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Ensuring Safe Use of the Machine Shop by Students

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1. Introduction

As Engineering Technology educators, we pride ourselves in providing relevant hands-on experiences for students in our courses. Hands-on experiences are important in ensuring that students can apply the theoretical concepts they learn in class to practical engineering situations not only in the laboratory, but especially in industry. Because equipment in a typical machine shop can be dangerous and even fatal when misused, it is imperative to put in place policies and procedures that will help to ensure student safety. As the author's institution was going through the process of revising and updating its policies for independent student use of the machine shops, the author sought input from other educators around the country regarding the procedures they followed. Input was sought though the ETD-L email discussion list. Particular focus was placed on situations beyond supervised classroom settings, for example when students are working on non-classroom projects. An email was sent to the list asking the following questions:

- Q1: Do you allow students to use machines independently?
- Q2: What training is required before such use?
- Q3: How is the training verified?
- Q4: What technical support (if any) is available to students during that time?
- Q5: How do you handle liability issues?
- Q6: Is yours a 2-year or 4-year institution?
- Q7: Are there any special issues we should pay attention to?

2. Results

There were a total of 33 responses received and the results are summarized in Table 1. The respondents are anonymized by assigning them individual identification numbers rather than using personal or institutional names. Not all respondents addressed every question and a blank entry indicates that no response was given to that particular question. Two of the respondents (ID# 5&6) were from the same program and so the corresponding data is aggregated. One respondent (ID# 23) did not give direct answers to the questions asked and therefore the data were not usable for this purpose. Thus were a total of 31 unique usable responses. Most respondents did not answer question 7 so that is not included in Table 1. The rest of this paper presents and discusses the results, and provides some general insights for others to consider when implementing policies for their own programs.

Table 1: Students' Independent Use of Machine Shop

ID#	Q1	Q2	Q3	Q4	Q5	Q6
1	Y	Certification	Completion			4yr
2	Y	Focused Training	Observation			4yr
3	Y	Focused Training	Records			4yr
4	Y	Focused Training	Observation			2yr
5						
6	N	Demonstration	Hands-on Test			2yr
7	N	Coursework only				4yr
8	Y	Pre-req Course	Transcript	Tech + Stud Asst	Umbrella	4yr
9	Y	Focused Training	Hands-on Test	None	Buddy system	4yr
10	N	Coursework only		Tech + Stud Asst	Umbrella	4yr
11	Y	Pre-req Course	C grade	Instructor	Safety Unit	4yr
12	N	Coursework only	Safety Test			2yr
13	Y	Pre-req Course	Transcript			4yr
14	N	Certification			Umbrella	4yr
15	Y	Pre-req Course	Safety Test	Tech + Stud Asst	Umbrella	4yr
16	Y	Safety Training	Attendance	Tech	Sign form	4yr
17	Y	Pre-req Course	Observation	Tech	Umbrella	2yr
18	Y	Pre-req Course	Transcript	Instructor		2yr
19	Y	Pre-req Course	Records	Tech	Buddy system	4yr
20	N					2yr
21	Y	Pre-req Course	Transcript	Instructor	Umbrella	2yr
22	Y	Focused Training	Observation	Tech		4yr
23	X					
24	Y	Safety Videos	Safety Test	Instructor		4yr
25	Y	Safety Lecture	Quiz + Hands-on	Tech + Stud Asst	Signed liability sheet	2+2
26	Y	Pre-req Course	Transcript	Buddy system		4yr
27	Y	Focused Training	Records	Tech	Follow protocols	4yr
28	Y	Pre-req Course	Transcript	Instructor	enrolled students only	2+2
29	Y	Pre-req Course	Dept approval	Tech + Stud Asst	Signed use agreement	4yr
30	Y	Pre-req Course	Transcript	Stud Asst	Signed liability sheet	4yr
31	N					4yr
32	Y	Safety Lecture	Safety Test	Tech	Umbrella	2yr
33	Y	Pre-req Course	Passing grade	Instructor	Umbrella	2yr

3. Discussion

Q1: Do you allow students to use machines independently?

