was held in a lecture theatre without access to computers during the training. To allow the participants to play the game, the randomly assigned participants were escorted to a computer lab where the game was installed on PCs. The participants were instructed to start the game tutorial, which then automatically launched the first level of the game. A total of 30 minutes was allocated for the students to play the game, but participants were able to stop playing at any point. When they were finished playing, the participants were asked to respond to a user experience online questionnaire about their perceptions of the gameplay with respect to Enjoyment, Engagement, Success, Control, Motivation, Feedback, Usability and Difficulty. The questions were adapted from similar questionnaires that characterise and measure user experience with interactive computer environments (Chen et al. 2005; Ijsselstein et al. 2007; Witmer and Singer 1998). Using a five point Likert scale, the participants were asked to indicate the extent to which they experienced each item: 1 - Not at all, 2 - A small amount, 3 - A fair amount, 4 - Quite a lot and 5 - A great deal. For example, one of the questions about engagement was: To what extent did the game hold your attention?

Semi-structured Interviews

We collected qualitative responses through a semi-structured interview. The interview was conducted after the candidates played the game and answered the questions on user experience survey. The interview consisted of 8 questions. Each question related to one aspect of the user experience survey. For example, the interview question: "Were you thinking about which controls at the bottom of the game to use or did you just try out completely random combinations?" was related to the set of questions in the user experience questionnaire about the control.

RESULTS

To date, we have data on the transferability photo test for 97 Construction Induction students, however only 24 students have played the game. As a result, the group sizes are unequal and there is a less than perfect set of statistics about the game. Nonetheless, we were able to identify some interesting themes about the user experience.

Enjoyment

The graph summarizing the survey results in Figure 2 shows that most of participants enjoyed the game (Figure 2, Q5) as an interactive classroom activity and as a way to engage with the OH&S content. From a design perspective, all participants enjoyed the graphics (Figure 2, Q1) and the interactive nature of the game (Figure 2, Q3). The sound and the music (Figure 2, Q2) received mixed responses and was probably one of the weaker aspects of the game. Surprisingly, over 80 % of the students really enjoyed the OH&S theme of the game (Figure 2, Q4).

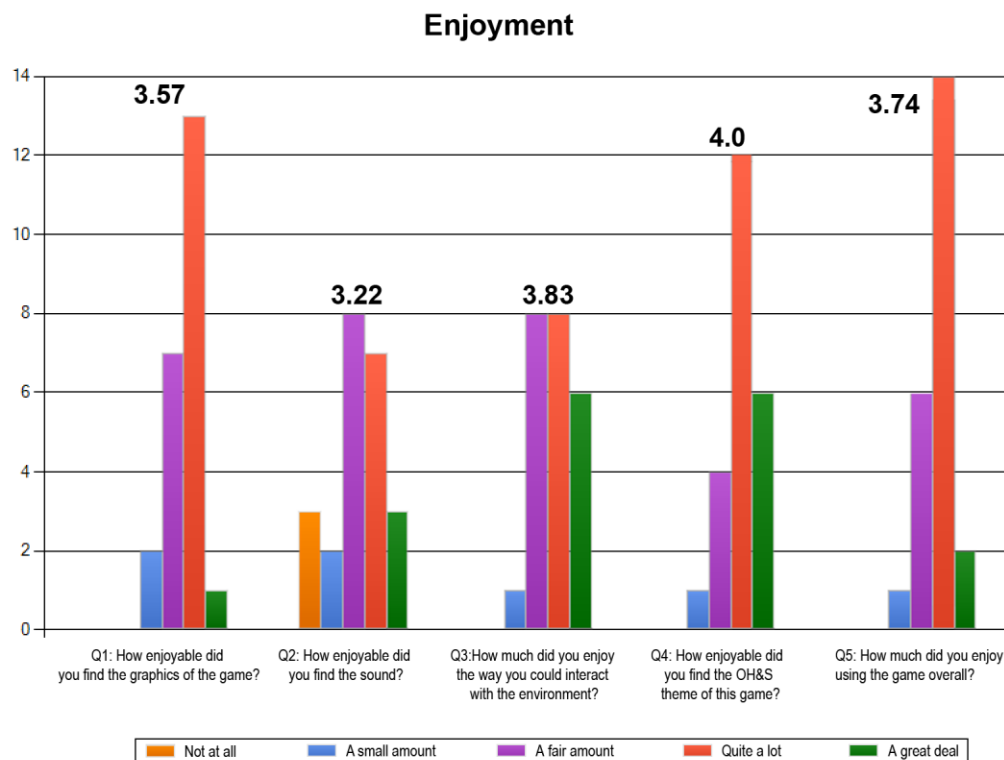


Figure 2: Graph of the survey results in the enjoyment category.

When questioned in the interview about what the students liked about the game, most students responded that it was a better way to learn about OH&S than the lecture and that they enjoyed the animation and interactivity. Most of them also liked that the game was easy to play. One student with English as his second language commented that the game supported his learning better than the lecture as the game contained only a few texts and allowed him to repeat and experiment.

