Health and Safety Executive

Integrating risk concepts into undergraduate engineering courses

Prepared by the **Health and Safety Laboratory**
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Research Report

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Integrating risk concepts into undergraduate engineering courses

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This report describes a joint project conducted by HSL and the University of Liverpool Engineering Department to integrate risk concepts into their undergraduate engineering course. The project defined risk education learning outcomes that can be integrated into an undergraduate engineering curriculum and implementing them by merging new teaching materials (involving real accident case studies) into core engineering modules. The success of the project has been evaluated in terms of student's understanding of risk, at different points during their course, and interactions of the project team with academic staff. A student questionnaire of approximately 50 multiple-choice questions to ascertain student's understanding of risk was developed to support both development of materials and their evaluation. The report makes a number of recommendations for future collaboration between HSE and a range of stakeholders and relates these to HSE's 'Be part of the solution' strategy (2009), the ongoing sensible risk campaign and the EU campaign (2008-2009) to promote and demystify the risk assessment process. Issues raised, which other educational institutions seeking to undertake a similar process should consider, are: (1) Promotion of the risk theme to other members of staff who do not view it as a priority and gaining their support to allow inclusion of new materials in their modules; (2) Overcoming competing demands for time on the curriculum; (3) Motivating students to engage with the materials from the perspective of relevance, interest and marks; and (4) Remaining focused on the key objectives.

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EXECUTIVE SUMMARY

Objectives

This report describes a collaborative project between the Health and Safety Executive (HSE), the Health and Safety Laboratory (HSL) and the University of Liverpool in support of HSE's commitment, in its strategic plan 2001/2004, to work with higher and further education institutions to ensure that safety-critical professionals received adequate education in health and safety risk management. The overall goal of the project was to ensure that all students who complete their engineering course have a basic understanding of safety and health risk issues relevant to their specific course of professional study. The objectives required to achieve this goal were:

- To define a set of learning outcomes;
- To design a tool to ascertain students' awareness of risk issues and key concepts;
- To develop engaging teaching materials to integrate health and safety risk concepts into the engineering course making use of accident case studies and;
- To do this in liaison with key stakeholders in health and safety risk management and engineering education, ensuring consistency with their relevant strategies, policies and earlier work.

Main Findings

All UK Engineering Institutions require chartered engineers to have some knowledge of their professional responsibilities for managing risk. However, the extent to which they are specified in requirements for accredited engineering courses is variable and difficult to interpret or audit. Several universities offer specialist diplomas, foundation degrees and master's degrees on occupational health and safety and risk management for major hazard industries. However for students not wishing to specialise in these areas the extent and content of risk education is not clear. There is a scarcity of published literature in this area and therefore it is not easy to find out what other universities are doing except through personal contacts.

A template consisting of a set of risk education learning outcomes that can be integrated into an undergraduate engineering curriculum has been developed, implemented by merging new materials into core engineering modules and evaluated at the University of Liverpool Engineering Department. A questionnaire consisting of some 50 multiple-choice questions developed during this project has proved useful to ascertain new engineering students' level of understanding of risk concepts and to aid the development of suitable teaching materials although motivating students to complete the questionnaire without marks being allocated was a major challenge.

Implementation of the new materials was only made possible by close collaboration with a member of staff taking responsibility for this process and liaison with other members of staff. The process was not without its difficulties, namely (1) promotion of the risk theme to other members of staff who didn't view it as a priority, (2) overcoming competing demands for time on the curriculum, (3) gaining the support from other members of staff to allow development and implementation of new materials for inclusion in their modules, and (4) remaining focused on the key objectives. These issues should be considered by other departments seeking to undertake a similar process.

The risk education project links well with the adoption of the MIT lead “New Approach to Engineering Education, Conceive Design Implement Operate” (CDIO) standards. Active learning methods are used (CDIO Standard 8) in the form of role-play of real-life scenarios to engage students to consider the wider implications of their activities as professional engineers in society (CDIO Standard 7). Moreover it supports CDIO syllabus items 2.5 Professional Skills and Attitudes, 4.1 External and Societal Context and to some extent assists in the development of 3. Interpersonal Skills and 2.3 Systems Thinking.

The project described in this report supports the HSE “Be part of the solutions” 2009 strategy consultation and ongoing sensible risk campaign. It is also relevant to the EU campaign for 2008 and 2009, which seeks to promote the use of risk assessment and demystify the process.

This project has generated a great deal of interest and support. It has benefited from advice received and previous work conducted by the acknowledged professional bodies, networks and working groups with the consequence of establishing excellent industry/academia links.

Recommendations

HSE and HSL should continue to build upon the working relationship with staff at the University of Liverpool to ensure that the longevity, potential and impact of the materials developed during this project are fully realized. Specifically an active involvement of the Industrial Liaison Board, delivery of the occasional lecture, assisting staff to build materials into their courses and co-supervision of student projects with summer placements as described below.

The development of a virtual-reality supported version of the Ramsgate accident investigation laboratory should be completed such that it can be embedded into an e-learning package suitable for use on University learning management systems.

A laboratory safety training and competency assessment e-learning package suitable for use on University learning management systems should be developed that incorporates materials developed and identified during this project.

A depository for the materials should be established once any copyright and intellectual property issues have been considered. This should be web-based and part of a forum to allow industry, institutions, regulators and academics to review the use of the materials, exchange ideas and information. This forum needs to be adequately funded to ensure that as a minimum the materials remain up-to-date and relevant, preferably grow and develop. Key stakeholders who would need to work together to achieve this are the HSE and the Higher Education Academy Engineering Subject Centre, Ethics and Engineering Centres for Excellence in Teaching and Learning (CETLs). Through this forum attempts should be made to gain an up-to-date insight into the extent of integration of risk concepts in undergraduate engineering courses at other Universities.

Contacts need to be maintained to exchange ideas and information with the other organizations mentioned in this report. In particular with:

- The chair of the Inter-Institutional Group on Health and Safety to provide input into their e-learning project as this would provide an ideal platform for the effective dissemination of the material developed during this project in a format which students will find both engaging and instructive.

- Institution of Mechanical Engineers (IMechE SRG) through their Safety and Reliability Group, particularly in light of education being a key theme this year, to discuss how the work of this project could best be taken forward with other universities with due consideration of the accreditation process.

Other receptive Universities in the UK need to be identified and assistance or training provided to help them make effective use of the materials e.g. those Universities striving to fulfill the requirements of the CDIO initiative.

Consideration should be given to running a workshop/seminar, with the interested parties mentioned throughout this report, in order to develop and agree an action plan to promote the teaching of the management of health and safety risk. This could coincide with the launch of the depository and web-based forum/community.

1 INTRODUCTION

"If a man can't make a mistake he can't make anything"

Abraham Lincoln, President of United States of America 1861 -1865

Experience may be the best teacher but when it comes to industrial accidents the price can simply be too high to pay, as illustrated in Figure 1. The long history of engineering has left a rich and varied collection of examples of mistakes and catastrophic failures. The challenge therefore is for engineers to learn through their own mistakes and those of others without endangering their own health and safety or that of others.

