THE POTENTIAL FOR USING INTERACTIVE SCENARIOS IN THE TEACHING AND LEARNING OF HEALTH AND SAFETY

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Despite recent improvement in health and safety, possibly stimulated by the Revitalizing Health and Safety strategy, construction still has more fatalities than any other industry. The education sector, industry and government have a clear responsibility to continue to improve the situation and push forward a more safety conscious industry. The Civil Engineering Group at Leeds Metropolitan University has undergone a process of embedding the teaching and learning of health and safety throughout the curriculum. Initially, one change to the delivery of health and safety material was introduced in a paper-based form set around a number of construction site scenarios. The scenarios were real world examples, facilitated and supported by industrial partners and were used with student groups in the identification of potential hazards and risks, and to prescribe control measures. Recently, utilizing web expertise developed on other education projects, work has started to explore the potential to create interactive 360 degree panoramas of construction sites to highlight health and safety issues. Previous experience in the use of interactive virtual training platforms has proved successful and is well received by students. The concept of integrating health and safety information within virtual environments created from 360 degree photographs and videos of real situations is an obvious one, but is not without barriers. Reflections on the experiences and benefits are presented together with methods of evaluating the use and effectiveness of these virtual training platforms.

Keywords: evaluation, panoramas, safety, scenarios, teaching.

INTRODUCTION

The Revitalizing Health and Safety strategy, launched in 2000 by the Government and Health and Safety Commission, set three measurable targets for improving health and safety performance across all industries over a 10 year period. These were to reduce the incidence rate of fatalities and major injuries by 10%, work-related ill health by 20% and the number of working days lost from work-related injury and ill health by 30%. The assessment of progress made against these national targets is produced annually by the Health and Safety Executive (HSE) based on statistics from a number of different sources. Based on the latest report published by HSE (2009) the majority of the targets will be met. However, despite significant reductions over the last decade construction still remains one of the most dangerous of the main industrial groups. The latest published statistics for 2008/09 show that there were 53 fatal injuries, a rate

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of 2.5 per 100 000 workers, whilst reported major injuries are the highest of any industrial group at 254 per 100 000 workers (HSE, 2010). The main causes of these injuries were falls from height, falling objects, contact with moving machinery, collapses/overturns and electricity. In addition to the legal and ethical aspects of health and safety, this incidence rate also has an economic consequence with estimates obtained from the Labour Force Survey indicating that three million full working days were lost in this period due to work related injury and ill health.

Over the last decade several documents have been published which have recommended the incorporation of health, safety and risk management concepts into the undergraduate curriculum. This was initiated by the Revitalizing Health and Safety strategy and was subsequently reinforced in a report commissioned by the HSE entitled Identification and management of risk in undergraduate construction courses (Carpenter *et al.*, 2004). This report challenged the construction professions such as CIOB, ICE, RIBA and RICS, the universities and other training organizations to improve the teaching of health and safety. In particular, improvements on construction courses for safety-critical professionals – those in a position to manage risk arising from work activities, were identified. This has subsequently led to guidance being produced by the professional bodies that accredit undergraduate courses, for example, Annex D – Health and Safety Risk Management produced by the Joint Board of Moderators (JBM, 2009).

The experience of the Civil Engineering Group in auditing and enhancing undergraduate health and safety provision is reviewed and critiqued. Consideration will be given as to how core health and safety is taught and assessed, together with the use of paper based scenarios in the learning process and in formative assessment and feedback. The experience gained through this process is now being used by the Centre for Knowledge Exchange at Leeds Met to develop 360 degree panoramas as a virtual training platform for the teaching and learning of health and safety. This technology allows a full 360 degree view of a site with the inclusion of descriptive texts, detailed still photography, video clips as well self evaluation exercises. This virtual training platform provides a more realistic view of the site operations with potential for improved recognition of hazards, risks and controls. Finally, the advantages and disadvantages of this learning media compared with other approaches will be explored and potential evaluation tools identified.

LEEDS MET CIVIL ENGINEERING GROUP EXPERIENCE

The Civil Engineering Group forms part of the School of the Built Environment at Leeds Metropolitan University and delivers undergraduate courses in civil engineering to both full and part-time students. Following a professional body accreditation visit, the group were tasked with improving the embedment of health and safety cross all of the modules and specifically, “health, safety and risk management need to be more overt within the course” (JBM, 2005). Prior to the visit, health and safety was being addressed at School level through an induction lecture and by risk assessments associated with practical work in laboratories and in surveying. In addition, a limited number of modules covered the legal framework for health and safety together with some coverage of the practical management of health and safety.