The majority of students did not respond to the question when asked about what they didn't like about the game. A small number of students (n=4) mentioned that the game was too easy for them. Other students (n=6) mentioned that there were too many OH&S

controls and that they got stuck for a while in the game until they figured out a solution for the hazard; no one mentioned using the SWMS or MSDS to help. A small number of students also commented that the music (n=2) and the graphics (n=2) of the game could have been better.

Engagement

Figure 3 summarises the level of user engagement. The game was able to hold the attention of all students over the duration of the game (Figure 3, Q6). However, quite a number of players were not engaged to a point where they lost track of time (Figure 3, Q7) during the activity and all players were quite aware of their surroundings (Figure 3, Q8). It also seems that most participants were happy to move on after about 30 minutes of playing time (Figure 3, Q9). The negatively geared question (Figure 3, Q10) indicates that only a few students found the activity boring.

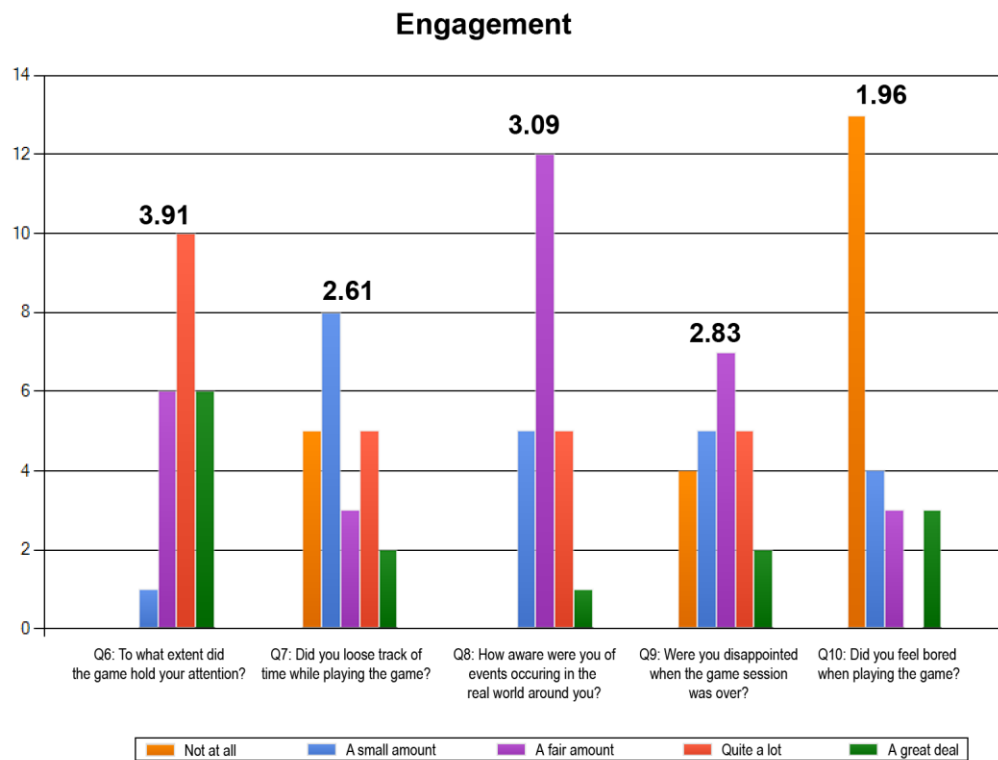


Figure 3: Graph of the survey results in the engagement category.

When we asked the students in the interview what they felt when playing the game, most student responded that they were engaged (n=11) and that they enjoyed (n=7) the learning experience. Also several of students said that they were motivated by game to keep going to see what happens in the next level (n=7), and see the end of the game. A few students (n=4) also commented that they thought that playing a game was better than attending a lecture.

Success

Overall, the survey indicated that the students felt that the game was successful in helping them to learn and reinforce the OH&S content, and they recognised the benefits of using

games as a classroom activity to learn about OH&S. The majority of students felt that they learnt something from the game (Figure 4, Q11). While several students felt that they only learnt a small amount, most students felt quite positive about the amount of learning that they received from the game. Most students could also relate the content of the game to the content of the construction induction training and saw the game as a good way to reinforce the learning of the content that was discussed in class (Figure 4, Q12). All students except for one could see the benefits of playing a contextualised OH&S game as part of the OH&S training (Figure 4, Q13). Despite the fact that several students got stuck in the game during the gameplay session, more than half of the students thought that the game was a too easy (Figure 4, Q14).