Figure 1 The price of mistakes, more than 200 lost lives year on year

The regulatory framework for health and safety in the UK firmly places the responsibility for managing risks with those who create and work with them. This is not just from a moral perspective; it acknowledges that those who create and work with risks should also have the understanding and direct opportunity to manage them. Engineers play a vital and central role in this process. But engineers (and their managers) need to have a strong belief in success if they are ever to bring a project to fruition. Unfortunately this can lead to reluctance to really explore what can go wrong. Time and time again accidents have shown that there has been a failure to: either understand how to manage risks, or to take the opportunity to do so. It is therefore essential that safety-critical professionals such as engineers are educated and encouraged to assess and manage risks.

The Health and Safety Executive (HSE) made a commitment, in its strategic plan 2001/2004, to work with higher and further education institutions to ensure that safety-critical professionals received adequate education in health and safety risk management [1]. This was after a consultation exercise in which a third of respondents specifically mentioned the importance of covering health and safety issues. Lord Cullen also made a specific recommendation relating to the education of engineers in his report on the Hatfield rail accident [2].

Around the same time various professional bodies and institutions [3], [4] also recognised the need to educate engineering undergraduates in aspects of risk relevant to their degree and future professional working life. The European strategy on health and safety 2002-6 [5], [6] identified education and training as key factors to prevent accidents among young people when they first enter the workplace. The Inter-Institutional Group[1] on Health and Safety and the Hazards Forum[2], went further by developing a syllabus template [7] and series of lectures [8]. The Safety and Reliability Society (SaRS) also produced a template but to the authors' knowledge this was never published. The EU campaign for 2008 and 2009 seeks to promote the use of risk assessment and demystify the process.

Several universities offer specialist diplomas, foundation degrees and master's degrees on occupational health and safety and risk management for major hazard industries [9]. However for students not wishing to specialise in these areas there is evidence that, across degree courses in the UK, the extent and content of risk education is varied, and there was the potential for it to not always be proportional to the level of risk that undergraduates could be responsible for managing in their professional working life [10]. To address this, HSE commissioned two projects. This report describes a joint project of the Health and Safety Laboratory (HSL) and the University of Liverpool, to incorporate risk education into the curriculum of an undergraduate engineering degree course. The other (led by the chair of the UK engineering institutions Inter-Institutional Group on Health and Safety, with the assistance of HSL and CMG Logica), was to develop an e-learning package that can be used flexibly in support of engineering degree courses or employers' graduate training programmes. The work so far completed on this latter project is summarised in a recent paper [11] and described fully in HSE research reports [12], [13]. The project is mentioned here due to its relevance to the project at the University of Liverpool.

The overall goal of both projects was to ensure that all students who complete their engineering course have a basic understanding of safety and health risk issues relevant to their specific course of professional study.

Integrating health and safety risk concepts into the engineering course at the University of Liverpool first involved defining a set of learning outcomes [14], and designing a tool to ascertain students' awareness of risk issues and key concepts [15], [16], [17]. These then informed the development of teaching materials. Taking into account Abraham Lincoln's and current opinion [18] the materials use real accident case studies, student interaction and experiential learning as appropriate to enhance students' understanding of the concepts of hazard and risk.

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[1] This influential group (www.theiet.org/publicaffairs/panels/iig/) is composed of senior representatives from the main engineering institutions in the UK, plus the Hazards Forum and the HSE.

[2] The Hazards Forum (www.hazardsforum.org.uk) was established in 1989 by the four major engineering institutions, the Institutions of Civil, Electrical and Electronic, Mechanical and Chemical Engineers to provide an interdisciplinary focus for the study of disasters and the promulgation of lessons learned from them. Since then the Forum has broadened its remit to inform the public understanding of risk, while continuing to develop its work on the assessment of hazardous events, dissemination of lessons learned and the promotion of risk reduction strategies.

2 WHY THE UNIVERSITY OF LIVERPOOL?

"Students develop their understanding and engineering skills through doing and reflecting on what they have done."

Prof. Padfield, Head of Engineering Department, University of Liverpool

The location of the University of Liverpool and the headquarters of the Health and Safety Executive in the same city provides unrivalled opportunities for collaboration and dialogue. This close proximity has been instrumental in the success of the project.

The primary reason, however, why this project was initiated at the University of Liverpool was to take advantage of the opportunities created by a strategy of long-term investment in the Engineering Department and the 'revitalisation' of their engineering courses. The risk education project has therefore evolved against a backdrop of strategic developments namely:

1. The alignment of teaching and learning within the Engineering department to the CDIO standards[3]. This requires a curriculum that stresses the fundamentals of engineering, set in the context of Conceiving – Designing – Implementing – Operating systems and products [18];
2. Several learning and teaching initiatives that aim to enhance the engineering education experience by developing programmes which strike an appropriate balance between theory, real-world applications, professional and personal development; in particular through a more active experiential approach to learning [19];
3. Industrial engagement in the development of the curriculum and extra-curricular activities through an industrial liaison board of which HSE and HSL are now active members;
4. Enhanced learning environment through investment of around £30M in a major refurbishment of engineering research laboratories and in building new teaching facilities for future generations of engineering students as can be seen in Figure 2.

The project therefore was timely in terms of its promotion and implementation as it allowed greater scope to introduce new materials into a developing curriculum in line with current thinking in engineering education. The academic year 2008/9 marks the fruition of these developments and official launch of the new 'Liverpool Engineer' programmes that will contain the risk education materials developed since 2004.

Figure 2 New Active Learning Laboratory at Liverpool

[3] Developed by MIT in the US, Chalmers and the Royal Institute of Technology in Sweden with input from academics, industry, engineers and students. It is adopted in total or in part by over 30 universities worldwide, see www.cdio.org

The new approach to teaching the engineering programmes at the University of Liverpool aims to stimulate the active learning of sound engineering principles and practices within an environment which fosters creativity, innovation and professional responsibility. Consequently, students will find their learning experience more stimulating and rewarding.

Professional engineering is about problem structuring and solving; applying theoretical knowledge in the conception, design, implementation and operation of new products, systems, processes and services. Technical knowledge and skills are complemented by a sound appreciation of the process involved, along with an awareness of the ethical, safety, environmental, economic and social considerations involved in practicing as a professional engineer.

Emphasis in the new programmes is therefore placed on creativity, project management, teamwork and hands-on engineering experience, which are achieved through a range of practical design-build-test activities, role-play and real-life simulations, many of which contain several of the desired learning outcomes in risk concepts. Other activities contain a major component of safety and risk issues, namely the Ramsgate role-play accident investigation lab in year one [20] undertaken by all disciplines and the Constructionarium project in year two [21] of the civil engineering course.

Future graduates with a degree from the Department of Engineering will become a 'Liverpool Engineer', having gained a thorough understanding of engineering principles, and having learned and practiced the skills to enable them to be creative, innovative and professional in their future career. They will be more prepared to meet the needs of modern industry and society; well rounded, qualified, risk aware and highly employable. Both the 'Liverpool Engineer' and risk education projects have been seen to benefit each other during this period of change and regeneration in the Department of Engineering at the University of Liverpool.

