NEW METHODS FOR HEALTH AND SAFETY TRAINING IN THE QATAR BUILDING CONSTRUCTION INDUSTRY

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ABSTRACT

Health and Safety in construction sites is a paramount issue that hunts the construction industry for the last two decades. In the local Qatar construction industry, and particularly the building construction, hazards are causing fatal accidents and local experts suggest a rate of four to five facilities per 100,000 workers is a common phenomena. Therefore, early identification of hazards and proper safety training are important requirements for construction safety in Qatar. Modern technologies using visualization tools and game engines can play a very important role to achieve these two objectives. The main purpose of this paper is to explore the readiness of the Qatar construction industry to accept new innovative methods of health & safety training. The study has conducted a series of interviews and questionnaire survey with construction industry personnel with the objective to investigate current practices of H&S, identify and rank risk factors and the applicability of new training technologies for Qatar construction industry. All the collected data were analysed using both qualitative and quantitative measures. The analysis showed that are "Working at High", lack of proper H&S guidelines and lack of appropriate training methods and tools are the main factors causing serious H&S accidents. Additionally the analysis showed that falling objects, manual handling, hazardous chemical, and noise risks are also causing H&S hazards. Similarly, the questionnaire showed that methods of mitigating the above mentioned risks are mainly traditional assessments tools carried by the planning and design teams before the actual construction starts on site. This study also showed that proper Personal Protective Equipment (PPE) plays a major role in mitigating safety risks. In addition, proper signage and tools are considered a first line defense in any project. Moreover, the study revealed a positive feedback on the utilization of visual aids, visualization and advanced game engines in training of workers. Such technique can greatly improve the interpretation and understanding construction sites' risks, and gives indication on proper mitigating solutions. The paper has hypnotized that traditional training methods alone have limitted influence on improving health and safety maters in the construction site and new innovative training methods using game engines technologies should be utilised. Moreover, previous pilot studies on using game engines in health and safety training showed that they can deliver better understanding of the project risks more than the regular training methods. In this regard, the development of training games for this kind of accidents should be considered intensively.

Keywords: Qatar, Health, Safety, Visualization, Training.

1. INTRODUCTION

Effective health and safety (H&S) management and training are critical, if projects are to be delivered on time, on budget and without experiencing accidents or injuries on construction sites. Currently safety is a major issue across global construction industries due to its economic and social burden. There are 9.5 fatalities reported per 100,000 construction workers in 2006 in Europe (Eurostat, 2006) and 11 per 100,000 construction workers in the US in 2007 (Laborsta, 2007). In the UK, 53 deaths and thousands major injuries were recorded in 2008, making the accident rate in construction twice that of manufacturing (National Statistics, 2008). In Hong Kong, a total of HK$1.02 billion was paid in compensation and 1.7 million working days were lost in 2006 alone (Occupational Safety and Health Council, 2006). On other hand, there is no exact figures for Qatar Construction Industry but experts suggest rate about four to five fatalities per 100,000 workers which is double the figure in the UK.(The Peninesula News Paper, October 8th, 2011).

This high accident rate is increasing year on year, although the legislative pressure has been increasingly tightened over the last two decades. This clearly suggests that the safety performance of the industry is not truly reflecting the tightened legislations. Meanwhile safety risks can be minimized or eliminated by considering them at earliest design and planning stages, the amount of safety risks left at the work interface remains very high in construction. One of the main mitigating measures to risks at the work interface is through training and therefore effective safety training across all skill levels in the industry is seen as an integral part of any solution. Current H&S training methods such as induction training sessions; lectures or presentations; on-site training exercises, video instructions and mock training exercises have the drawback to be repetitive, specific, poorly engaging and often are developed for complying with legislations rather than for acquiring new skills. Similar issues can be encountered with assessment methods.

The main drawback of these methods is the ability to model behavioral H7S risk factors as these are important in order to avoid occupational injury and illness (Lingard, 2002). A study investigating the trend of construction employment, as a means to predict training needs, concluded that, in a rapidly changing market, suitable training on a short timescale is essential to providing skilled workers to required areas of work (Wong et al, 2010). Advances in serious game and virtual reality technologies were only recently seen as a bridging gap between the need of the industry for new training tools and its need to improve safety performance, although applications in other industry such as the aeronautic and automotive industry have been frequently researched and implemented over the last 12 years (Mizell, 2001; Echtler et al., 2003; Doerner et al., 2002; Tamura et al., 2001). In this context, the objectives of this report are: to identify current practices of H&S implementation in Qatar, analyze critical H&S hotspots at construction site level and develop an understanding on the use of serious game engine technologies for H&S training and identify functionalities requirements for H&S training.