The course team recognized that there needed to be a core structured delivery of health and safety together with substantial assessment and for this to be reinforced by specific embedment and consolidation across all appropriate modules. Civil

Engineering Management modules at Levels 4 and 5 were amended to incorporate the core delivery as shown below.

Civil Engineering Management A – level four
Health and safety performance in the construction industry. Recognition of key hazards. Health, safety and welfare legislative requirements in the design and delivery of civil engineering projects including the Health and Safety at Work Act (1974), approved codes of practice and guidance notes. Current industry initiatives. Professional responsibilities of civil engineers in relation to health, safety and welfare. Reporting of Incidents, Diseases and Dangerous Occurrences Regulations (RIDDOR). Preparation of qualitative risk assessments and method statements from typical civil engineering construction scenarios using a 3 x 3 matrix.

Formative assessment through critiqued group exercise and summative assessment as a specific component of coursework and as part of a closed-book phase test.

Civil Engineering Management B – level five
Construction (Design and Management) (CDM) Regulations 2007 and roles and responsibilities, preconstruction information, construction phase health and safety plan and the health and safety file. Principles of prevention from Schedule 1 of the Management of Health Safety and Work Regulations (1999). Fault and event tree analysis. Health and safety considerations in relation to more complex construction situations. Economics of risk reduction expenditure. Site layout, accommodation and facilities. Quantitative risk assessment using a 5 x 5 matrix.

Formal assessment through application during coursework and as a compulsory component of a closed book end examination.

In addition to formal delivery of this material through lectures, students also attend an IT session where attention is drawn to the range of HSE material available from their website (www.hse.gov.uk). All students are required to download the Approved Code of Practice (ACOP) Managing Health and Safety in Construction (HSE, 2007) for use throughout their studies and they are encouraged to register on the e-bulletin service to receive latest information on health and safety developments.

Approximately 30% of the assessment of each of the two Civil Engineering Management modules is health and safety specific and the assessment comprises both coursework and the use of a multiple choice examination. A particular feature of the Level 4 module is the use of scenarios where students work in small groups to identify hazards and risks associated with a construction activity and make a short presentation back to the whole cohort.

The changes made to the delivery of health and safety continues to be evaluated through formal module evaluation and through discussion groups with students. A key point made by students has been the importance of revisiting and consolidating important concepts. Both full and part-time students identified that health and safety was being contextualized appropriately in relevant modules. Particular emphasis was placed on the use of the scenarios which the students found especially useful. They did, however, consider that these might be of more use if available prior to the presentation session. The embedment process was also discussed with the civil engineering staff. The consensus was that their awareness of developments within health and safety in their own professional expertise had been raised but it was recognized that this was an area where cascading of latest information and developments to staff is important.

SCENARIO DEVELOPMENT FACILITATED BY CKE

The development of the scenarios used at Level 4 was facilitated by a Construction Knowledge Exchange (CKE, 2009) project working with industry partners with the objectives of.

- Visually enhancing and further developing scenario based health and safety teaching material.
- Ensuring the teaching material is fully relevant to all aspects of civil engineering construction.
- Ensuring the teaching material properly reflects the latest developments in industrial practice.

Written scenarios had been used previously which simply described a construction situation from which students were to identify hazards and associated risks. These were not really adequate. A small group of industrial partners was identified from Advisory Group members and past students. These were selected to cover a broad range of industry and because of their commitment to supporting the University. It is recognized and is the authors' experience that there is reluctance to provide health and safety materials. This was overcome by working collaboratively to capture examples of good practice. Working with these industrial partners, the CKE project developed new scenarios with each having a description of a civil engineering process together with associated photographs of the process and health and safety control measures. Whilst still paper based, these are a considerable improvement on their word-based predecessors. An example of a typical scenario, facilitated by Amey, is shown in Figure 1.

Six of these scenarios have been developed. Working in small groups, students review the activity, identify potential hazards, risks and control measures and develop a basic method statement. This is then presented to the whole cohort and receives formative feedback from both tutors and peers.

The engagement of industrial partners through the CKE Project has not only ensured the availability of high quality up to date learning materials but has also been of considerable benefit in terms of staff development. This engagement of industrial partners is wholly in line with Appendix 3 of HSE Research Report 275 (Carpenter *et al.*, 2004) where both industrial and professional body contributions are identified as good practice in the development and delivery of health and safety.

