TEACHING SAFETY IN ENGINEERING

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Abstract: The UK Health and Safety Executive (HSE) would like all engineering degree courses to teach students about safety in their respective discipline. The Engineering Council (EC) requires as a condition of accreditation that degrees should include risk assessment (which is not quite the same thing as safety). There is an Inter-Institutional Group (IIG) on health and safety which includes the engineering institutions and some safety organizations, which has been working to promote safety in engineering degrees, and has projects to produce material for this purpose.

Some of the work of the IIG and the HSE, separately and jointly is presented, along with experience of teaching safety, and a graduate survey of the topics found most useful.

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1. INTRODUCTION

1.1 Professional Responsibility
Professional engineers are, directly or indirectly, responsible for the health and safety of other people. Sometimes it is people they know, in a management role. More often it is people they will never know who can be harmed by their errors or poor judgement in engineering decisions. In addition to the harm to people, there is a financial cost to such failures, so the field of safety now incorporates what is called loss prevention, which has the advantage of providing economic arguments for expenditure. A number of organizations have been active in encouraging good teaching to enable engineering graduates to meet their responsibility for safety and loss prevention.

1.2 Engineering Council
The Engineering Council makes repeated reference to health, safety and risk issues in its accreditation documents (Engineering Council, 2004), and publishes “Guidance on Risk” (Engineering Council, 2011) as a brochure and wallet card. This is based on 6 principles:

1. Apply professional and responsible judgement and take a leadership role
2. Adopt a systematic and holistic approach to risk identification, assessment and management
3. Comply with legislation and codes, but be prepared to seek further improvements
4. Ensure good communication with the others involved
5. Ensure that lasting systems for oversight and scrutiny are in place
6. Contribute to public awareness of risk

1.3 Inter-Institutional Group on Health and Safety (IIG)
This consists of representatives of 5 engineering institutions, IET, IMechE, ICE, ISE, IChemE, plus ECUK, HSE, IOSH, Safety & Reliability Society and the Ergonomics Society. Its purpose is to coordinate efforts in common areas of health and safety policy. (IET, 2012) It has two working groups, one on Occupational Health and one on Risk Teaching.

The Risk Teaching group developed a prototype e-learning package for engineering undergraduates. (Taylor et al., 2006a, 2006b)

1.4 Health and Safety Executive
In 2000, the HSE set up a Risk Education programme to “identify and influence the degree to which risk management techniques are taught in schools and other educational establishments, including universities where undergraduate courses lead to entry into safety critical professions such as engineering and design.” (HSE, 2012) This resulted in a statutory requirement for school pupils to be taught about hazards, risks and control, which means that UK students should in future enter university with some idea about these topics.

The HSE also worked with the IIG on the e-learning package mentioned above (Taylor et al., 2006a, 2006b), and with the University of Liverpool on developing teaching materials for first year engineers. (Schleyer et al., 2006) This was intended as a pilot to encourage all university engineering departments to embed such teaching in their engineering degrees.

2. HAZARDS, RISK AND SAFETY

2.1 Hazard and Risk
According to the HSE advice to teachers (2012): Hazard means anything that can cause harm. Risk is the chance, high or low, that somebody will be harmed by the hazard. Risk control involves taking steps to reduce the chance, and/or mitigate the consequences, of the hazard causing harm. Risk assessment evaluates the risks and decides whether precautions are adequate or more should be done.

2.2 Safety
Safety is of course the absence of danger, and danger comes from the hazard being realised through failure of risk control. I personally take the view that risk assessment is a somewhat reactive, analytical approach, and it would be a better aim to teach safety as a positive feature of engineering activity. In particular there is the concept of Inherent Safety pioneered by Kletz (1984), and now very positively encouraged by the HSE in its industrial activity. Basically this consists of removing a hazard altogether (or at least drastically reducing it) rather than protecting against risk. An example would be light bulbs which can be changed from the floor or ground by lowering the fitting rather than getting someone to go up a ladder or scaffold. In aeronautical engineering the default condition for a commercial aircraft is a stable glide if all power is off. This concept of fail to safety is a powerful one in engineering, and we should be proud of it.
Clearly, we cannot remove those hazards which are essential to the function of the engineering (such as height and velocity in an aircraft, or energy in a fuel) but we can think about those which may just be there for historical reasons, or where some convenience in construction makes maintenance dangerous.