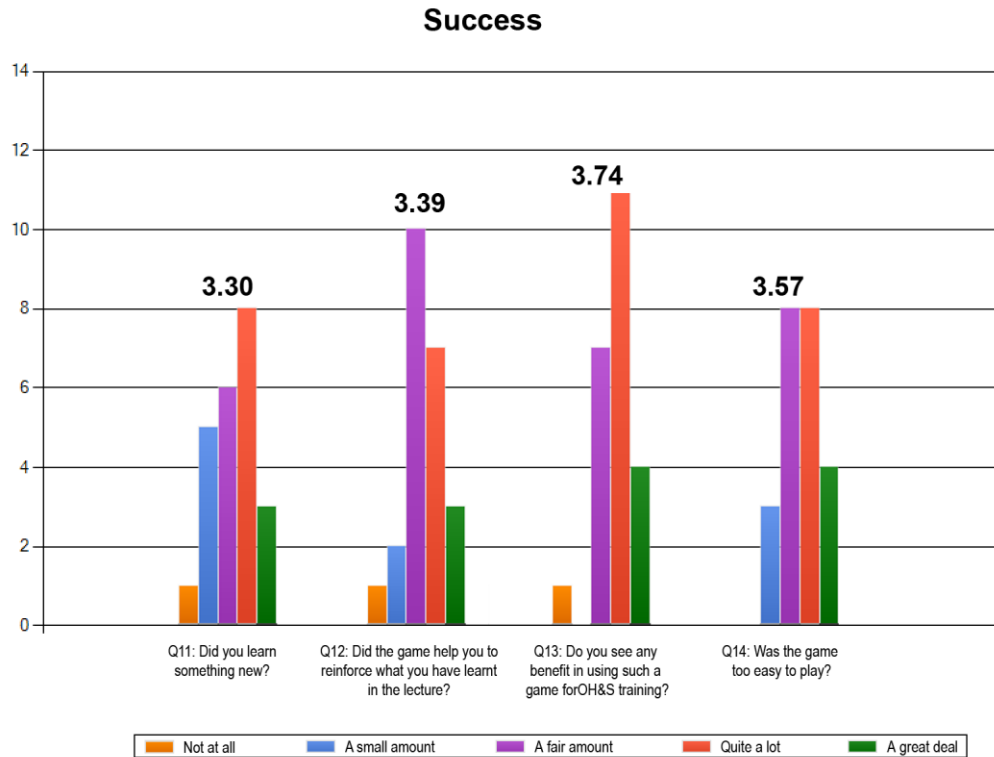


Figure 4: Graph of the survey results in the success category.

In the interview we also asked the students if they felt that they learnt anything from the game. Thirteen of the twenty four participants felt that they learnt something new about O&S hazards in the game. Most students in this category could precisely describe the hazard in the game and the OH&S controls to resolve it or describe the situation where the hazard can occur. Other students reported that the game was a good activity to reinforce (n=13) what they learnt in the lecture.

Control

The data in Figure 5 shows that most students were able use the interface to resolve hazards with appropriate OH&S controls. All students reported that they were able to predict what would happen if a certain OH&S control was applied to a hazard (Figure 5, Q15). The actual user interface received mixed responses (Figure 5, Q16). While most students were able to deal with the number of controls provided by the user interface, it was too complex for some and frustrating (Figure 5, Q17) for others.

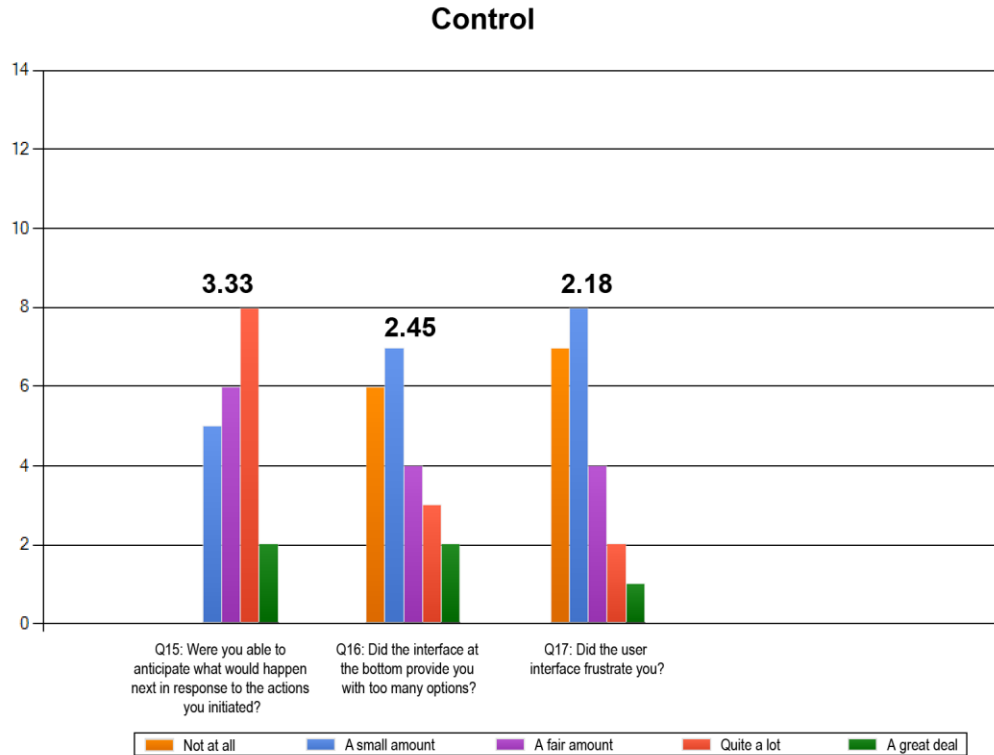


Figure 5: Graph of the survey results in the control category.

