Safety on a hands-on computing science unit: Not merely an accidental extra

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Abstract

There are increasing demands from students, employers and government bodies for more work-relevant education. However, employment related hands-on education with regard to PC hardware includes important safety as well legal implications, with potential traps for the unwary. CIM is somewhat unusual in computing science units in that students work in contact with the insides of a PC. Staff contemplating initiating similar programs need to be aware of the potential safety hazards and legal issues associated with such provision. An understanding of such issues is therefore crucial to students, teaching staff, and management. Computer Installation & Maintenance (CIM) is a hands-on unit offered at Edith Cowan University (ECU) in Western Australia This unit has a weekly two hour theory lecture and an accompanying two hour hands-on workshop session. Although these workshops may superficially appear safe there are a range of potential hazards. In the CIM unit students are introduced to the relevant Safety and Health (S&H) issues for each workshop, with tutor demonstrations where appropriate and Competency-Based Assessments (CBAs) and Multi-Choice Questions (MCQs) have been designed to assist in testing students' safety awareness as well as testing the results of the efforts of staff in helping to inculcate such awareness.

I. Introduction

Demands for more work relevant education [14] can have important safety implications. Computer Installation & Maintenance (CIM) is a hands-on unit introduced by the computing science department at ECU. This unit was derived from the results of surveys of employers in the area of Computer and Network Support and surveys of third year computing science students at ECU. The CIM unit has a weekly two hour theory lecture and an accompanying two hour hands-on workshop session. Depending upon such factors as the available dedicated laboratory space and demand the number of students on this unit has ranged from 70 to 125 students per semester. The CIM unit can be studied as a full credit elective unit or as a part of a required unit within the ECU course minor structure. Many CIM students come from a non-technical background and so the effective teaching of computer hardware concepts within a single semester can be problematic.

The CIM unit was resulted from previous investigations at ECU which had revealed that none of the students surveyed could fulfill the employer requirements in this field, even though they had successfully passed all of their previous units that were Australian Computer Society (ACS) accredited [6]. Maj notes that:

"The initial ECU questionnaire first used in 1993 was also conducted at two universities within the UK. Both universities were BCS accredited. The degree programs offer students the opportunity to examine a PC in the first year however they never take a PC apart" [7].

The ECU survey included an open PC, and students were invited to demonstrate their procedures and a major concern of the staff taking part was the lack of safety awareness demonstrated by students. As computing science graduates are often present on committees, in taskforces, and in employment where knowledge of Safety and Health (S&H) practice and law is needed, hence this could be regarded as a generic requirement. The authors therefore proposed that S&H practice and law be included as an integral part of national computing societies' core curricula for the education of computing science professionals. This could be additional to topics currently listed such as software legalities & safety and ergonomics [10]. On the CIM unit S&H is addressed via:

- CIM Workshop and Workplace Safety.
- Legal Issues.
- Hazard Awareness.

2. CIM Workshop and Workplace Safety

The hands-on components of the CIM unit are delivered via thirteen two-hour weekly workshops and each of these workshops is associated with a theory component delivered via a corresponding two-hour lecture. During the workshops CIM students are exposed to potentially hazardous situations therefore good safety practices and an understanding of potential hazards is mandated. According to Maj:

"The first workshop was concerned entirely with workshop practice and students were required to read both the university and workshop regulations - it was emphasised that misconduct would not be tolerated. Misconduct is taken to include failure to observe good workshop practice. Compulsory attendance at the first lecture and workshop were verified by a signed declaration. Failure to comply was an automatic disqualification from continuing the unit" [6].

This unit has been consistently oversubscribed and attracts many cross-institutional enrolments from other universities within the Perth area and cross faculty enrolments from within ECU. There are no unit prerequisites and consequently many students come from non-technological educational backgrounds [20]. Students are exposed to a range of PCs using sets of decommissioned PCs, which considerably reduces the equipment costs [11, 19].