Issues with the recent H&S plans and processes are that the design documents provided by the consultant (2D drawing, specification, etc) and safety plan and procedures are not integrated and fragmented. Therefore, to be able to undertake a better and efficient H&S analysis and plan, integration of 2/3D with H&S rules and plans. By that each object in the 3D model to be linked with risk related to that object. (Hadikusumo & Rowlinson, 2002). Moreover, current practices of drafting in 2D format does not allow all stakeholders to be involved in H&S identification and each one of them may not have the same mental picture about the "object" they are working on, especially when discussing health and safety against site activities (Dodge et al., 2008). Due to this fact that visualization of different interrelated activities is very difficult in large complex projects without visualizing and integrating 3D objects and site activities. Therefore, Virtual Construction Environment (VCE) that was proposed by Waly and Thabet (2002) which involves 3D modelling techniques with object-oriented technics to initiate an virtual environment is seen to be essential. Project team members can experiment with different scenarios related to the way in which a construction site is executed and check the validity of different execution strategies in virtual world. This all should be achieved before the actual work starts at construction sites. By

rehearsing different scenarios in virtual environment, construction congestions and H&S hotspots can be identified and resolved.

Moreover, traditional training methods have certain deficiency in delivering the knowledge of safety identification as compared with new eLearning methods (Ho, C. and Dzeng, R., 2010), and through experiment; 3D models proved to deliver better understanding of construction objects rather than 2D drawings (Dawood and Sikka, 2008). Moreover, using 3D game experience can improve the learning of the students and construction personnel in identifying the safety hazards though a game playing scenarios (Lin et al., 2011). In order for virtual training methods through the use of 3D game engines to be effective, they should have the following design functionalities which was proposed by Sherif and Mekkawi (2006) for effective computer based learning. These are:

- The real effect of the game using the optimum visual effects with least possible complex "collection boundaries"
- Stimulation of self-learning environment
- Interaction of the game by providing different levels
- Guidance to the player to able to deal with the game, like sample scenarios
- Unpredictability of the game situations even within the same game level
- User level of performance, by providing score bar shows how the player is progressing
- To have level of enjoyed game experience like allowing players to have more customization to their avatars
- The minimum risk learning experience though learning from the games instead from real site situations

Previous research projects have tested two pilot studies using game engines for construction safety. The first one was tested using Torque 3D game engine on construction engineering students where a game developed to allow students to identify the site hazards and it was found that the students had a passive impact in learning hazards though game. (Lin et al., 2011). The other study was developed to simulate plant operation using 3DVIA, and it was tested by plant operators. The feedback was quite positive from the operators that the technology assisted them to identify some of the risks in virtual environment prior to starting the actual site work. (Guo et al , 2011).

This paper is a part of a major study regarding current practices of H&S in Qatar construction industry, which is important to identify the safety hazards within the industry ultimately proposing strategies to reduce the effect of these hazards and how new training methods using visualization and serious game engines to integrate design, construction and H&S rules can improve such practices. The reminder of this paper discuss data collection techniques, analysis of data, discussions of findings and a brief introduction of how serious game engines can utilized for H&S training to improve the overall construction site risk hazards awareness.

2. DATA COLLECTION

In this study, the semi-structured interview technique was used to collect data from construction managers. This is an essential technique for tacit knowledge and information acquisition methodologies. The purpose of using the semi structured interview is to obtain specific quantitative and qualitative information from a sample/pre-selected number of people, and to gain relevant information on specific issues. The semi-structured interview combines a structured agenda with the flexibility to ask subsequent questions.

From the consideration discussed above, in order to achieve the desired objectives from a semi-structured interview, the following precaution should be taken into a consideration:

- Design an interview framework prior to data collection,
- Send the set of questions to interviewees so they can prepare answers,

- Prepare an interview guide,
- Take only brief notes during the interview,
- Take a full record of the interview,
- Use probes and prompts to get as much information as possible,
- Don't fail to listen,
- Analyze the information at the end of each interview or day of interviewing.

Questionnaire were designed in order to be used as a guide for the interview; these questionnaires had 16 questions distributed into 3 sections, which are General information about the organization to draw an understanding about the company, Identification of H&S risks within the organization, and Understand the possible methods of training. These questioners shared with 19 professional companies and feedback was collected and analysed.

3. DATA ANALYSIS

3.1 Type of Hazards

From the analysis of questionnaire, the major health and safety risks Qatar and their ranking according to responses are shown in table 1.