In the interview we wanted to know whether students made a considered choice about which OH&S control they needed or if they used a trial and error approach. The responses varied across the sample interviewed. The interviews conducted for this paper showed that about half ($n=13$) of the students questioned said that they were thinking about which control to apply and almost equal number ($n=9$) indicated that they were using a trial and error approach to get through the game. This discourse echoed the notion that most students first tried out what they thought was right and if that failed they made an educated guess to try another control. Only one student said that he was reading the description of the OH&S controls and learnt in which situations to apply them.

Motivation

Figure 6 shows that more than half of the students were not too motivated about playing a game about OH&S to begin with (Figure 6, Q18). However the student's motivation increased as they kept playing the game (Figure 6, Q19). The majority of students indicated that they were happy to play more OH&S games in the future (Figure 6, Q20). Even though all students completed the game, many students were interested in exploring the game further (Figure 6, Q21). The negatively geared question revealed that for most students, the game did not reduce the student's motivation to further engage in OH&S content.

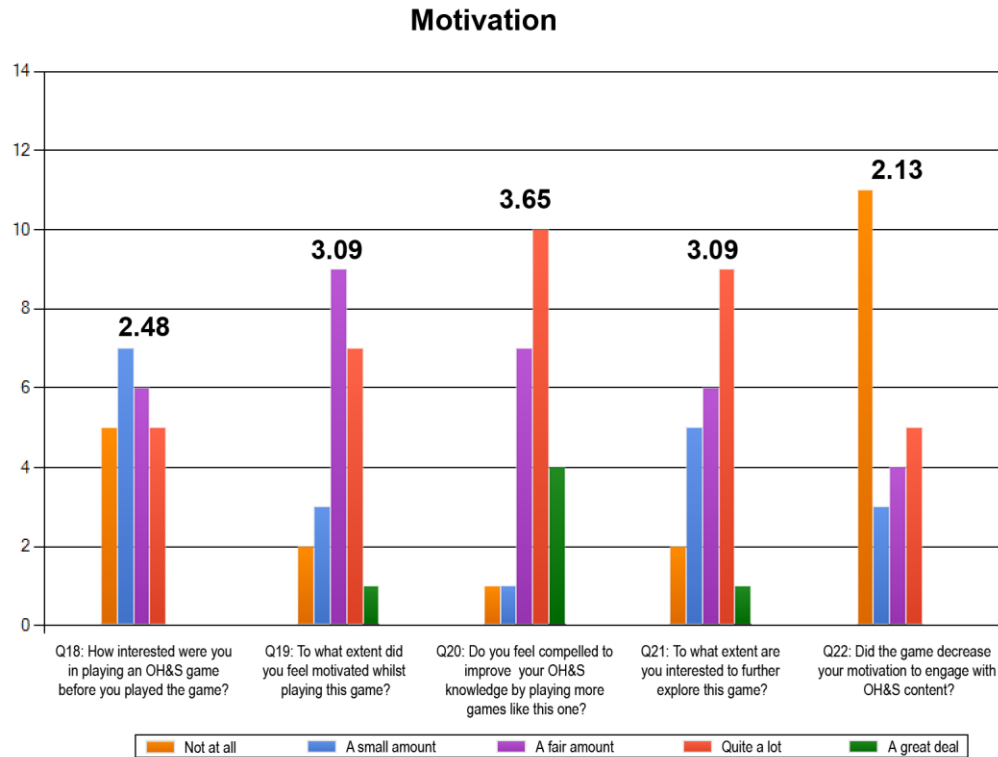


Figure 6: Graph of the survey results in the motivation category.

When we interviewed the students about their motivation before, during and after the game, eight students told us that they were excited from the start to play the game and that they were motivated till the end. A larger number (n=14) stated that at first they were not very motivated to begin with, but that their motivation increased as they played the game. Only one of the students reported that his motivation decreased as the game progressed. One student stated that he wasn't motivated: "I got nothing out of it other than a bit of fun", which is not surprising as game based learning is not for everyone (Prensky 2001).

Feedback

The data in figure 7 indicates that for most students the game provided adequate visual and audible feedback for their actions (Figure 7, Q23) and it helped to guide most of the students as they progressed through the game (Figure 7, Q24). Interestingly, the negative geared question revealed that some students would have liked to receive more feedback (Figure 7, Q25).