For most computing units at ECU only the first hour of each workshop is supervised, for the second hour students are guaranteed access to computing laboratories but are unsupervised. They have unrestricted access to any vacant laboratories twenty four hours a day, seven days a week during the semester. However, given the nature of the CIM unit workshop access is restricted to allocated workshop periods that are fully supervised [2].

Potential hazards in the CIM workshops include lasers used inside CDROM drives which could damage eyesight. There are also potential hazards in leaving equipment in an unsafe condition such as with Cathode Ray Tubes (CRTs) or Power Supply Units (PSUs) exposed. The lifting of equipment, in particular heavy CRT monitors could cause injury if undertaken incorrectly. Correct methods of lifting are taught and the lifting techniques of the CIM students are observed by tutors to ensure correctness. Because CIM students may work in this field either now or in the future, so potential hazards from equipment or procedures not included in workshop exercises also need to be addressed. With respect to laser printers, which are not part of the current workshop exercises, Brooks notes that:

"Unlike other printer types, the laser printer tends to have several high-voltage and high-temperature hazards inside it. To get the laser printer into a position where you can observe its operation, you must defeat some interlock sensors. This action places you in potential contact with the high-voltage, high-temperature sensors mentioned above" [2].

Injury can also result from the incorrect storage of PC equipment. With a shortage of convenient space and little spare time it can be tempting to pile equipment in stacks that are too high. To avoid this situation machines should only be allowed to be stacked to a maximum height. Students also need to be aware of the danger of implosion from vacuum tubes used in desktop CRT monitors. Taylor considers factors that affect the severity of an electric shock and notes that: *"Skin resistance is greatly reduced when the skin is wet or moist, and so the degree of shock will be greater"* [9]. Taylor also notes that there are other factors involved such as the magnitude of the electrical current, the length of time the current is applied, length of the current path through the body, as well as the medical and health status of the individual [9]. It should be noted that in Australia the electrical mains voltage is 240 volts. An understanding by students that certain electrical shocks can cause powerful muscular contraction which can result in people being thrown some distance or being unable to release their grip is also required [13,18], as is the fact that severe burns can result from excessive electrical current passing through the body. Goldwasser notes that when engaged in maintenance work on computing equipment people should not *"wear any jewellery or other articles that could accidentally contact circuitry and conduct current or get caught in moving parts"* [4].

CIM students are informed of the importance of Earth, or Ground, Current Leakage Detectors and their basic operation and are told that fuses provide no protection against electrocution. Students are also informed of the danger of stored charge in capacitors and the risk of severe

electric shock in close proximity to Extremely High Tension (EHT) potentials due to the breakdown of the electrical insulation properties of the surrounding air.

3. Legal Issues

One of the requirements discovered from the employer survey undertaken by Maj was that potential employees in computer and network support need to be aware of their legal responsibilities and obligations.

CIM is somewhat unusual in computing science units in that students work in contact with the insides of a PC. Staff contemplating initiating similar programs need to be aware of the potential hazards associated with such provision. Furthermore they also need to be cognizant of their legal obligations under S&H Acts of failing to ensure that both students and staff have the necessary S&H training. A failure to implement such training could leave both staff and their institutions exposed to possible legal challenges in the event of an accident. The CIM unit uses studies of accidents to demonstrate legal findings. Maj et al state that:

"*Many students have little or no knowledge of legal issues. The unit therefore included a lecture on law and technology in order to fully appreciate the significance and importance of H&S legislation. After a brief overview of the legal system, the tort of negligence was addressed with reference to negligent misstatement. However, particular emphasis was placed on negligent acts and the associated Duty of Care (foresee ability and proximity) and Standard of Care (gravity and practicality of precaution) of both employee and employer. Extensive use was made of appropriate benchmark case citations relevant to this application area"* [6].

4. Promoting Hazard Awareness

Workshop tutors and other staff involved in the CIM unit need to be proactive in respect to hazard awareness. Veal and Maj note that:

"Unlike traditional, standard computer science tutors, laboratory CIM workshop tutors must also be aware of potential safety hazards and legal requirements. They need to pay particular attention to other potential safety hazards elsewhere in the laboratory even though they may be engaged in dealing with the problems of a particular student" [11].