Table 1: Rank Comparison table for the major health and safety risks on-site

Type of Work	Rank*
Working at Height	1
Falling objects	3
Use of Dangerous Machinery	5
Excavation	1
Manual Handling	2
Electrical Hazards	1
Housekeeping Hazards	2
Hazardous chemical	3
Noise	3
Confined Spaces	2
Sharing workspace	4
High Pressure Equipment	5

From table (1) responses showed that "Working at High" is one of the most critical risk factors which conforms the HSE Qatar annual report results and in term this report emphasize the importance of this risk within the Qatari construction sites. The second rank was shared by Electrical hazards which is due to bad practices within the Qatari construction sites in dealing with electricity on construction sites and causes a lot of accidents, and Housekeeping is highly ranked by Qatari industry, which is due to bad construction practices too in the Qatari Construction industry which cause serious accidents to the workface or even fires, and Confined spaces are highly ranked by Qatari which is due to bad practices too in the Qatari Construction industry which cause serious accidents or death to the workforce and Risk in excavation which can be explained by the nature of the construction projects in Qatar are high raised buildings with deep excavation. Also, Electrical hazards are highly ranked by Qatari industry, which is due to bad practices within the Qatari construction sites in dealing with electricity on construction sites

and causes a lot of accidents, 'manual handling' , and "Housekeeping" is ranked second by Qatari industry, which is due to bad construction practices too in the Qatari Construction industry which cause serious accidents to the workface or even fires, and Confined spaces are highly ranked by Qatari which is due to bad practices too in the Qatari Construction industry which cause serious accidents or death to the workforce

Then followed by 'falling object', 'chemical hazardous', and 'noise' risks which implies that Qatar industry understand the effect these types of risks and their effect on the construction sites. Moreover the Use of Dangerous Machinery is low ranked by Qatari industry as the construction labour within the Qatari construction are expatriates and in case of accident the insurance company pays the indemnity then the labour is sent to his country of original.

3.2 Mitigation Methods

When they were asked about the methods of mitigating these risks. Questionnaires showed that traditional risks assessments and method statements are usually carried by the planning and design team before the actual work starts and/or during the construction phase. And the questionnaire showed that proper Personal Protective Equipment (PPE) plays a major role in mitigating these risks, and proper signage and tools, which are considered as first line defense in any construction project, because if these are not implemented training alone will have no effect on improving health and safety maters in the construction site.

3.3 Current methods of training used by the companies

Table 2 shows current training methods, it was found the most preferable training method is' induction training sessions', which is used to introduce the workers at the site risks and the risks related to their work at the site, followed by 'lectures or presentations', 'on-site training exercises', and 'mock training exercises' with are the most common methods within the both construction industries because of their low cost, and easy to implement. However, 'third party training' and 'external certification' are not applicable at the Qatari Construction sites because there is no authorities that request this type of training or certification. Moreover, Video instructions was raked law may be due to work culture issues.

Table 2: Ranking table for the current methods of training used by the companies

Training Method	Rank
Induction Training sessions	1
Lectures or presentation	2
On-site training exercises	3
Video instructions	5
Mock training exercises	4
Training computer game	0

3.4 Methods allow worker to be aware of their safety responsibilities at site:

Table 3 shows types of factors that will assist works to be aware of H&S at site. It was noticed that the both industries in UK and Qatar have similar ranking for the Health and Safety training which was ranked the first and the periodical training was ranked second, while Tool box talks was ranked 1 and 2 in UK and Qatar sequentially. This implies that level of maturity of both counties in the ways of ensuring that the safety methods implementation during working at the site. However, the Qatari industry showed less interest on the On-site documentation and safety passport as there is no certain authority in Qatar responsible on the health and safety which requests these items.

Table 3: Ranking table for the methods allow worker to be aware of their safety responsibilities at site:

Type of training for H&S	Rank
H&E training	1
Periodic checks	2
Use of HSE tools : Tool box talks	2
On site documentation	3
Use of HSE tools: Safety passport	4

3.5 Barriers of proper training

The feedback from the Qatar questioner showed that the cultural (like: Literacy/intelligence, qualification, age, experience, and language) barrier is affecting the level of safety awareness in Qatari construction. Other drawbacks can be communications (different languages) as most of the workers in Qatar are uneducated and from countries like India and Nepal (which are known with different languages within the same country) with no English or Urdu background makes the communications of H&S difficult and almost impossible, lack of motivation, routine, budget, time, attitude, changing the workforce frequently, and management support and believe on the necessity of the training, are the most important barriers.

3.6 Best method to deliver H&S training

Responses showed that on-site training exercises and Mock training exercises as the best practices, however the training using game engines was placed third and one of them suggested Monthly Gathering for discussion, achievements, and Safety Awards my improve the workers interest and improve health and safety practices at side.