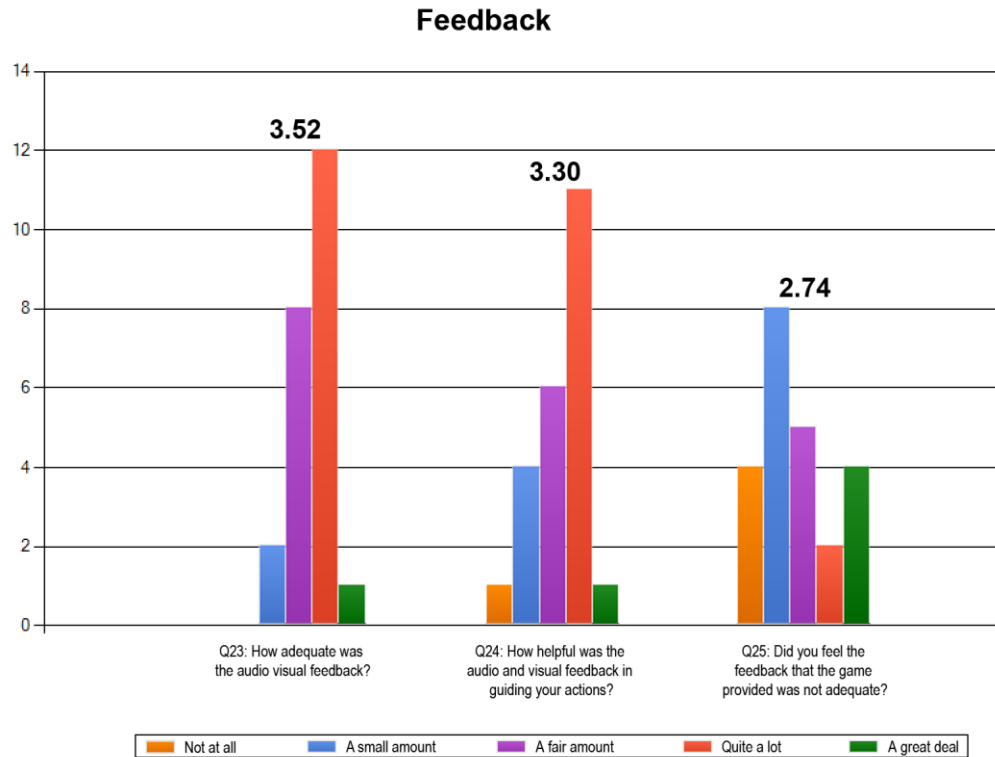


Figure 7: Graph of the survey results in the feedback category.

We asked in the interview if the game provided the students with sufficient feedback when they got stuck, half (n=12) of the students responded that the feedback was sufficient. The other half of the questioned participants clearly wanted more feedback. Five students indicated it depended on the situation. The rest replied that they used a trial and error approach to resolve the hazards as there was not sufficient feedback available to them to point them to the appropriate solution.

Difficulty

The survey results in Figure 8 show that the students didn't find the game very challenging (Figure 8, Q26) and for quite a few students the game was too easy (Figure 8, Q27). This is consistent with very few indicating that they wanted to give up (Figure 8, Q28). Despite this, all participants reported that they made mistakes when trying to resolve the hazards with the OH&S controls (Figure 8, Q29), but obviously were able to resolve it in the end as all of them completed the game in the allotted time (Figure 8, Q30).