Bell uses virtual reality to simulate potential accidents: *"not so much to teach new information or to test students' knowledge, but rather to stimulate reflective thoughts and discussion"* [1]. Butrej draws on case studies of accidents to enhance safety awareness [3].

It might be thought that a 5V line inside a PC is completely safe. However, a potential hazard exists in the CIM workshops if this line is 'shorted out' whereby the +5V line can connect to earth, or ground, potential as could occur by the misalignment of the floppy disk drive power

connector. The resultant overheating, due to excessive electrical current flow, can cause the PVC covering of the 5V cables to become nearly molten. Should a student touch this cabling, in a mistaken attempt to avoid further damage to the machine, then this could result in burns to their hand and fingers. The hot PVC may also stick to their skin. Smoke from the effects of overheating cables can also present a hazard. Mueller also notes that injury can result from misalignment of PC power connection plugs carrying power from the PSU to the motherboard.[16] and Andrews warns of the potential dangers of charged capacitors in PSUs and CRTs [15].

Another example of a potential hazard in the CIM unit is the use of an open hard disk drive used to demonstrate its operation to students. If a student touched the moving platters, rotating at between 60 and 120 revolutions per second, these could act as a rather effective meat cutter.

The following safety issues may also need to be considered:

- When would a tutor in a workshop press the fire alarm button? Under what circumstances would this be an appropriate action? An interesting exercise would be to set various scenarios and to note staff responses. Pressing the alarm would result in the evacuation of the whole building and the arrival of the fire brigade. However, not raising the alarm could result in needless extra damage to persons and property. Staff could be helped to make an early appropriate decision if assured of management support for such action, even if it was later deemed not strictly necessary. Viewing videos of actual fires can help to give a better appreciation of the speed and intensity of fire in common scenarios and help to engender an awareness of the dangers of late evacuation.

- Should a first aid kit not be readily available, easy to find, and well stocked then this could be problematic in a subsequent post accident S&H investigation.

- The avoidance of over-involvement in fighting a fire to the detriment of staff and student safety is also important. Tutors and students need to be aware of the position, types, and uses of fire extinguishers within the workshop and in its vicinity.

- An appreciation of only potential dangers that could occur inside the laboratory is insufficient, because the hazard may arise from outside. The background noise within a laboratory means that the fire alarms need to be heard above this noise and this needs to be tested under actual working conditions.

Getting students to take S&H seriously can be problematic with some students expressing incredulity when informed of possible dangers inside a PC. Hence the compulsory first workshop that students must sign to say that they have both attended and read the required safety instructions.
In an effort to explain the reasoning behind such requirements the concept of 'rings of safety' was used. Each ring provides protection that can be breached under certain conditions. With more than one ring of safety should one ring be breached then another may prevent injury. Even though there

may normally be exposed voltages of only plus or minus 5 volts or 12 volts inside of the system box, should a fault develop in the power supply keeping the mains unplugged from the back of the system box can provide an extra ring of safety. It may be possible to work for many years with only a single ring of safety. However, should that ring be breached then serious injury or death could result. The 'rings of safety' concept could be considered analogous to forms of medieval castle defense where a moat surrounded an outer wall which surrounded the inner wall, which in turn enclosed central defensive keep. Should an outer defensive ring be breached then the next inner defensive ring may have sufficed to repel an assault.

An anonymous questionnaire asked CIM students what they thought of the level of emphasis on safety on the unit. The results revealed that no students thought that safety needed more emphasis, ninety percent thought that it was about right, nine percent thought that it needed less emphasis with only one percent noting that they thought that it was a waste of time. It is noteworthy that a qualified, practicing and experienced electrician was amongst the ninety percent who thought that that the emphasis placed upon safety in this unit was about right.