It is important to reiterate that this question focused on the use of the machine shop outside of regular course instructional activities. The responses indicate that a very high proportion (24/31) of institutions do indeed allow students to use machines independently. However, all the institutions that allowed independent student work had some associated restrictions to prevent students from working alone in the machine shop. These will be discussed in more detail under technical support (Q4).

For the institutions that did not allow independent student use of the machine shop, concerns about student safety and potential liability issues were said to be the primary deterrents. One respondent emphatically stated: “Open labs are an accident waiting to happen.” Another one cited the case of the student at Yale University who died in a machine shop accident. For those unfamiliar with this tragic case, it will be discussed in more detail in Section 4 of this paper.

Q2: What training is required before such use?

All the institutions that allowed independent student usage required some form of prior training. The majority, (13/24) relied on students having successfully completed some formal prior coursework. The next largest group, (7/24) implemented a focused training or certification process concentrating on the specific equipment that that the student was going to work with. The remainder conducted some type of Safety training either by lecture or by having students watch an appropriate video.

The results indicate that the institutions that allow student use of the machine shop, are cognizant of the risks involved, and are taking steps to mitigate them.

Q3: How is the training verified?

Clearly, the responses to this question would depend on how the associated training was undertaken. For institutions that relied on completion of a pre-requisite course, the student transcript served as the ordinary means of verification. One institution included an additional step of requiring the student to fill out a formal request form which required a faculty member or the Department chair to sign off for approval. Another of these institutions incorporated observation of the student’s work by a trained machinist as an additional level of verification.

Observation of students’ work was the primary method of verification for institutions that had implemented focused training. The person responsible for conducting the training would certify whether the student had achieved the requisite ability. One institution relied on having a record of student attendance at training sessions. For the institutions that conducted Safety training, the primary method of verification was to administer a test or quiz. One of the institutions included a hands-on element to the test. The test performance required to satisfy the requirements varied, with one institution requiring 100%.

Q4: What technical support is available to students (if any) during that time?

Only twenty of the respondents gave answers to this question. Among these, the technical support provided to students consisted of one or more of the following three elements: lab technician/machinist, faculty member, or student assistant. In one form or another, all respondents that allow independent student use of the machine shop discussed the importance of ensuring that a student does not work alone in the shop. Several of them required a 'buddy system', and a couple of them relied on the 'buddy system' to serve the functions of technical support.

Q5: How do you handle liability issues?

While only seventeen respondents answered this question, it also generated the most expansive comments. The comments indicated that there was a great deal of uncertainty and unease as to what was the appropriate course of action. Most respondents indicated that they relied on the institutional liability policy but there was wide variance in the approaches used to ensure compliance. Some counted on the training/verification procedures specified under Q2 and Q3. Many took the additional steps of providing written safety procedures that have to be observed by all students. Several went even further by having students sign a use agreement or liability sheet. However, they said that these documents had not been reviewed by legal experts and that they were given to students primarily to instill in them a greater sense of responsibility for their personal safety. The safety procedures followed at the author's institution are given in the Appendix. These are very similar to the examples given by survey respondents.

Another common practice was having in place procedures to ensure that only enrolled students would use the shop and, equally important, that they would use the shop only for work related to the institution. One respondent cited the procedures followed by California Polytechnic State University and the University of Wisconsin as being exemplary. (The person was not from either of these institutions). Many again echoed the importance of ensuring that a student does not work alone in the shop. One respondent also addressed the issue of student liability for damage caused to equipment. If the damage was considered to be intentional, the matter would be taken up to institutional administration for review.

Q6: Is yours a 2-year or 4-year institution?

Of the thirty-one usable responses, twenty were from 4-year institutions, nine were from 2-year institutions, and 2 were from 2+2 institutions that grant both associates and bachelor's degrees in the field. The author believes that while this can by no means be considered to be a statistically robust sample, it is nevertheless substantially representative and valid lessons can be drawn from these results.

4. The Case of Student Death in a Machine Shop

In April 2011, Michele Dufault, a student at Yale, died when her hair got caught in a lathe she was running. According to a New York Times article reporting on the incident, she had previously completed an introductory machining course and was experienced with the

equipment. She was also taking an advanced course in machine shop protocols. Colleagues described her as always being very careful with the equipment. On this occasion, she was working alone in the machine shop at night. Other students entered the shop around 2:30 AM and discovered her, with her ponytail caught in the lathe and her body "compressed against the machine," She died of asphyxiation and her death was ruled an accident[1]. It should be noted that Yale had a policy not allowing students to work alone in the machine shop.