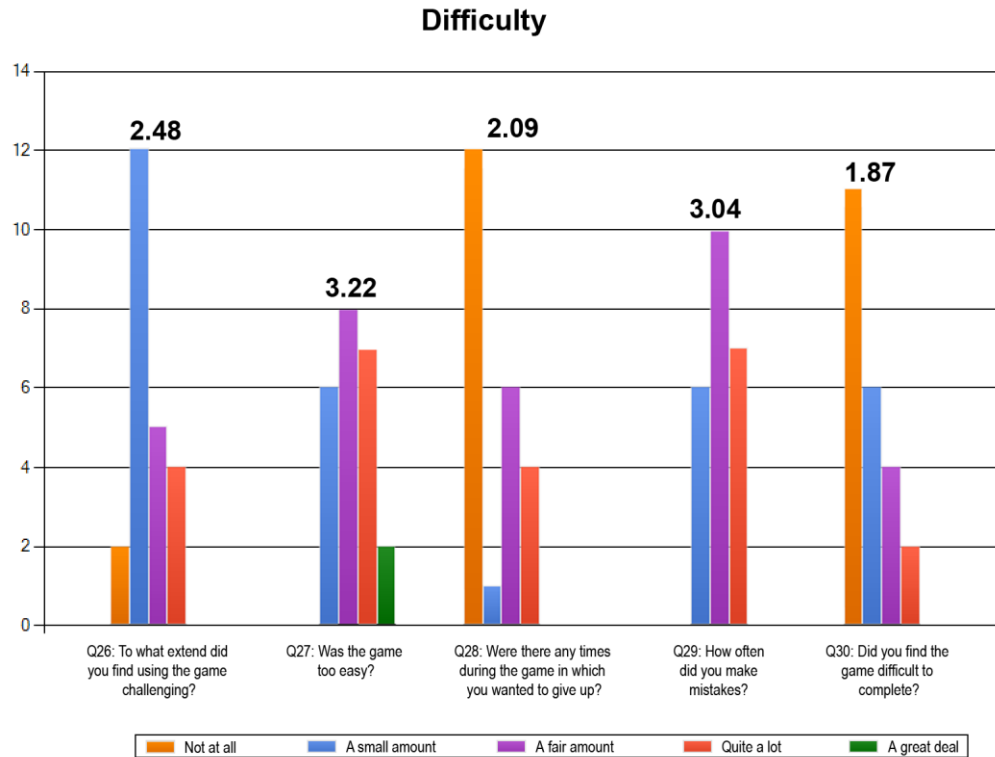


Figure 8: Graph of the survey results in the difficulty category.

When we asked the students in the interview if they got stuck anywhere in the game and if they can describe the situation, nine students identified a situation in the game that depicted a saw that was missing a guard protecting the worker from the saw blade. The students said that you had to look at the situation very closely to notice that the guard was missing. Another situation that was missed by a few students (n=3) was the worker who was working at heights, but was not secured with a harness. Other situations mentioned by some individual students included situations depicting a fire hazard, an oil spill, a missing dust extractor and housekeeping issues.

TRANSFERRABILITY

The data collected to date does not show a statistical difference in score for total number of hazards or percentage of right answers when comparing the pre-test and post-test results. We were also not able to identify statistical differences among the Training Group and the Training Plus Game Group with the data available.

DISCUSSION

Learners must be engaged in active and interactive learning activities (Prensky 2001; De La Harpe and Peterson 2009). Trouble Tower is an engaging learning experience that requires the active participation of the learner. Many students commented positively on the interactivity that the game provided. Several students also explicitly stated that learning from the game was “better than learning in a lecture”.

Students were not only engaged, but they also had fun. During our user tests the participants who played the game appreciated and laughed about the character animations in the game and we noticed that some participants rejoiced when they resolved hazards.

All participants (n=24) played the game through to the end because they were engaged and had fun. This was surprising because often players don't play a game to the end (Snow 2011) and as the participation was voluntary, the students could have opted to finish the game early.

Spiro (1992) states that learning environments should provide authentic and contextualized experiences. Trouble Tower was structured in alignment with the CI course but also contextualized the hazards. Several students' commented that they thought it was good to see examples of where hazards can occur on construction sites. Most students thought that they learned something new or that the game reinforced their learning.

The students also responded positively about the OH&S theme of the game (Figure 2, Q4). We expected that the students would compare the game to games with a pure entertainment focus and that they would have disliked Trouble Tower's educational focus, but this was surprisingly not the case. For most students this game was still a classroom activity that they did as part of the course and not a game that the students would choose for the purpose of entertainment.

The game was not designed as an immersive game, so it is no surprise that the students did not lose track of time (Figure 3, Q7) or lose track of their surroundings (Figure 3, Q8), as can be the case in an immersive first person shooter game or a good movie. The idea with Trouble Tower was to create a game that was portable, so that it could be used in a classroom and was developed with a modest development budget.

The sound and music of the game had mixed responses which might have been a result of the students not using headphones. The sound and music of approximately 20 games running at the same time, but at different stages the computer lab transformed into a game arcade-like sound scape. While Harfield et al. (2007) claim that construction students prefer a noisy learning environment, the arcade-like soundscape probably became a distraction for the students. Had the participants used headphones, the experience might also have been more immersive and the participants would have been able to concentrate better on the game. However, the use of headphones, would have isolated the participants from each other and restricted their ability to collaborate with their peers when they got stuck in the game, which Harfield et al. (2007) identified was learning preference of construction students.

Dalgarno and Davies (2009) stated that providing learners with options to exploring multiple outcomes was viewed as positive by learners. However, in Trouble Tower, many students commented that the number of controls available to them was overwhelming. As a result many students thought about which control might resolve the hazard but if that failed they resorted to a trial and error approach to match controls with hazards. We observed that very few students made use of the help in the game. In hindsight, the reaction of the students is not too surprising as Harfield et al. (2007) already pointed out that construction students require a high degree of guidance in their learning.

Overall the students criticised the level of difficulty of the game. Some students reported that the game was too easy. We expected that the students would experience situations in the game that they could easily resolve; the aim was to present scenarios that reinforced the concepts required in the teaching curriculum. Had the game been integrated as a

classroom activity to support the lecture and not played after, perhaps the students would have responded more positively.

Harfield et al. (2007) points out that “almost a quarter of the students in this trial indicated a preference for food intake as part of the learning process”. To thank the students for their participation in the user testing, we organised lunch before the after-course testing and game play. A significant learning from this experience was to not feed students before they participate in the testing, as many students disappeared after lunch. This became quite obvious when many of the students who were randomly assigned to the game test did not come to the computer labs where the testing was conducted.