The assessment of safety theory and practice is problematic. Scouler has noted that different forms of assessment can help to promote different forms of learning [8]. Therefore safety awareness and practice are assessed via a range of different methods on the CIM unit. These include:

- Written Examination Questions
- Multi-choice Questions (MCQs)
- Competency-Based Assessments (CBA)s

4. Written Examination Questions

Maj et al note that: *"Arguably the most important theme in the CIM unit is H&S - employees and employers have non-delegable legal responsibilities"* [6]. The CIM Students' understanding of their basic legal responsibilities is assessed via a compulsory question on the written examination paper that is worth 20% of its overall marks.

5. Multi-Choice Questions (MCQs)

MCQs have been designed to test student understanding in the CIM unit [17]. Moreover, MCQs have been designed to test student safety awareness across a range of possible situations in a timely and efficient manner. MCQs can also yield results that are cause for concern such as the student responses to the following question:

A practical joke in the workplace by an employee resulting in the serious injury of a colleague occurs. Then:

A *the employee could be fined only if they had previously been officially warned against such actions by their employer first verbally and then subsequently in writing if this behavior had persisted.*
B *only the employer faced a possible fine because they would be held responsible for these actions undertaken by the employee during company time.*
C *the employee could suffer dismissal, although not a fine, because an injury sustained during working hours would only be regarded as an internal company matter.*
D *this could result in a fine being imposed upon the employee.*
E *a fine not being imposed upon the employee because no harm was intended.*

The results of CIM students answering the above question were as follows:
Twenty five students chose answer A, eleven chose B, twelve chose C, and sixteen chose D which was the correct answer within Western Australia as in many other jurisdictions, whilst none chose answer E. Such results occurred despite a whole lecture and a significant part of a first workshop being devoted largely to S&H matters. Clearly more needs to be done to improve student understanding of such matters and the MCQ has helped to highlight this problem.

6. Competency Based Assessments (CBAs)

Goldsworthy as has defined competency as the: *"ability to perform in the workplace"* [5]. Part of a CBA was tested on a group of CIM students containing the following requirements marking scheme for safe work practices and the protection of equipment.

1 Mark Disconnects from mains when appropriate.
1Mark Takes power lead out of back of system box.
1 Mark Uses an Earthing (Ground) strap at appropriate times.
1 Mark Places equipment not to cause potential problems.
1 Mark Re-assembles computer correctly.
1 Mark Polarity of all cables is correct.

Of ten students evaluated, three did not disconnect equipment from the mains when appropriate, three failed to take the power lead out of the back of the system box, one failed to use an antistatic strap at appropriate times, one placed equipment in unsafe positions, and another got the cable polarity incorrect. Veal et al note that: *"CBA is essential in the CIM unit. It is mandated by S&H requirements and also employer expectation. It must therefore be fully addressed"* [12].

7. Conclusions

S&H awareness and training is a vital part of the CIM unit for both students and staff. The CIM workshop presents unusual hazards when compared to many traditional computing science units and S&H is important both from a legal and from a practical and ethical perspective to reduce the risk of harm to both students and staff.

All staff involved need to be aware of their non-delegable legal responsibilities, and of the potential hazards existing in what may superficially appear to be a "hazard free zone". Leaving such considerations until after an accident could have serious ramifications, both in respect to the long-term health effects of an accident on the victim and the possibility of legal and disciplinary proceedings that could be instigated against staff. This could also include those acting in a managerial function; should be shown that they had failed to take appropriate action.

Students entering the workplace need to aware of their legal obligations with respect to clients, employees, and employers. The CIM syllabus addresses these issues in both their practical and theoretical aspects by including safety awareness and law in lectures, examinations and workshops. Additionally, CBAs and MCQs may also be used, yet further work may be required to help to promote better S&H understanding and practice amongst students.

Compared to potential hazards faced by students and staff on some engineering units those faced on the CIM unit may appear minor. However, staff need to maintain a proactive approach to S&H issues within units such as CIM.

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