Quality and relevance of engineering education at the University of Liverpool will continue to be monitored, reviewed and informed by departmental and university learning and teaching strategy and the engineering institutions' accreditation panels. The relevance and rigour of this education provision will also be underpinned by an active and highly rated research programme and established industrial links. In this, the HSE has an important role to play to ensure that its policy on risk education continues to be promoted at the highest possible level through on-going student project technical support and sponsorship initiatives, participation in workshops and on the industrial liaison board, and visiting appointments.

3 INTEGRATING RISK CONCEPTS INTO AN UNDERGRADUATE ENGINEERING COURSE

"Good Engineering is about making systems that are fit for purpose in an economic, effective and efficient way. A system is not fit for purpose if it is unsafe or cannot be built properly"

Joint Board of Moderators – Degree Guidelines

3.1 WHY TAKE AN INTEGRATED APPROACH?

Risk within educational institutions can all too easily become associated with overzealous health and safety officials, compliance with legislation, tedious form filling and the fear of litigation should a student or member of the public be injured. To counter this the philosophy of the risk education for engineers project, described in this final report and the numerous publications listed in section 8, was to demonstrate how risk is part of everyday life and an essential responsibility of every practicing professional engineer. More specifically that the management of risk was a thread, rather like the writing in a stick of rock shown in Figure 3, that runs through everything a professional engineer designs, the judgements and decisions that they make. Furthermore, that risk management is not a bolt-on extra and cannot simply be left to the end user or safety officer to write and police the procedure that will keep everyone safe and healthy. This is consistent with the latest strategy of HSE [22], published for consultation at the time of writing this report.

Figure 3 Management of risk like writing running through stick of rock

There are also sound pedagogical reasons for taking an integrated approach. Risk concepts can be introduced in several different contexts and at different times throughout the years of the course. In this way the learning is reinforced so that awareness can be developed into good understanding and skills based on experience in accordance with Bloom's taxonomy [23]. Moreover, this avoids the learning becoming specific to the regulatory context, thereby enabling better recall [24] in contexts not normally associated with risk management, such as during the design process. This also avoids a sense of the topic being detached from the rest of the course. Developing material that supports the learning of other topics also reduces the burden upon students thereby improving the chances of the messages being absorbed.

Finally, there are overwhelming practical reasons for taking the integrated approach. The primary reason is a lack of time and space on the curriculum. Any new module is almost certainly, therefore, going to be optional and only reach a limited number of students. Allowing students to in effect 'opt out of risk management' does not fit into the underlying philosophy of this project.

It is more feasible, due to lack of space on the curriculum, to add a lecture to several different modules or a few new slides to existing presentations or just emphasise relevant points. Furthermore the motivation, time, expertise and resources needed to develop and assess a complete new module are rarely available within Universities. The integrative approach also fitted well with a key ongoing initiative at Liverpool, namely CDIO, as described in section 2 above, which helped achieve staff buy-in.

There are of course some disadvantages in taking an integrated aproach. The main ones are described below. However the project team believe that the advantages given above outweigh these disadvantages.

- It can be difficult to prove and assess specific learning outcomes and/or accreditation requirements and there is the danger that the content gets lost in amongst the other material;
- The need to rely on students achieving the necessary understanding from material taught by someone else and possible inaccurate assumptions about what has been delivered and how;
- Many universities tend to have a modular culture, i.e. academic staff teach in the area of their expertise in which they do research. Therefore, an integrative approach will be unfamiliar and may be resisted. An integrative approach relies on getting buy-in from other busy members of the academic staff.

The authors are aware, through the limited literature and personal contacts, of staff at other universities and the Higher Education Academy Engineering Subject Centre, Ethics and Engineering Centres for Excellence in Teaching and Learning, who are developing good quality health, safety and risk elements for specific modules and courses. The University of Bath both integrate risk concepts into their compulsory design modules and run an optional module, "*Machines and Products in Society*," for third and fourth year MEng students [25]. Feedback from students, who did this module, after leaving University, stated that it was the single most useful thing they had learnt that was directly applicable to their job. The module resources are now available as a BSI priced publication [26]. The University of Southampton have developed interactive safety videos to support offsite project work carried out during the Civil Engineering course [27]. The University of Portsmouth have been applying a zero tolerance assessment strategy to the health and safety risk content of student course work whereby course work is returned to students if the health and safety risk content does not come up to the required standard [28]. This would imply that risk is integrated into undergraduate construction courses at Portsmouth.

Whether a modular or integrated approach is taken, as with many other topics, industrial input and real case studies are vital to make the subject come alive for students.

3.2 THE DESIRED LEARNING OUTCOMES

Learning outcomes for integrating risk concepts need to balance the necessary knowledge of risk concepts for graduate engineers on entering the professional arena with the competing demands of other topics in an already full curriculum. Moreover they need to be grounded on current professional requirements of the engineering institutions, legislation, and best practice described in relevant HSE publications. The process by which the desired learning outcomes, summarised below, were defined is described in the first report of this project [14].

On graduation students should be able to demonstrate *knowledge and understanding* of:

1. Concepts of hazard, safety and risk as part of everyday life;
2. An engineer's professional responsibilities for safety and managing risk;
3. Principles of hazard identification and risk assessment relevant to the discipline;

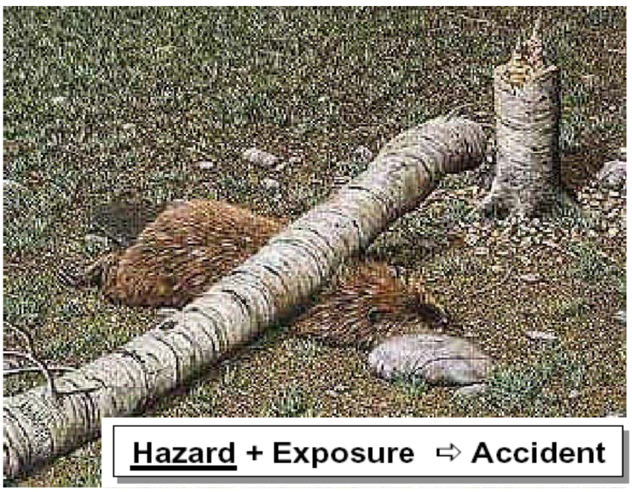
4. Methods of hazard identification and risk assessment relevant to the discipline;
5. Techniques for reducing and controlling risk;
6. Personal safety and potential exposure to hazards and risk in the workplace; and
7. Underlying causes of accidents and failures.

On graduation, students should be able to demonstrate *ability in applying knowledge* of the topics to:

1. Design simple engineering systems for safety accounting for uncertainties;
2. Perform a risk assessment using appropriate methods, avoiding some of the common pitfalls, and implement, where necessary, effective risk reduction measures;
3. Learn from documented failures and accidents the underlying hazard, safety and risk issues and relate this knowledge to their future professional responsibilities; and
4. Identify and control safety hazards to themselves and others in the course of work activities.