2.3 Occupational Safety
There is a tendency to think of engineering safety purely as the dramatic events which reach the media. However, engineers also damage people (and sometimes kill them slowly) by causing them to trip, fall, bump, strain, breathe fumes or dust, touch sharp edges, hot or cold surfaces etc, due to poor design or management. As mentioned above, the IIG would like to promote this aspect of the responsibility of professional engineers.

3. WHAT SHOULD BE TAUGHT?

3.1 IChemE Survey
In 2005 the IChemE surveyed graduates to find out what they had been taught about safety, and what topics they had found most useful. The most relevant subjects (more than 90%) were:

- Hazard Identification (99%)
- Hazop (98%)
- Case Studies (98%)
- Health and Environment (96%)
- Terminology (96%)
- Inherent Safety (95%)
- Safety Culture (95%)
- Permit to Work (95%)
- Risk Perception (95%)
- COSHH [UK legislation: Control Of Substances Hazardous to Health] (93%)
- Benefit Analysis (92%)
- Fires and Explosions (91%)
- Protective Systems (91%)
- Human Factors & Ergonomics (91%)

Obviously these results would not be expected to translate the same to all engineers, but I would argue that Hazard Identification must still be first – you will only control those hazards you recognise. Hazop (= Hazard and Operability Studies, a way of looking at how a process could go wrong) and COSHH might be counted specific to chemical engineers. However, the others would generally apply to engineering workplaces.

3.2 Hazard Identification
Engineering students have the (potential) advantage that they can be shown how hazards work, with calculations of energies and forces etc. Lesser mortals have to follow rules, but engineers should understand the hazards and thus be in a better position to control them. We commonly teach design (making things work) – it is not too hard to turn this to how they could fail. In fact, I do precisely this by teaching safety along with design in a third year course. Stored energy in almost any form is a hazard.

In addition we can look at scenarios and ask students to spot potential hazards. This is best done in small groups. The IIG project was intended to provide a bank of these, and may well do so if further funding can be obtained. It was hoped that individual institutions could make short videos relevant to their speciality. If you are really brave, ask the students to spot hazards in your department!
3.3 Case Studies
These are generally disasters in a particular field of engineering, many of which are available on the Internet. They are relevant and stimulating both intellectually and emotionally. If successful, students may empathise with the victims and understand how seemingly small decisions can lead to major failures, or how small failures can affect many people. The IIG material provides examples of individual people talking about their experience which can really bring the situation home.

A less successful outcome is when students learn to recite the times, dates, numbers of people killed etc, but take no useful appreciation which they can apply in their work. Cutting and pasting from the web for coursework proves little or nothing. The official ‘lessons learned’ can be pasted in or even memorized for the exam but not applied elsewhere. It is hard work but can be worthwhile to take an incident apparently unrelated to your speciality and draw out from the students the generic failures of communication, decision making etc.

3.4 Doing It Right
If the course is genuinely about safety and not risks, then the benefits of good engineering can be promoted. Early decisions to make things more inherently safe, careful analysis, scrupulous documentation, the value of proven methods such as standards – these all contribute to the relative safety of engineering and of which we should be proud.

3.5 Mitigation
While designing to avoid failure, we must have means to deal with it. It is important to distinguish between safety and dealing with failures. Fire safety is about preventing fires, but we must have some provision for fire fighting to mitigate it. So-called passive protection which requires no human action but contains or limits fire is especially valuable. The electrical fuse is a simple example of mitigating failure, by controlling the way in which it happens to do the least damage and be most easily put right. Crumple zones in cars and seat belts are examples in which engineering calculations can be applied to quantify how we control unwelcome events.

3.6 Management
A number of items valued in the IChemE survey really relate to management rather than design. Of course we should design for safety, but most of our graduates will have some management responsibility, and it is appropriate to teach good management.

We have for the last few years had safety management as an integral part of a third year management and economics course. Here there is an obvious overlap with loss prevention. Operations going wrong or producing unsatisfactory items may not always hurt someone, but they generally have negative financial consequences. Techniques which help people work better and not make mistakes both help safety and also help the work in general. Techniques normally considered for safety may have wider uses in management.(Pitt, 1994)
4. CONCLUSION

The aim of the IIG to produce a bank of electronic resources to aid all engineering disciplines in teaching safety has unfortunately not been realised, though the pilot material is available and should provide some help.

There is a need for further cooperation and sharing of resources between the disciplines, and we should build upon what is happening in schools so that hazard recognition, risk assessment and an active attitude towards safety are a fundamental part of all engineering degrees.

5. REFERENCES


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