OSHA conducted an investigation and among its findings stated that the lathe in question did not have a physical safeguard that met American National Standard Institute (ANSI) standards. It also stated that the university did not address machine safeguarding during safety inspections, did not complete or document personal protective equipment assessments, and did not post machine shop rules and regulations. But because the incident involved a student rather than an employee, OSHA could not issue fines or citations. In any case, Yale vigorously disputed OSHA's findings and asserted that OSHA had referenced an outdated standard, and that at the time of the incident, Yale met the then current requirements through student training and shop oversight[2].

This is not legal column and the author does not presume to offer legal advice. Nevertheless, the following points seem to be beyond dispute and the reader is urged to the draw appropriate lessons:

- The student was qualified and had experience working with the machine in question
- The student was working alone in the machine shop at night

Institutions need to implement protocols to ensure that policies are in fact followed, and consider how to handle situations where policies on the books are not followed.

Yale's response to the incident included a change in and a tightening of their policies. According to the new policies, student shops will have electronic or mechanical access controls. Students are also warned that fatigue is a significant source of risk[3].

5. The Death of a Researcher in a Chemistry Laboratory

On the afternoon of December 29, 2008; Sheharbano Sangji, a 23-year-old research assistant, was involved in an accident while conducting an experiment in a Chemistry research laboratory run by Patrick Harran, a professor at the University of California, Los Angeles. The chemical reagents Sangji was working with ignited and caught on fire, as did her clothes. A second researcher working in the lab at the same time struggled to put out the fire. A third researcher in an adjacent lab heard Sangji's screams and when he saw that someone was already helping to put out the fire, he returned to his own lab and called 911. The fire was out by the time emergency responders arrived but Sangji had been severely burned. After decontamination in the lab's safety shower, Sangji was taken to the University's Medical Center. From there she was transferred to the Grossman Burn Center, where she died on Jan. 16, 2009.

Because Sangji was an employee rather than a student, the California OSHA investigation of the incident resulted in the university being fined. The agency cited the relevant university departments for lack of training; failure to document training; failing to correct unsafe laboratory

conditions and work practices identified in a previous inspection of this particular lab; and failing to ensure that employees wore appropriate personal protective equipment (PPE), such as lab coats[4].

In addition to the Cal/OSHA investigation, the local District Attorney (DA) filed criminal charges against both the university and Professor Harran for violations of the state labor code. On July 27, 2012; in exchange for the DA dropping the charges against the university, the University of California regents accepted responsibility for the conditions under which Harran's laboratory was operated at the time of the incident. They also agreed to establish an environmental law scholarship in Sangji's name with a $500,000 endowment, to be funded within one year[5]. On June 20, 2014; a county judge approved a separate deal with Professor Harran requiring him to complete 800 hours of community service and pay a $10,000 fine. The charges against Harran were effectively put on hold for five years during which he would complete the terms of the agreement, after which the DA's office will move to dismiss the charges if he meets all his obligations[6].

6. Federal Regulations for Machine Shop Safety

The difference between the Yale and UCLA cases is significant for our present discussion. In the case of Yale, the victim was a student of the university while in the case of UCLA, the victim was a university employee. That distinction was central to the difference in the legal consequences of these two incidents.

Under the Occupational Safety and Health Act of 1970 (OSH Act), employers are responsible for providing a safe and healthful workplace. The mission of the Occupational Safety and Health Administration (OSHA) is to assure safe and healthful *workplaces* by setting and enforcing standards, and by providing training, outreach, education and assistance. Employers must comply with all applicable OSHA standards. Employers must also comply with the General Duty Clause of the OSH Act, which requires employers to keep their workplace free of serious recognized hazards[7]. The OSH Act covers most private sector employers and workers in all 50 states, the District of Columbia, and the other United States (U.S.) jurisdictions either directly through federal OSHA or through an OSHA-approved State Plan. State Plans are OSHA-approved job safety and health programs operated by individual states instead of federal OSHA. The OSH Act encourages states to develop and operate their own job safety and health programs and precludes state enforcement of OSHA standards unless the state has an OSHA-approved program. However, state-run safety and health programs must be at least as effective as the federal OSHA program. This provision is responsible for the variation in safety standards around the country. OSHA provides minimums which the states are free to exceed.