The use of the scenarios has received positive feedback from students who enter into lively debate during the analysis and who generally develop a comprehensive range of hazards, risks and control measures. The students comprise both full-time with no industrial experience, and part-time with extensive industrial experience and exposure to a broad range of health and safety training. A common confusion at this stage by both groups is the difference between hazard and risk and the presentation to tutors and peers allows this to be discussed and corrected. Interestingly, this process receives acclaims from the part-time students who can sometimes be disengaged and even cynical when faced with academics discussing matters in which they feel they are already well experienced. The successful engagement with students links to a common feature of student feedback. Students frequently ask for more relevant examples and case studies which these scenarios satisfy. They also fulfil the visual learning style needs within the student cohort.

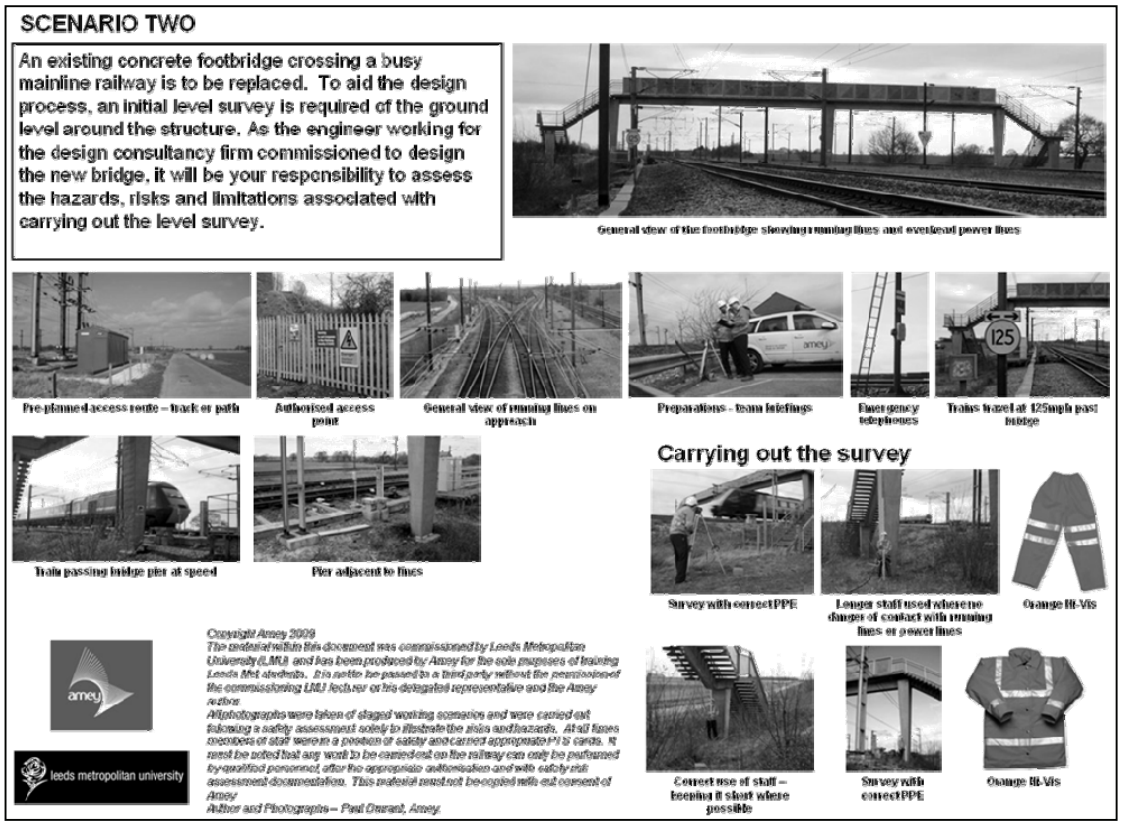

Figure 1: A typical scenario

THE DEVELOPMENT OF 360 DEGREE PANORAMAS

While these paper based scenarios are well received by students, technological developments in the creation of learning platforms provides the opportunity to further develop the scenarios using an interactive environment. Panoramic environments have been used for several years as part of the development of the School of the Built Environment's Virtual Site. They are invaluable to construction as they can show a full view of a site or the development stages of a building. In the last year these tools have been turned towards health and safety after internal funding was granted by the University to develop a pilot learning example. The University estate has undergone considerable development over the past decade. Establishing partnerships with the contractors involved has enabled the development of a number of virtual training platforms, together with 24 hour web cam surveillance of construction activity, site visits and contributions to the still photograph library.