3.3 ASSESSMENT OF STUDENTS' AWARENESS OF RISK CONCEPTS

The objectives in establishing a baseline indicator in the form of a questionnaire were twofold. Firstly the results from using the questionnaire with students at the very beginning of their undergraduate course informed the level and content of new materials, for example some students struggled to relate to the language of risk so the photo shown in Figure 4 is often used as an ice-breaker to help students get started. Secondly repeating the use of the questionnaire after the delivery of the new risk teaching materials provides a useful benchmark against which to monitor on-going improvements in students' knowledge and understanding of risk concepts. It not only fulfilled this expectation but has also since proved to be a valuable tool for on-going assessment of the risk education learning outcomes. Furthermore, other researchers have also asked to use it to promote risk education in their courses [29]. The re-usability of the questionnaire has been maintained when publishing the results by limiting the number of questions reproduced and insisting on controlled conditions whenever a test is given.



The questionnaire, which was based on key concepts of the learning outcomes, was first given to the cohort of new students in the academic year 2004/05. Since it was intended to assess awareness of a topic that students had not yet encountered in a formal sense, it was not surprising to discover that the risk questionnaire results were largely independent of academic performance on subjects in which the students had received formal education; both the risk questionnaire and formal examinations were measuring different attributes.

Figure 4 Icebreaker to help students understand language of risk

The results of the 2005/06 questionnaire concluded that over half of the students improved their score by more than 10% at the end of the year in which the new materials had been delivered. Further details of the development and results of the use of the questionnaire are described in the second report [17] of this project and various papers [15], [16].

3.4 COURSE AND MATERIALS DEVELOPMENT

The challenges facing the task to embed suitable materials into a developing curriculum were (in no particular order):

1. To ensure that students view safety and risk as an overarching theme rather than an isolated topic with no connection to their core engineering subjects;
2. Health and safety risk being seen as a non-academic subject which is the remit of industrial training rather than part of higher education;
3. A lack of explicit requirements or specific learning outcomes for health and safety risk in accreditation requirements for undergraduate course in UK-SPEC [30];
4. To promote the initiative to other key staff not directly connected with the project;
5. The delivery of material by staff outside their direct expertise or experience;
6. Sustaining the necessary level of activity and enthusiasm;
7. To make the material relevant and interesting;
8. An already very full curriculum; and
9. To weave the new materials into existing taught material without detracting from the original material i.e. so not merely seen as an add-on component.

These challenges were largely overcome through a graduated and integrated approach to embedding the new materials. The project avoided teaching health and safety and instead focused on risk management being part and parcel of the design process and acting as a professional engineer. The separate modules of the engineering course were reviewed to find the most appropriate modules into which the concepts could be woven. This involved looking at existing materials in some detail. In some cases a few additional slides were needed to explain where health and safety risks needed to be considered. An example of an additional slide that integrated risk into the teaching material is shown in Figure 5. This shows how risk analysis (or assessment) is just another type of analysis and an integral part of the engineering process needed to enable a design that is fit for purpose. The risk analysis block is 'greyed-out' to illustrate that it is often over-looked or not done as well as the other analyses. In other modules of the course, additional lectures or tutorials were prepared.

The process of integrating risk concepts throughout the undergraduate engineering courses was only possible by close collaboration with a member of academic staff taking responsibility for key elements of the implementation and liaising with other members of staff. In order to ensure that students took the material seriously, part of the risk questionnaire has been turned into a computer-based class test.

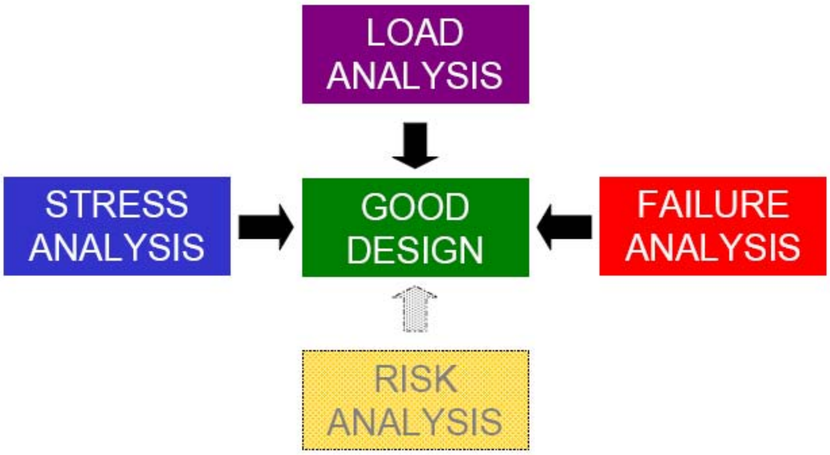


Figure 5 Analyses required for good (i.e. fit for purpose) design

Students are introduced to the importance of risk management during fresher's week when the new students are encouraged to think about what engineering is all about. In year one, students are made aware of risk concepts and their relevance to their personal safety and decisions they will make in their future career. Materials have been developed to allow year two students to assess risk in their design project work. In their final year, students undertake a substantial project (in some cases over two years) that involves risk assessment and may contain further opportunities to advance their knowledge in risk management. Students are also reminded of the 'risk' theme through guest lectures given by practicing engineers and specialists arranged from time to time. In some of the courses, more formal arrangements are provided whereby students attend general seminars given by visiting speakers on a regular basis. A small reminder by the Head of Department of the role of risk management as students are about to enter their professional careers during their graduation address effectively bookends the integration of risk concepts.

Development of materials focused on year one [17] because it was felt important that students were introduced to the concept of risk early in the course. This enables them to begin to relate fundamental engineering principles to their professional responsibility to manage risk. Moreover there was more scope for implementation in year one and, as this year was common to all engineering programmes, a more comprehensive reach.

Most of the materials developed along with other resources identified during the project were put on the on-line virtual interactive teaching and learning environment (VITAL[4]), which students could access at any time. A more detailed summary of the materials developed or used during this project can be found either in the Bibliography or Appendix A.

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[4] *VITAL is a learning management system hosted on the University network. Students can logon to access supporting information uploaded by staff, which may include copies of lecture notes and even podcasts of lectures. It is also used by students to book certain services, choose projects and optional modules and submit assignments. Staff can also issue online tests and alert students to timetable changes or special events.*

3.5 EVALUATION

The class test/questionnaire gave a good indication of learning in year one with new materials compared to year one without new materials and is now being used for student assessment in year one. The results are documented in various papers and reports; section 3.3 has further details. The class test was also presented to students at the end of year three without new materials and with new materials. Unfortunately despite many reminders and financial incentives insufficient students completed the test for any meaningful results to be obtained. We therefore had to think very carefully about how to gain access to students. Motivation being a key factor we therefore offered tutorials for students to assist them with their year three individual project risk assessments. These were conducted in such a way as to get a feel for what they had learnt. The guide questions that were used are listed in Appendix B.

We held three sessions on a Wednesday afternoon, each one lasting one-hour which students had to pre-book on VITAL. Numbers were therefore kept to a maximum of 12 (i.e. 6 students each). The sessions were fully booked and there was a two-thirds turnout. We initially asked a few questions to establish what they had picked up about health and safety risk during their first two years of study and which lectures they could remember that considered health and safety risk. A number of students were direct entry so therefore missed the keynote lectures in year 1.