Limitations

This study had a number of limitations. The user test was conducted on students who were scheduled to complete the construction induction courses in order to receive a construction induction card, issued by the government organisation WorkSafe Victoria, allowing the cardholder to enter a construction worksite. The course content was strictly controlled and it was therefore not possible to replace part of the course by the game to compare test results. The research project could only add the game as part of the course, which is less ideal situation to compare the results. In addition, the course has a very high pass rate, so using changes in the pass rate between test groups was not a viable option.

The sample size of students who actually played the game was disproportionately small. Despite the random allocation of participants into groups, only a small percentage of students opted to play the game. Furthermore, the random allocation of students to test groups caused peer groups of students to be split up. Harfield et al. (2007) view peer group interaction as an important learning preference of construction students, which probably influenced students to stick with their peer group rather than go to their assigned test group, resulting in a smaller than expected number of game participants. It was therefore not possible to arrive at a sufficient number of participants to infer any of the test results to a larger population. All findings are descriptive of the group of students tested at RMIT and only indicative at this point.

The game was developed for the iPad but the game was tested on PC's to facilitate the testing of larger groups of students. The iPads however, would have provided the students with an even more tangible interface than the PC. The test environment was also a different setting than what the game was intended for.

The transferability test has not been validated. The test was designed on the widespread assumption that cartoons and photographs in a lecture environment helps students to make a connection to the real world and hence a game would have that same transferability. In addition, the test required that the test subjects to recognise words describing the hazard, which were only briefly discussed in class and not used in the game at all. Arguably there was also too much testing involved in the post-course testing. The students might have suffered survey fatigue; certainly an anecdotal observation is that students took less time to complete the post course tests than to complete the initial test. These factors might have had a negative impact on the data collected about transferability.

CONCLUSIONS AND FURTHER WORK

This game was perceived to have many desirable outcomes. While the group of students that played the game was small, we found consistent indications that they were engaged

and motivated to engage with the OH&S material in the form of a game. All of the students thought that they learned something new. The students also viewed the game as reinforcing their learning. The students felt that the course would greatly benefit from activities like this game. The students did not mind that the game was not immersive, but identified issues in relation to the number of OH&S controls that were available to them in the user interface and were generally not so interested in exploring multiple possible outcomes. The students exhibited a level of cautious excitement towards the game at the beginning, but most students felt more motivated to play the game as the game progressed. Unfortunately, we were not able to identify that game playing made student's statistically better at recognising hazards at this stage of the research. This certainly calls for more research to determine how transferability of information from a game to a real world construction situation can be measured and used to design games with high transferability.

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REFERENCES

- Anderson, J M, M E Aylor, and D T Leonard. 2008. "Instructional Design Dogma: Creating Planned Learning Experiences in Simulation." *Journal of Critical Care* 23 (4): 595–602.
- Bruner, Jerome S. 1966. *Toward a Theory of Instruction*. Cambridge Mass Harvard.
- Chen, Mark, Beth E Kolko, Elizabeth Cuddihy, and Eliana Medina. 2005. "Modeling and Measuring Engagement in Computer Games." *Digital Games Research Conference 2005, Changing Views: Worlds in Play*. Vancouver, British Columbia, Canada: DIGRA.
- CPSISC, Construction & Property Services Industry Skills Council. 2011. "CPCCOHS1001A Work Safely in the Construction Industry ." Edited by Employment Department of Education and Workplace Relations. Canberra: Australian Government. <http://training.gov.au/Training/Details/CPCCOHS1001A>.
- Csikszentmihalyi, Mihaly. 1990. *Flow: The Psychology of Optimal Experience*. New York: Harper and Row.
- Dalgarno, Barney, and Amanda Davies. 2009. "Learning Fire Investigation the Clean Way: The Virtual Experience." *Australian Journal of Educational Technology* 25 (1): 1–13. <http://www.ascilite.org.au/ajet/ajet25/davies.html>.

