Experiential learning using a computer-based virtual reconstruction of an accident investigation

Nicola Stacey* (Nicola.Stacey@hsl.gov.uk), Nick Underwood^ (N.J.Underwood@liverpool.ac.uk), Dr Graham Schleyer^ (Schleyer@liv.ac.uk), Dr Olanrewaju Okunribido* (olanrewaju.okunribido@hsl.gov.uk).

*Health and Safety Laboratory, UK; ^The University of Liverpool, UK

Abstract: When major engineering projects end in disaster, there is often also loss of life, heavy financial cost and fines for those involved. While the consequences of engineering failures can be tragic, they do provide a unique opportunity to learn from reality, which is rarely possible in a traditional laboratory exercise. Indeed, the analysis of engineering failures can help students to better understand the importance of applying engineering principles correctly.

A group exercise has been developed for use with first year students, which is based on a real life accident, the collapse of a passenger walkway at the Port of Ramsgate in 1994. This exercise has evolved from a paper based exercise in which students retrieve information from folders and explore models of the accident scene and failed structural component in order to complete tasks specified on worksheets. Students work in teams, sharing out tasks amongst themselves to look at different aspects of the accident (design appraisal, stress analysis, metallurgical inspection and operational management). They then share their findings with one another in sufficient depth so that each student can then individually write a one-page 'expert witness' statement. The exercise is currently run using a virtual reconstruction of the accident scene as a computer simulation with all the relevant information embedded and presented in a stimulating manner. Removing the dependence on the physical model of the accident scene means that the exercise could potentially be used more widely, for example by other universities.

In this workshop delegates will be given the opportunity to use the computer package, discuss student learning outcomes and how the package could be made more widely available by others.

Introduction

The Health and Safety Laboratory (HSL) and the University of Liverpool have for several years collaborated to develop teaching materials for use in undergraduate engineering courses to increase knowledge and awareness of health and safety risk concepts in the context of engineering design (Stacey et al, 2009). During this time an experiential accident investigation laboratory exercise for first year undergraduate engineering students was developed. Other resources developed and discovered during this project can be downloaded from the risk education network (Stacey and Bowen 2012).

The purpose of the laboratory exercise is to help students understand how engineering design, project management and quality assurance, if not done properly, can have catastrophic consequences. The exercise also helps students understand the wider implications of their activities as professional engineers in society and appreciate their responsibilities as professional engineers to adequately manage risk.

The accident upon which the student exercise is based.

Just before 1 am on 14th September 1994 at the Port of Ramsgate, one end of a walkway, used by foot passengers to embark onto cross-channel ferries, fell 10 metres causing the death of six
passengers and severe multiple injuries to seven others. The walkway had only been in service for four months. Health and Safety Executive (HSE, 2000) inspectors quickly found that the immediate cause was the failure of the weld securing the end of the right-hand seaward stub axle to the walkway.

Come to this workshop to find out why it happened, who was fined £1.7 million and ordered to pay HSE’s £0.7 million costs - or read the HSE investigation report.

**Description of accident investigation exercise for students**

The accident investigation exercise was originally paper-based (Schleyer et al, 2008) and designed to run as either a single 3-hour ‘jig-saw’ learning session (whereby students each seek out different information and report back to the rest) or as a series of five 3-hour sessions, each of which build upon the findings of the previous one. Students working in small groups of up to ten individuals take on the role of an accident investigation team sorting through information about the accident. They have to agree how to share out the tasks specified in the worksheets between themselves in order to look at the accident from different perspectives (design appraisal, stress analysis, operational risk management, and metallurgical inspection). They might work on these tasks individually or in smaller groups. Based on their analysis of the available evidence, students then present their findings to the whole group and are encouraged to question and discuss one another’s findings. After the exercise, they each write short individual ‘expert witness’ statements about the accident, including their opinions about why the accident happened, the root causes, and who was responsible. Marks are awarded for the worksheets completed during the session and their individual statement, which is handed in later.

The computer-based version of the exercise, using the simulated accident scene, was fully integrated into an undergraduate laboratory at the University of Liverpool in March 2010. It has since then been used annually, with all first year students in the Engineering School, to successfully deliver an enriched experience with the same learning outcomes as the paper-based version. All the information the students need, including an introductory presentation to set the scene, explain the accident and in general what students are required to do, is embedded in different parts of the simulation. For example design drawings, a diary of key dates, correspondence between the different organisations, a maintenance log and analyses conducted by the accident investigators are located on the shelves, on the desk and wall in a simulated office building. Various witnesses are located around the site, which when selected provide statements as to what they saw or did in the form of a speech bubble. These give graphic details of the damage and injuries caused by the accident to help emphasise the severity of the accident but also sometimes give clues as to where to look for more information. The safety critical component is modelled in detail and the six degrees of freedom of the floating pontoon are animated. The simulation allows students to interact with it to retrieve information, study different aspects, in an order of their own choosing, at their own pace, returning to them as necessary. In this way the exercise better caters for a wide range of abilities. Removing the need to use the wooden models also enables the exercise to be used more flexibly and potentially makes it easier for other universities to use it.

**Student Feedback**

Feedback from students (Underwood, 2008) on the paper-based exercise found that over half of the students (53%) felt that the there was insufficient time to carry out the exercise, an appreciable number (27%), found it difficult visualising the structural components or identifying the cause of the accident and the majority (94%) said that they thought a virtual reality reconstruction of the accident scene would be useful with over half (57%) saying it would be very useful.