Most students remembered the lecture on risk assessment in the year two design module and one had printed it out from VITAL. Many remembered some parts of the keynote lectures and the accident case studies from the mechanics year one lectures and were able to mention them by name. A few mentioned the Ramsgate lab. Quite a lot mentioned the Constructionarium and the health and safety briefing they had as part of that. One mentioned Prof. Steve Millard’s lecture on concrete. No-one really mentioned the lab safety talk unless they were prompted. About half were able to give a satisfactory description of their legal duties under the Health and Safety at Work etc. Act and most understood the importance of following rules and procedures and not using equipment without permission, training or supervision.

Most students were able to give a satisfactory explanation of the purpose of doing a risk assessment. About half were able to describe the process fairly well and one or two demonstrated a thorough understanding including that it was an iterative process.

All had already had a meeting with their supervisor. More than half had specifically talked about safety and all that were doing ‘design-build-test’ (D-B-T) type projects or experimental work had discussed safety, and a few had been given more detailed risk assessment templates to complete.

Over half of the projects were theoretical, e.g. literature review or computer simulations/ modelling and therefore low risk. Most students however recognised that extensive use of computers was not good for them, most mentioning eye strain or headaches, about half RSI in hands or shoulder and neck pain. Although very few were aware that regulations or guidance existed. A small minority did not take it at all seriously.

Most students understood risk assessment to be about their own safety and others sharing a lab with them or working jointly on projects. About a third understood the implications on safety of not properly communicating uncertainty of experimental results, product quality/defects or other safety issues to future users of their results. One picked up very quickly that there could be conflicts between economy, environment and safety when making recommendations as a result of their studies.

Those doing D-B-T or experimental work found the check-list of hazards provided very useful. Most did not grasp the idea that the risk assessment needed to be regularly reviewed. In particular the idea of first doing a high level risk assessment and then filling in the detail when they knew more about what they would be doing. In fact a few felt that they could not do the risk assessment until they had designed their product and knew how they were going to make it.

The following week there was an open tutorial for students between 2-4pm. About 20 students attended. Only about three had been to the first tutorial and wanted to go through what they had prepared. What they had done was acceptable, although there was a tendency to include every trivial risk in the belief that the more they wrote down the higher the mark they would get for their proposal report. The discussions gave essentially the same results as in the previous tutorial. However in this group at least half of the students had thought about the risk assessment and had some ideas or specific questions they wanted to ask such as ‘do I need to do a COSHH assessment?’

Unfortunately those students who completed the course without the new materials had already handed in their year three projects by the time we did the class test so it was not possible to benchmark these findings against students who had completed the course without the new materials.

Looking at student’s project reports from the two different cohorts was considered with a view to comparing the quality of their risk assessments. However it would have been difficult to obtain copies of the reports, as they are not held centrally, and also very time-consuming to read a representative number.

3.6 SCOPE FOR ONGOING SUPPORT

It takes time for new materials to bed-in, with the need to update and refine them, particularly in the first few years. Some of the material has already gone through several iterations and is now firmly embedded into the undergraduate course. This includes the Solids and Structures lectures (ENGG104) and associated Ramsgate accident investigation lab; a structural problem presented in the introductory lecture of ENGG104 is shown in Figure 6. Other material that has been developed for modules delivered by other staff in the department is not so firmly established and slots have disappeared due to the reorganization of the overall course structure. Further work is therefore needed to support staff to fully utilize and refine the materials to better suit their needs.

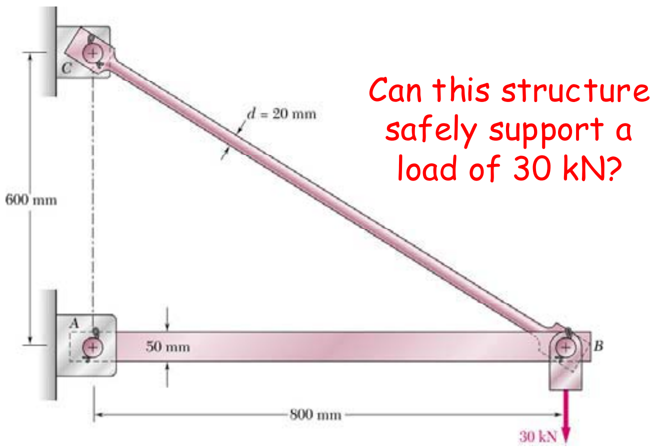

Figure 6 Example showing how theory and risk concepts mutually support one another

It takes some considerable time, effort and presence to develop working relationships with other staff in the department, particularly when coming from a field that is not seen as having an academic background. Unless staff get to know members of the project team on a personal level and understand what they are trying to achieve there is a danger of HSE simply being seen as trying to impose unnecessary extra burdens on an already demanding workload, thereby limiting the integration of risk concepts into the course.

The University of Liverpool over the last few years has put considerable effort into creating and fostering relationships with industry through an industrial liaison board. HSE and HSL are currently active members. The valuable contribution of this board to enhancing the quality of the student learning experience is currently realized through the development of real-world case studies, guest lectures, team-based and personal projects, student placements and field visits.

Only through an active involvement on several different levels will the longevity and potential of the materials developed during this project be fully realized.

4 PROMOTION AND LIAISON

"To bring about improvements in health and safety performance we should all be working together towards a set of common goals"

HSE Strategy Consultation 2008

This project has benefited from previous work, encouragement and support of a number of organizations with essentially the same goals as regards promoting, in the words[5] of the Inter-Institutional Group (IIG) on health and safety, the "teaching of health and safety risk to undergraduate engineers in the UK through the provision of flexible teaching materials that could be incorporated into engineering".

The learning outcomes and materials have drawn upon syllabi and materials developed by the Inter-Institutional Group (IIG), the Hazards Forum, the Institution of Occupational Safety and Health (IOSH), the Safety and Reliability Association (SaRS), Royal Society for Prevention of accidents (RoSPA), the British Standards Institution (BSI) and the Universities of Sheffield and Bath.

The philosophy behind the project has been promoted and also influenced by liaison throughout, in particular, with the Institution of Mechanical Engineers Safety and Reliability Group (IMechE SRG), the chair of the Inter-Institutional Group on Health and Safety (IIG), the Institution of Occupational Safety and Health (IOSH), and the Universities Safety and Health Association (USHA) working group on student health and safety.

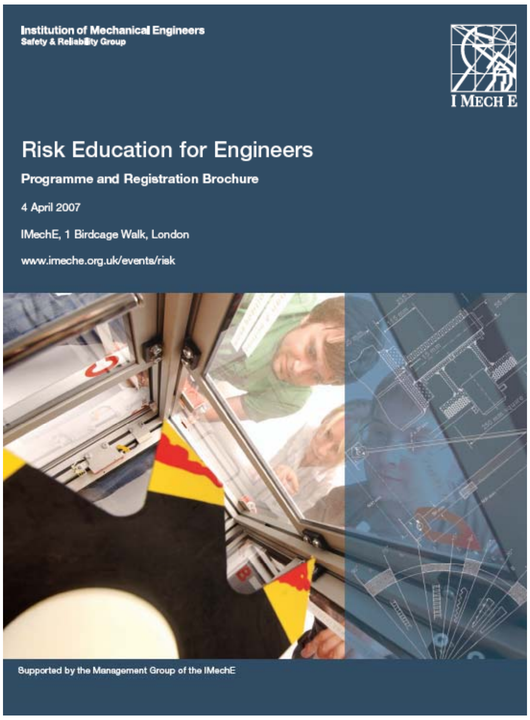

Figure 7 IMechE seminar brochure

The project has also been promoted through the publication and presentation of numerous papers at various conferences, given in section 8. Through attendance at the engineering education conferences, staff at the Higher Education Academy (HEA) Engineering Subject Centre have become aware of our aims and of the related e-learning project. As a result they have indicated their willingness to support the dissemination of the materials directly to other Universities. Attendance at the CDIO conferences has given a good indication that the CDIO platform would also be a good way through which to disseminate directly to Universities who have signed up to the initiative.