3.7 Alternative Training Methods

The feedbacks from the questionnaire was 83% though that it will have an influence while 17% thought it will not. The participants who agreed on that elaborated that advantages of that is Self-based training sessions can be taken any time to fit busy lives of professionals, It can explain better than lecture practices, Training them first and provide them with the material after that they can train independently using computer at any time, Increase awareness by knowing the construction hazards, the lessons learned through this type of training will help them to deal with a real life situation to a safe ending, Improve knowledge and confidence, and It will be easier for the employees to understand the visual methods.

4. FINDINGS

Form the above results above, questionnaire and interviews; we can list the following findings:

- Qatari Health and Safety procedures are still not mature, and not well developed and regulated by law. Therefore, the Qatari questionnaire showed that more support is required to implement the safety requirement from owners, and higher managements.
- Health and safety at the Qatari construction sites regulation is scattered between ministry of municipality, civil defense, and labor authority. Even though, the new QCS 2010, provided a chapter including the safety procedures on sites, but these guidelines are not regulated and it is optional to

be implemented and no authority within Qatar produces data related to fatalities within the construction industry.

- Most of the companies in Qatar uses the regular methods of risk mitigation like PPEs, proper signage and risk assessment.

- Results showed that the best training method is the induction training sessions, and the best methods to keep the workers aware of the health and safety training were H&E training, and periodic checks. Were we can say that the training is the most preferable method for educating the workers about the health and safety.

- It was noticed that workers cultural habits plays a major role in site accidents, which with good training plan these habits can be changed as proved in case study was done in USA in one of the companies. They have been able to change the workers cultural habits and they became part of safer construction site committee. Each workers started to look for the risks and report them, rather than only to be the safety officers responsibility. The result of that, significant reduction of accidents was noticed (Flentge, 2011). This case study is a living proof that cultural habits can be changed with proper training and responsibility is given to the workers.

- Pressures on schedule is affecting the training procedures which sometime shift training to second priority than first to be first priority. this serious issue can be mitigated by proper safety planning in the planning phase, which will reduce rework and project's time and cost risks.

- Companies at Qatar preferred the onsite training exercises and mock-up training are the best, which virtual training may support to a good extend.

- At the end, replies regarding if they think that game engines may support the training of health and safety were positive, which opens the door to develop more this technologies in these counties, and reflect the readiness of the market of these counties to introduce new training method such as game engines at least the higher level of the project employees. However, the study showed that there is some limitation for the game engines like simulation of the manual handing and simulation of using tools, rather than other technical difficulties using the collision detection function for many objects at the same area.

- Even though, Qatar construction sites has not tested the possibilities of using the gaming engines within the construction sites as yet, but from the literature review many studies was initiated to develop health and safety training games at different countries (table 4) , because from the experiments it was proved 3D models proved to deliver better understanding of objects rather than 2D drawings (Dawood and Sikka, 2008). Moreover, using 3D game experience can improve the learning of the students and construction personnel in identifying the safety hazards though a game playing scenarios (Lin et al., 2011), which may help to overcome some of the regular training barriers like language barriers within Qatar construction industry. However, each study has considered one part of the following issues which are the compatibility of current 3D engineering software (AutoCAD, BIM, Revit…etc) with game engines, how these games can be more dynamic to mimic the changing status of the project, interaction with the game and other players, but no one considered them all in one training game. Different game engines were used in previous studies which listed in table 4.

Table 4 : Different game engines

Game Engine Used	Application	Implementers
Torque 3D	Training for Construction Management Students	University of Washington, USA University of Nebraska-Lincoln, USA
3DViva	Training for plant operators (specially crane operators)	The Hong Kong Polytechnic University, Hong Kong Tsinghua University, China Queensland University of Technology, Australia
World Up	Risk Visualization in design phase	University of Hong Kong, Hong Kong

5. CONCLUSION

In conclusion, the construction industry in Qatar still need more improvement in health and safety procedures due to high number of fatal injuries comparing it with the other industries. The semi-structured interviews was developed and conducted amongst 19 professional construction companies in Qatar to understand more H&S risks, and investigate how new technology can improve H&S knowledge. It was found that in order to improve the health and safety training of site workers plays a major role to minimize H&S accidents and injuries. And most of the companies gave a positive feedback about the role of visualization, especially serious game engines in training of workers where it can improve their understanding for the sites risks, which gives indication that both of countries can be ready to accept the new method of visualized training. Moreover, previous pilot studies on using game engines in health and safety training showed that they can deliver better understanding of the project risks more than the regular training methods, furthermore, Falls accidents are the major cause for fatal accidents as resulted from the both questionnaires. In this regard, the development of training games for this kind of accidents should be considered intensively. And, from the pilot studies many game engines were used like: Torque 3D, World Up, and 3DVIA. In this study we will consider unity because it offers better file exchange experience, easy to use, it supports different well known programming languages like JavaScript, and C#, available free sources of scripts, and many other advantages.

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