The Centre for Knowledge Exchange tools are open access and online (for example the Virtual Site project – www.leedsmet.ac.uk/teaching/vsite and the Virtual Maths site – www.virtualmaths.org). Open access technology repositories are being created for research and education through JISC funds (JISC 2010). In areas such as research, the savings gained through the development of open access resources are claimed to be in the region of £172 million (JISC 2010; Houghton *et al.* 2009). By reducing duplication and increasing widening participation, web-based health and safety could elicit huge savings. Although the materials being developed for this project are highly interactive web based resources, previous research into online teaching and training tools were found to be more effective when they combined interactive tools with more traditional paper based tools that were downloadable from the site (Gorse *et al.* 2008; 2009a, b.). A health and safety repository that has both interactive panoramas

supported with video and downloadable resources improves the potential to capture the learner's interest.

The potential of 360 degree panoramas for health and safety

The development of the panoramas has the potential to modernize education on health and safety. Existing methods rely on a significant amount of specific knowledge to pass tests and gain credentials (e.g. the Construction Skills Certification Scheme). By utilizing a 360 degree panoramic environment users are able to see a snapshot of a building site in action. These virtual training platforms can be customized to show almost any information. This versatility creates a dynamic tool that has applications at both site level and to the wider public as an educational resource.

Benefits and barriers

Panoramic virtual training platforms have a wide usability in many formats. When used as an educational resource they can help inform people on the health and safety issues that exist on a construction site. They allow a user to view the site without having to actually be there, thus avoiding issues that may result from taking people onto site who are not fully qualified or experienced. This virtual experience can also prepare users for when they arrive on site. In addition, providing a real context for learners has already been found to be beneficial in other learning environments (Gorse *et al.* 2008; 2009a, b). Stothers (2007) reported on the benefits of these technologies in training construction managers. It was found that 'learning by doing' in a virtual environment was more successful than traditional teaching methods alone. This was attributed to the wide range of information that can be presented. The relative ease with which they can be created means that any site could have a panoramic virtual training platform to show new employees or visitors as part of a site induction. The use of virtual technology at this stage may well mitigate against the greater risk of injury to new arrivals on a site (CITB, 2006). Finally, virtual training platforms, being web based, are accessible at all times and can be continually revisited. This links directly to student evaluation of paper based scenarios where time to research was requested and the ability to revisit to consolidate understanding.

There are issues however when creating any resource based on a construction site. The most significant is the issue of bad practice; no site is perfect and there will always be something that may be open to criticism. Understandably companies do not wish to suffer any damage to reputation, and there is often reluctance to facilitate the capture of site operations. Recently, two panoramas developed from separate site visits were rejected by the site manager on the basis of minor health and safety housekeeping issues. In addition to time and cost implications, this poses a potential barrier to developing this research. There are also issues with integrating this approach into existing training materials. The panoramas are intended to be an in-depth view of the site, its layout and operations at one point in time. As work changes they will need to be updated to keep pace. Some companies may prefer to keep something simpler that doesn't require the same maintenance and upkeep.

The ability to produce materials that are accessible, through web environments, is increasingly important for education (Hodges 2009; JISC 2009). As a medium, the web can be used to distribute resources globally, improving the potential for distance learning and open access. Indeed, to help capitalize on this there are a number of programmes underway to expand and release open education material with the aim of reducing duplication, reducing the cost of producing materials and improving quality (Attwood 2009; JISC 2009; 2010).

EVALUATION TOOLS

Evaluation of the virtual training platform will be essential for the successful development of a usable and effective learning tool. It is possible to evaluate technology based education and training packages in a number of ways. Many disciplines, including ergonomics, human-computer interaction, psychology, sociology and computer science, can contribute to this process (Waterson, 2000). Literature focussed on training evaluation, as well as literature on the usability of software provide a useful starting point for the evaluation of this package. These two bodies of literature focus on different aims. Training evaluation, mainly stemming from the areas of Human Resource Management and Occupational Psychology, seeks to assess the effectiveness of training in terms of learning and transfer of learning beyond the training session. Literature from the discipline of Ergonomics, encompassing human-computer interaction, attempts to assess the usability of the software and bring about improvements in design.

Evaluation of software usability

> *"Usability is a measure of interface quality that refers to the effectiveness, efficacy and satisfaction with which users can perform tasks with a tool. Evaluating usability is now considered an essential part of the system development process…"* (Dillon, 2001: 1110).

Evaluation methods used to assess the usability of software fall into three main groups: user-based, expert-based, and model based. Although user-based methods, where intended users trial the package, are more research intensive, they are said to provide the most reliable and valid assessment of usability (Dillon, 2001).

It is envisaged that user-based assessment will be employed to determine the usability of the platform. There are a number of options in terms of methods, including.