An active participation on the committee and various working groups of the IMechE SRG has given the project access to relevant expertise, including the development of two keynote lectures, one of which was reproduced on DVD.

[5] *see www.theiet.org/publicaffairs/panels/iig*

With the support of several members of the SRG committee it has been possible to keep the overall aims of this project on their agenda. The 2009 president of the IMechE is from an academic background, therefore education is currently a key theme. There is considerable support from the SRG committee to set up a new working group on education and competency, possibly chaired by the authors of this report.

The events working group of the SRG also sponsored the seminar "Risk Education for Engineers" (the front cover of the brochure given in Figure 7) held at IMechE's headquarters in London on 4th April 2007. Despite considerable promotion of the event, a letter encouraging participation sent to University Head's of Engineering Departments from HSE's Chief Scientist the attendance by academic staff was disappointing. It is likely that the reasons for poor attendance by this target audience are similar to the challenges facing the project described above. Another reason put forward was getting the right date; during term time academic staff are generally tied up with lectures and outside term time, marking exams, attending conferences, busy with research projects or on leave. Linked to this was the narrow scope of the seminar. Better attendance from the target audience may have been achieved if the seminar had covered a wider but relevant scope (for example to include project and financial risk).

The project team has, through conferences and liaison with the organizations mentioned above, gained some insight into what other universities have been doing in the area of risk education. However, there is currently little published literature or an obvious forum for exchanging views and information.

The DVD of the professional responsibilities lecture given at the University of Liverpool by Graham Dalzell, Director of TBS cubed, a CD of documents and materials in the public domain and the demonstration e-learning CD developed under the other risk education project mentioned in this report have been made freely available to educational establishments and other stakeholders. There has been sufficient interest generated through personal contacts, papers and conferences for over 100 of each to be given out on request. A further 500 or so of the e-learning demo CD have been distributed to potential future collaborators. Currently the materials developed during this project are not freely available as potential issues relating to intellectual property, copyright, dissemination costs and keeping them up-to-date need to be considered.

5 CONCLUSIONS

> *"Education of engineers should deliver professionals who understand their professional responsibilities for the safety of the public, including the need to act on safety critical defects, and who can apply the principles of risk management."*
>
> *Lord Cullen, Hatfield Rail Enquiry*

In no particular order the conclusions drawn are:

- A template consisting of a set of risk education learning outcomes that can be integrated into an undergraduate engineering curriculum has been successfully developed, implemented and evaluated at the University of Liverpool Engineering Department.

- A questionnaire consisting of some 50 multiple-choice questions has been developed to ascertain new engineering students' level of understanding of risk concepts. The concepts upon which the questionnaire was based have been used to aid the development of suitable teaching materials. The re-usability of the questionnaire has been maintained when publishing the results by limiting the number of questions reproduced and insisting on controlled conditions whenever a test is given. Motivating students to complete the questionnaire without marks being allocated was a major challenge.

- New materials have been developed and merged into core engineering modules in the form of case studies and real-life examples to teach the fundamentals of safety and risk concepts including a role-play accident investigation simulation. These materials were not merely an add-on to an existing module but embedded so as to demonstrate direct connections between the risk theme and the main subject, in this case strength of materials.

- Students' answers to the key question set in the risk awareness questionnaire ("why is engineering regarded as a safety critical profession?"), show that engineering students at the University of Liverpool understand to a significant extent their professional responsibilities for the safety of the public as recommended by the Hatfield rail accident investigation board [2].

- The responses of students to questions asked during the personal project risk assessment tutorials indicated that a good proportion of students had remembered and understood many of the key risk concepts that had been presented to them

- Implementation of the new materials was only made possible by close collaboration with a member of staff taking responsibility for this process and liaison with other members of staff.

- The process was not without its difficulties, namely (1) promotion of the risk theme to other members of staff who didn't view it as a priority, (2) overcoming competing demands for time on the curriculum, (3) gaining the support from other members of staff to allow development and implementation of new materials for inclusion in their modules, and (4) remaining focused on the key objectives. These issues should be considered by other departments seeking to undertake a similar process.

- To motivate students to make use of materials and complete exercises, such as the risk concepts questionnaire, they need to be presented in engaging ways and marks need to count towards their final grades. An e-learning platform such as that developed during the sister project led by the IIG would be ideal [11].

- The risk education project links well with the adoption of the CDIO standards. Active learning methods are used (CDIO Standard 8) in the form of role-play of real-life scenarios to engage students to consider the wider implications of their activities as professional engineers in society (CDIO Standard 7). Moreover it supports CDIO syllabus items 2.5 Professional Skills and Attitudes, 4.1 External and Societal Context and to some extent assists in the development of 3. Interpersonal Skills and 2.3 Systems Thinking.

- The project supports the current HSE "Be part of the solution" strategy and sensible risk campaign as it helps give engineers the tools and understanding necessary to assess and manage risk that will enable them to "Be part of the solution".

- The project is relevant to the EU campaign for 2008 and 2009, which seeks to promote the use of risk assessment and demystify the process.

- All UK Engineering Institutions require chartered engineers to have some knowledge of the issues addressed by this project. The extent to which they are specified in requirements for accredited engineering courses, however, is variable and difficult to interpret or audit. In the opinion of the authors the requirements of UK-SPEC [17] are currently insufficient in themselves to provide the impetus for universities to more fully integrate risk concepts into their undergraduate courses.

- The authors are aware of staff at other universities who are developing good quality health, safety and risk elements for specific modules and courses. However the published literature in this health and safety risk management field is somewhat sparse. Except through personal contacts it is therefore not easy to find out what other universities are doing and following up every individual lead is prohibitively time-consuming.

- Only through an active involvement on several different levels will the longevity, potential and impact of the materials developed during this project be fully realized and the materials kept relevant and up to date.

- Excellent industry/academia links have been established through this project

6 RECOMMENDATIONS

"Only when consideration of safety, imposed by the professional engineer's code of conduct, permeates everything the practising engineer does in his/her professional work, and safety is seen as the watchword of the profession, will the profession have discharged its responsibilities and the public be reassured that with confidence they may place their lives in your hands"

Hazards Forum

The following recommendations arising from this work are made.

- Continue to build upon the working relationship with staff at the University of Liverpool to ensure that the longevity, potential and impact of the materials developed during this project are fully realized. Specifically an active involvement of the Industrial Liaison Board, delivery of the occasional lecture, assisting staff to build materials into their courses and co-supervision of student projects with summer placements as described below.