Feedback from students on the computer simulation of the accident scene has been very positive. Whilst this exercise is not evaluated separately from the other laboratories, associated with the Strength of Materials module to which it is linked it is often singled out by students as the main reason why they have given positive feedback. Many say that they find the computer-based exercise engaging and easy to follow. Observations of how students used the simulation to compete the accident investigation exercise and what aspects they continued to find difficult, along with their suggestions has led to a number of refinements and enhancements. This included a demand for more information to be embedded into the simulation. The latest version, which should be completed in time for this workshop for example will embed a stress analysis model of the critical foot assembly that failed, showing how the stresses change with the movement of the pontoon. Once final enhancements have been made to the exercise, both the simulation and the worksheets, it will be formally evaluated through observation and student feedback.
Implementation

This laboratory exercise has been designed to be directly linked to a relevant teaching module such as (as in the case of the University of Liverpool) Strength of Materials, a Civil Engineering Structural module or a Project Management module. However the approach taken in creating this laboratory exercise could be taken to develop a similar exercise, but based on a different accident that links better to other engineering topics. Information about several relevant accidents can be found on the Risk Education Network (Stacey and Bowen, 2012).

The laboratory demonstrator’s role is vital (Schleyer et al, 2008). They facilitate the exercise to give students the best chance of succeeding by: getting them to work as a team; ensuring that they understand what they need to do; encouraging them to search for clues; making sure they do not get overwhelmed with information and guiding them if they stray too far in the wrong direction. A good lab demonstrator knows when to step back to give students time to think things through for themselves and when to intervene to give them a nudge in the right direction. They also need to spot when the group is not working as a team, be able to encourage participation by asking questions and stimulate discussion. Several fun ice-breakers were also developed for the purpose of getting the students into the right frame of mind in terms of thinking about risk and also talking to one another at the start of the session. The workshop described below will benefit from being facilitated by those who created the laboratory exercise and which includes Nick Underwood who also has three years experience as a Laboratory Demonstrator.

Workshop Structure

Introductory presentation

This will be a short presentation about the Ramsgate accident investigation laboratory exercise including how it was developed and how it is currently used with first year students at the University of Liverpool.

Group activity 1: Role play and collaborative working

Delegates will be allocated into small groups and assigned to a computer, upon which is installed the virtual reconstruction of the accident scene. Each group will have an opportunity to use the simulation to complete one of four worksheets, based on those used by students, to look at the accident from different perspectives.

Debrief

Each group will then present their findings to everyone else. Once all the information has been gathered, they will engage in discussion about, why the accident happened, the root cause and who or what was responsible. This will also allow the participants to reflect on the experience of using the simulated accident scene and worksheets.

Group activity 2: Student learning outcomes

In this activity, delegates, in the same groups, will discuss potential learning outcomes for students based upon their experiences of using the simulation and worksheets.

Debrief

Each group will present their learning outcomes and discuss how they compare with those intended by the authors.

Final Q&A session

Delegates will have an opportunity to ask the facilitators any questions about the accident investigation exercise including the computer simulation of the accident scene, the worksheets, how it was developed, the time and resources required, why the particular approach taken was chosen, and how it is or could be used. Delegates will be invited to make suggestions on how the features of the simulated accident scene may be enhanced and to comment on whether and how the package could be made more widely available.
Workshop facilitation

The authors of this paper, who developed the accident investigation exercise, will facilitate the workshop session. They will be available to help delegates navigate around the computer based virtual reconstruction of the accident scene and to answer questions. In addition, one or both of the current laboratory demonstrators could also help facilitate if the number of delegates anticipated to attend the session will be greater than 20.

Workshop learning outcomes

By the end of the session, participants will:

- Have had experience of a unique approach to teaching professional, ethical and health and safety issues to students.
- Understand how a range of student learning outcomes can be achieved through using the computer-based accident investigation package.
- Understand the basics of how an accident is investigated to establish the root causes.
- Know how to use the package alongside the teaching of basic engineering principles to illustrate how inadequate application of engineering principles in practice could lead to a design that fails when put into service.

Acknowledgements

The Authors wish to thank the following for their invaluable contribution: Dean Turner and Anton Gordon at HSL for creating the simulation of the accident scene. Rui Fang Duan, a past postgraduate student at the University of Liverpool who helped develop the paper-based exercise. Steve Joel and Graham Norton (retired) from HSL who were part of the original team who investigated the accident, for their advice on how to use the accident as the basis for a student exercise and their memory for detail about the design and actual investigation. All the students who have tested the package, provided feedback and made suggestions. HSE and the University of Liverpool for providing the necessary funds and staff resources to bring the project to fruition.

References


Stacey, N, and Bowen, J., 2012. A community for sharing best practice and resources for teaching risk. 4th International Symposium of Engineering Education, Sheffield, UK 19 - 20 July 2012,


Copyright statement

University of Liverpool and Crown Copyright, Health and Safety Laboratory, © September 2012, authors as listed at the start of this paper. This work is licensed under the terms of the Open Government Licence. To view this licence, visit http://www.nationalarchives.gov.uk/doc/open-government-licence

This publication and the work it describes were co-funded by the Health and Safety Executive (HSE) and the University of Liverpool. Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE or the University of Liverpool policy.