- De La Harpe, Barbara, and J F Peterson. 2009. "The Theory and Practice of Teaching with Technology in Today's Colleges and Universities." In *Information Technology and Constructivism in Higher Education: Progressive Learning Frameworks*, edited by C Payne. Hershey: IGI Global.
- Dewey, John. 1972. *Experience and Education. The Kappa Delta Pi Lecture Series*. New York: Collier. (Reprinted from the Kappa Delta Pi Lecture Series, by J. Dewey, 1963, New York: Collier).
- Encyclopædia Britannica Online, s. v. "learning," accessed July 25, 2013.
<http://www.britannica.com/EBchecked/topic/333978/learning>.
- Gee, James Paul. 2005. "Learning by Design: Good Video Games as Learning Machines." *E-Learning and Digital Media* 2 (1): 5–16.
<http://www.worldwords.co.uk/elea/>.
- Gee, James Paul. 2012. "Foreword." In *Games, Learning, and Society: Learning and Meaning in the Digital Age (Learning in Doing: Social, Cognitive and Computational Perspectives)*, xvii –xx.
- Greuter, Stefan, Susanne Tepe, Frank Boukamp, Fiona Peterson, Kimberley Grace D'Amazing, Kalonica May Quigley, Rhys van der Waerden, Thomas Nicholls Harris, and Tim Goschnick. 2011. "Comments on White Card Training." Edited by Stefan Greuter and Susanne Tepe. Melbourne.
- Harfield, Toby, Mary Panko, Kathryn Davies, and Russell Kenley. 2007. "Toward a Learning-Styles Profile of Construction Students: Results from New Zealand." *International Journal of Construction Education and Research* 3 (3) (December 11): 143–158. doi:10.1080/15578770701715060.
<http://www.tandfonline.com/doi/abs/10.1080/15578770701715060>.
- Ijsselstein, Wijnand, Yvonne de Kort, Karolien Poels, Audrius Jurgelionis, and Francesco Bellotti. 2007. "Characterising and Measuring User Experiences in Digital Games." *ACE 2007 International Conference on Advances in Computer Entertainment (13-15 June 2007)*. Salzburg, Austria.
- Kolb, D A. 1984. *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice Hall.
- Lauriola, P, F Tosatti, A Schiavi, M Fiandri, G Frank, and M Michelacci. 2000. "Confidential Enquiry into Avoidable Vehicle Accident Deaths in the Province of Modena." *European Journal of Epidemiology* 16 (1): 67–74.
- Li, Heng, Greg Chan, and Martin Skitmore. 2012. "Visualizing Safety Assessment by Integrating the Use of Game Technology." *Automation in Construction* 22 (March): 498–505. doi:10.1016/j.autcon.2011.11.009.
<http://linkinghub.elsevier.com/retrieve/pii/S0926580511002160>.

- Murphy, Curtiss. 2011. "Why Games Work and the Science of Learning."
http://www.gametools.dk/files/papers/WhyGamesWork_TheScienceOfLearning_CMurphy_2011.pdf.
- Power, Michael. 2009. "Safety Game Gets Serious About Online Learning."
OH & S Canada 25 (2): 20.
<http://proquest.umi.com/pqdweb?did=1769464531&Fmt=6&VInst=PROD&VType=PQD&RQT=309&VName=PQD&>.
- Prensky, Marc. 2001. *Digital Game-Based Learning* New York: McGraw-Hill.
- Rowland, Bevan, Barry Watson, and Darren Wishart. 2006. "Integration of Work-related Fleet Safety Within a Workplace Health and Safety Management System: A Case Study Approach." *Australasian Road Safety Research Policing and Education Conference*. QLD: Centre for Accident Research and Road Safety Queensland (QUT).
- Snow, Blake. 2011. "Why Most People Don't Finish Video Games - CNN.com."
August 17.
<http://edition.cnn.com/2011/TECH/gaming.gadgets/08/17/finishing.videogames.snow/index.html>.
- Spiro, R, P Feltovich, M Jacobson, and R Coulson. 1992. "Cognitive Flexibility, Constructivism and Hypertext: Random Access Instruction for Advanced Knowledge Acquisition in Ill-structured Domains." In *Constructivism and the Technology of Instruction*, edited by T Duffy and D Jonassen. Hillsdale, NJ: Erlbaum.
- SWA, Safe Work Australia. 2011. "Construction Fact Sheet."
<http://www.safeworkaustralia.gov.au/ABOUTSAFEWORKAUSTRALIA/WHATWEDO/PUBLICATIONS/Pages/FS2010ConstructionInformationSheet.aspx>.
- SWA, Safe Work Australia. 2012. "Australian Work Health and Safety Strategy 2012–2022: Healthy, Safe and Productive Working Lives (draft for Public Comment)."
 Edited by DEEWR. Canberra: Australian Government.
- Van Wyk, Etienne. 2006. "Improving Mine Safety Training Using Interactive Simulations." In *World Conference on Educational Multimedia, Hypermedia and Telecommunications 2006*, edited by Elaine Pearson and Paul Bohman, 2454–2459. AACE.
- Whitton, Nicola. 2010. *Learning with Digital Games: A Practical Guide to Engaging Students in Higher Education*. Edited by Fred Lockwood, Tony Bates, and Som Naidu. *Open and Flexible Learning Series*. New York: Routledge.
- Witmer, Bob G, and Michael J Singer. 1998. "Measuring Presence in Virtual Environments: A Presence Questionnaire." *Presence: Teleoperators and Virtual Environments* 7 (3): 225–240. doi:10.1162/105474698565686.
<http://dx.doi.org/10.1162/105474698565686>.

Wolf, C. 2007. "Construction of an Adaptive e Learning Environment to Address Learning Styles and an Investigation of the Effect of Media Choice." *Faculty of Education*. Melbourne: RMIT University.