- Complete the development of a virtual-reality supported version of the Ramsgate accident investigation laboratory such that it can be embedded into an e-learning package suitable for use on University learning management systems. This should use the models and storyboards developed by HSL and Nick Underwood, an undergraduate project student, during his personal project and embed training for laboratory demonstrators in its use. This could be done with input from a student as part of their personal project as long as they had ability in and enthusiasm for HTML design. To maximize the output of the project close supervision by HSL would be essential with an 8-10 week summer placement.

- Develop a laboratory safety training and competency assessment e-learning package suitable for use on University learning management systems. In order to realize their full potential this should incorporate materials developed and identified during this project. This would make an ideal personal project for a student with ability in and enthusiasm for HTML design. To maximize the output of the project it should be co-supervised by HSL and include an 8-10 week summer placement at HSL.

- Establish a depository for the materials once any copyright and intellectual property issues have been considered. This should be web-based and part of a forum to allow industry, institutions, regulators and academics to review the use of the materials, exchange ideas and information. This forum needs to be adequately funded to ensure that as a minimum the materials remain up-to-date and relevant, preferably grow and develop. Key stakeholders who would need to work together to achieve this are the HSE and the Higher Education Academy Engineering Subject Centres, Engineering Centre for Excellence in Teaching and Learning and Ethics (CETLs). Through this forum attempts should be made to gain an up-to-date insight into the extent of integration of risk concepts in undergraduate engineering courses at other Universities.

- Continue and build liaison with IMechE through their SRG, particularly in light of education being a key theme this year. Discuss how the work of this project could best be taken forward with other universities with due consideration of the accreditation process.

- Maintain contacts to exchange ideas and information with the other organizations mentioned in this report such as IOSH, other professional institutions, the HEA’s and CETL’s.

- The Inter-Institutional Group on Health and Safety e-learning project would provide an ideal platform for the effective dissemination of the material developed during this project in a format which students will find both engaging and instructive.

- Identify other receptive Universities in the UK and provide assistance or training to academics to help them make effective use of the materials. For example those Universities striving to fulfill the requirements of the CDIO initiative.

- Consider how best to ensure that the teaching materials are kept up to date and how this might be funded.

- Consider running a workshop/seminar, with the interested parties identified above, in order to develop and agree an action plan to take these recommendations forward. This could coincide with the launch of the depository and web-based forum/community.

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- RIDDOR explained (2006)	HSE31(rev1)
- Simple guide to the provision and use of work equipment regulations 1998 (2004)	INDG291

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8 Published by the Health and Safety Executive, www.hsebooks.co.uk, HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA Tel: 01787 881165

APPENDIX A – LIST OF RESOURCES

A.1 DEVELOPED AS PART OF THIS PROJECT

The following materials have been developed for delivery by various staff in different contexts and modules.

A short lecture that links professional responsibilities for risk management to the Head of Department's introductory lecture "What is Engineering" theme given during fresher's week.

A few additional slides for incorporation into the laboratory safety talk given to first year students. The purpose was to get over key messages about personal safety and every individual's responsibility under UK health and safety law. The longer-term intention is to produce an on-line interactive competency assessment tool that all students have to complete before they can do laboratory practicals.

Lecture materials for the engineering module 'Solids and Structures 2' (ENGG104), taken by all year one students (thereby achieving maximum reach), were comprehensively revised. This module now introduces basic concepts of hazard and risk using every-day examples and incorporates accident case studies. The case studies are used to show what can happen when engineers get it wrong, make mistakes, or even worse, ignore the warning signs that something is wrong. In this way key learning outcomes are achieved reinforcing rather than diluting in-depth engineering theory. Part of the questionnaire originally used for the initial assessment is now used as an on-line computer-based class test for this module.

A role-play virtual laboratory accident investigation/analysis team exercise, based on the HSE/HSL investigation of the collapse of a passenger walkway at the Port of Ramsgate[9], was linked to the lecture material.

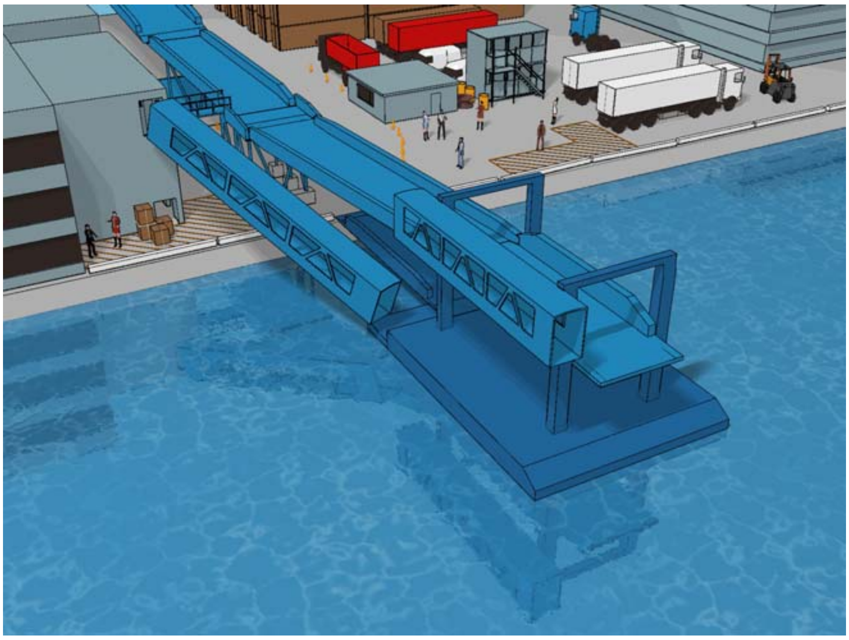

Figure A.1 Screen shot of 3D computer model of Ramsgate walkway

[9] *HSE (2000), Walkway collapse at Port Ramsgate. A report on the investigation, HSE Books (out-of-print).*

The development of this lab drew upon exercises developed by HSL with the University of Sheffield engineering department some time ago. It can be delivered in a single 3-hour lab format or as a series of five 3-hour labs that build upon the findings of the previous lab and was particularly well received according to student feedback. Consequently a 3-D virtual reality model, Figure A.1, was developed in a format suitable for delivery within an e-learning package during a year three student project jointly supervised with HSL. Further work to turn this into a product that can be used semi-independently by students (as a pre-lab) is envisaged.

Professor Taylor (IIG) also prepared a role-play exercise to compliment the engineering issues associated with the Ramsgate incident by looking at the underlying organisational and cultural issues. This involves students representing the different organisations and describing what they would have done differently and how they believe this would have prevented the collapse.

A number of experts have developed and given keynote lectures with student handouts, as part of first / second year core design modules and optional third / fourth year project management module, on the following topics:

- Professional responsibilities, available on DVD
- Human factors
- Inherent safety
- Use of codes and standards
- Engineering risk and safety
- Risk assessment of technical systems
- Risk reduction measures
- Managing project risk

The first four were recorded but to date only the first has been edited and made available as a DVD. This can also be viewed on VITAL (Dept of Engineering General Site > RISK > Year 1 materials).