- Questionnaires, interviews or focus groups – these could be conducted once the user-group have tried the platform and would focus on their likes, dislikes and suggestions for changes.
- Think-aloud (verbal) protocols – require the user to verbalize their thoughts. This can be: concurrent, while performing a task; retrospective, post-task, while viewing a recording; or constructive interaction, two users perform the task and verbalize together (Van den Haak, de Jong and Schellens, 2004). Verbal protocols are said to be one of the most effective means of evaluating the usability of software (Henderson, Smith, Podd and Varela-Alvarez, 1995).
- Logged data – monitors what the user does on the computer (e.g. click rate, duration, errors, keys activated). The advantage of this is that it is an inconspicuous form of data collection, but there are potential problems with interpretation (Linek, Marte, and Albert, 2008) e.g. someone spends a long time in one area of the platform, does this mean they like it OR that they have difficulty using it? This type of data could be useful, but subjective user information should be collected to ensure accurate interpretation.

Learning/training evaluation

Training evaluation is conducted to determine (1) whether the training objectives were achieved, and (2) if this resulted in improved performance on the job (Kraiger, Ford, and Salas, 1993). It can take place at a number of levels and can be performed using a wide range of methodologies. The most widely referred to model for training evaluation is Kirkpatrick (2007) who advocates evaluation at four levels.

Level 1 – reaction
This is typically assessed with reaction (happy/smile) sheets. This will simply assess how happy people are with the platform. Although items will be included assessing factors such as what people find most useful, it should be noted that a comprehensive usability evaluation with be carried out in the training sessions.

Level 2 – learning
This level assesses new knowledge, skills and attitudes. Attempts will be made to assess if the platform has enabled the students to learn about health and safety effectively. This could involve tests embedded within the platform or paper based tests. In order to demonstrate that a change has taken place tests should also be carried out before people use the platform.

Level 3 – behaviour change
Behaviour change or the transfer of training to the workplace is a key stage of the evaluation process. This will not be assessed until the platform is trialled with industry. This could be measured using interviews with managers or observing behaviour. Again, pre and post measures should be used.

Level 4 – results
This level assesses how effective the training programme has been at producing the desired results in the workplace. The desired results in this instance are a reduction in workplace accidents and near misses, and improved safety behaviour. This will be assessed when the platform is trialled with industry by comparing sites that have used the platform and those that have not. This comparison will also give an indication of return on investment, by analysis of the cost savings produced by reduced accident levels and the resources needed to implement the system.

Evaluation design of 360 degree panoramas
The final research design has not been decided upon. However, several recommendations are made for the evaluation research design. This will enable the evaluation to accurately assess whether 360 degree panoramas are fit for purpose (i.e. are usable, have an effect on learning and behaviour, determine the cost / benefit implications for organizations, and counter threats to validity).

Design recommendations

- Multiple methods should be used to comprehensively assess the usability of 360 degree panoramas e.g. a combination of focus groups, think-aloud protocols and logged data.
- Pre and post measures should be taken when assessing learning. Ideally, immediate and long-term learning will be assessed.
- A control group should be used to determine the influence of other variables.
- When trialled in industry, it is important to determine changes in safety behaviour and accident levels (e.g. by using accident data, direct observation, or management assessment).
- Accident and safety behaviour data should also be used to determine the cost effectiveness of the use of 360 degree panoramas in comparison to other types of safety training / intervention.

CONCLUSIONS

The importance of the incorporation of health, safety and risk management into the undergraduate curriculum has been recognized. The initiatives established by the HSE and the specific requirements of professional bodies have been reviewed and the

particular experience of the embedment of health and safety into the civil engineering undergraduate curriculum at Leeds Met has been described and student evaluation critiqued.

Although health and safety is not always perceived as an interesting subject, experiences of developing and using paper based scenario activities have received positive feedback from students and have enhanced student learning, particularly that of full-time students. The positive response to the immediate formative assessment given during scenario use is of particular interest as this is easy to include in a virtual training platform.

The potential for the incorporation of these scenario activities and other exercises into a virtual training platform has been considered but engaging appropriate partners willing to allow capture of site operations has been identified as problematic. These panoramic environments have been used for several years for other subjects such as construction technology and mathematics, however, their potential for use in the teaching of health and safety is yet to be established.

Finally, the evaluation of this virtual learning platform is currently hypothetical, however it is envisaged that usability of the platform and the reaction and learning of students will be assessed. The potential for trialling the wider use of the learning platform in industry will also be considered to assess its impacts in relation to safety behaviour and incident levels.

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