Tutorials and guidance on risk assessment for students' individual projects have been developed.

A.2 IDENTIFIED DURING THE PROJECT

These are in addition to the books, journals and papers listed in the bibliography:

RoSPA Posters available from http://www.rospa.com/shop/occupational/posters.htm

HSE Posters on slips, trips and falls

Risk Assessment – The Facts, DVD ROM produced by Safety Media (2004)[10], (16½ mins)

This shows a workshop containing various hazards. *The lecturer could pause the DVD at this point to have an interactive discussion with the class until they have identified the hazards* before continuing the DVD which next goes through the same scenario highlighting all the hazards and discussing the risk and how to determine the level of risk (high, medium, or low) and gives examples on how to control risk. *The lecturer could again pause the DVD to have an interactive discussion with the class about when, where and how to use each control measure.*

German High Speed Train Crash shown on national geographical satellite channel[11], (1 hour)

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[10] *www.safetymedia.co.uk, tel: 0845 345 1703 Kinmel Park, Abergele Road, Bodelwyddan, Rhyl, LL18 5TX*

This explains the events leading up to the crash of a train travelling at 250km/hr in 1988 in which 101 people die in less than two minutes. The immediate cause was fatigue cracking of a new wheel design (untested for high-speed applications) that led to a derailment and ultimately the train hitting a road bridge. This was exacerbated by poor maintenance, the length of time it took for a conductor to respond to incident reported by a passenger, and warnings about fatigue problems from another train operator.

Potters Bar Railway Accident (UK), BBC[12], (approx 30 mins)

This explains the events leading up to the derailment of a train at a station leading to the death of 7 people. The night before the accident a train driver reports that the carriage moved violently over the tracks and gives a detailed report of the position of the fault, despite this the night maintenance workers go to check the point but are sent to the wrong side of the tracks and find no problem. The next morning the fourth carriage of a train is derailed and catapults onto the platform. The critical part to cause the accident was a linking bar between points on the track. It was originally thought to be sabotage, however this was later ruled out and poor maintenance was blamed.

Texas oil disaster (UK), shown on national geographical satellite channel[13], (1 hour)

This explains the events leading up to a massive explosion that kills 15 people and injures 170. At 2:00am the start up of a distillation tower commences after a standard shut down that occurs once every few years. The process can take up to 12 hours and is manually operated. This means the risk of human error is very high. As level increases an alarm goes off which the operator bypasses (against safety guidelines). It’s an unofficial procedure commonly used (routine violation). The next day a new operator continues the procedure. Liquid escapes from the blow down stack and is ignited, probably by a vehicle that has parked in the vicinity. Underlying causes were identified to be inadequate operating practises and poorly maintained equipment.

Challenger and Columbia Space Shuttle Disasters, BBC[11], (Challenger: 30 mins)

Challenger failed on take-off due to the failure of O-rings in the fuel tanks leading to a fire and the break-up of the shuttle killing all 7 on board. The underlying cause was management overruling concerns raised by scientists regarding the potential but uncertain effect of low temperatures on the integrity of the O-rings.

Columbia failed on re-entry due to damage of the high temperature protective material on the leading edge of one wing. This damage was caused by insulation foam breaking away from the fuel tank on take-off. This was a common occurrence that had not led to serious damage in the past. Despite the impact being observed and the shuttle being in orbit for two weeks no attempt was made to check the condition of the wing or make repairs.

Piper Alpha Disaster, BBC[11], (30 mins)

This explains the events leading up to a massive explosion and fire on an offshore oil platform in which the platform is completely destroyed and 167 are killed. The immediate cause was the failure of a flange on a pump that led to the release of a flammable vapour that ignited. The pressure relief valve on a backup pump had been removed for maintenance by one shift and the

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[11] *Have not been able to discover whether recordings can be purchased for educational use*
[12] *Generally videos or DVDs of BBC programs can be purchased for educational use with the option of putting on University learning management systems for a license fee based on student numbers who can access it.*
[13] *Have not been able to discover whether recordings can be purchased for educational use*

next shift started the backup pump when the in-service one stopped. The consequent fire was fed as another platform continued to pump oil to the damaged one despite the fire being seen in the distance. The underlying causes were a poor permit to work systems and emergency procedures.

Engineering a safer future demonstration e-learning CD, which contains presentations, video clips of personal stories and disasters, tutorials and virtual-reality construction site hazard spotting exercise. The development and content of this CD is summarised in a recent paper [11] and described fully in HSE research reports [12], [13].

Youtube – Lost Youth[14] can be watched online. They are all less than 20 minutes in duration and re-enact various accidents to young people in the US. One involved a forklift truck when the young man put it into gear to move whilst standing outside the cab and he was crushed against a wall breaking his back. Another was where a young woman loses three fingers in the chain drive of a dough kneading machine. Another shows how a young man fell into a machine after cleaning it (there was no safe means of access for the job he was required to do) and had his leg amputated. The recordings are aimed at apprentices rather than undergraduates, are very realistic and quite gruesome with a lot of bad language so need to be used with care.

[14] *Produced by WorkSafeBC www.worksafebc.com*

APPENDIX B – STUDENT FOCUS GROUP QUESTION SET

What is your project about?

What have you learnt about risk assessment and health and safety since you began your course?

Prompts
- Lab Safety Talk?
- Keynote Lectures?
- Solids and Structures / Strength of Materials / Mechanics of Solids?
- Design?

What are your legal duties?

What does that mean in practice?

Prompts
- Following rules, procedures, asking for advice, reporting problems
- Can they give examples?

What is the purpose of doing a risk assessment?

What is the process? What do you need to do first?

(Explain if struggling - What can harm you or others, what precautions, more needed?)

Have you had your first meeting with your supervisor?

What did they say about safety?

For those who have already completed a risk assessment

Have you ignored any hazards because you assumed control measures will protect you?

What happens to the risk assessment now? When will it be complete?

When do you need to review and update?

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Integrating risk concepts into undergraduate engineering courses

This report describes a joint project conducted by HSL and the University of Liverpool Engineering Department to integrate risk concepts into their undergraduate engineering course. The project defined risk education learning outcomes that can be integrated into an undergraduate engineering curriculum and implementing them by merging new teaching materials (involving real accident case studies) into core engineering modules. The success of the project has been evaluated in terms of student's understanding of risk, at different points during their course, and interactions of the project team with academic staff. A student questionnaire of approximately 50 multiple-choice questions to ascertain student's understanding of risk was developed to support both development of materials and their evaluation. The report makes a number of recommendations for future collaboration between HSE and a range of stakeholders and relates these to HSE's 'Be part of the solution' strategy (2009), the ongoing sensible risk campaign and the EU campaign (2008-2009) to promote and demystify the risk assessment process. Issues raised, which other educational institutions seeking to undertake a similar process should consider, are: (1) Promotion of the risk theme to other members of staff who do not view it as a priority and gaining their support to allow inclusion of new materials in their modules; (2) Overcoming competing demands for time on the curriculum; (3) Motivating students to engage with the materials from the perspective of relevance, interest and marks; and (4) Remaining focused on the key objectives.

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