As the Yale case in section 4 above demonstrates, students are not employees and therefore are not directly covered by OSHA regulations. While Yale changed it policies in response to the incident at its campus, the institution and its employees were shielded from sanctions under OSHA regulations. OSHA regulations cover employees like instructors, technicians, student assistants, if they are injured in the course of their work. However, these employees in their turn have the responsibility to be familiar with appropriate safety requirements of the laboratories they ran or supervise. It is the employee's responsibility to minimize the likelihood of a student

suffering an accident. If an accident does happen through negligence, the institution and the responsible employee may be liable in any legal action that arises from the accident.

Of course the author reiterates that he has no legal expertise and this opinion should be taken in that light. Nevertheless, the author strongly recommends that anyone running a typical university or college machine shop, should be familiar with the requirements of the subparts of the OSHA standards given in Table 2 and ensure they are complied with to minimize liability issues.

Table 2: US Department of Labor and Regulations Deemed Relevant for Machine Shops
29 CFR §1910 OSHA General Industry Standards[7]

OSHA Standard Subpart
1910 Subpart K - Medical and First Aid
1910 Subpart L - Fire Protection
1910 Subpart M - Compressed Gas and Compressed Air Equipment
1910 Subpart N - Materials Handling and Storage
1910 Subpart O - Machinery and Machine Guarding
1910 Subpart P - Hand and Portable Powered Tools and Other Hand-Held Equipment
1910 Subpart Q - Welding, Cutting, and Brazing

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6. Michael Torrice and Jyllian Kemsley: "Patrick Harran And L.A. District Attorney Reach Deal In Sheri Sangji Case". http://cen.acs.org/articles/92/web/2014/06/Patrick-Harran-L-District-Attorney0.html [accessed 3/15/2015]
7. https://www.osha.gov/law-regs.html

Appendix:

Laboratory Safety Procedures

You will be operating some very high-powered equipment in this laboratory. If not handled properly, **the equipment can cause serious injury or even death**. It is important to observe the following safety procedures:

1. When you do not know how to do something, ask!
2. There are several large red **STOP** buttons scattered around the walls of the room. In an emergency, use one of these to turn off all the power to the lab. Familiarize yourself with the locations of these buttons.
3. Each machine has an emergency stop button. If you are closer to the machine where an emergency occurs than to the wall, use the machine's emergency stop to turn off power to the particular machine.
4. No horseplay is allowed in the lab.
5. Always wear safety glasses before operating any machine.
6. Wear short sleeves. If you have long-sleeved clothing on, roll back the sleeves.
7. Tie back long hair before operating any machine.
8. Open shoes such as sandals are not permitted in the lab.
9. Dangling earrings, neckties, pendants, or bracelets are not permitted to the lab.
10. Clear the operating area of debris or any unused tools such as wrenches or chuck keys before starting work. Loose items can become flying objects.
11. DO NOT run your machine until you have understood all machine controls.
12. DO NOT run your machine for the first time without a qualified instructor present. Ask your instructor for help when you need it.
13. Never operate a machine after taking strong medication, alcohol, or illegal drugs.
14. Stop the spindle fully before changing tools, loading/unloading a work piece, or adjusting a work piece or fixture.
15. Keep your work area clean and dry by removing chips, oil and obstacles from the machine and the work area. Use a brush or chip scraper, not your hands.
16. Stop the spindle fully before you clear away chips or oil.
17. Stop the spindle completely before you take measurements.
18. Stop the machine before you change or adjust belts, pulleys or gears.
19. Keep hands and arms clear of the spindle start switch when changing tools.
20. Securely clamp and locate work piece. Use stop blocks where necessary.
21. Prevent cutter breakage. Use correct tables for feed and spindle speed for the job. Reduce feed and speed if you notice unusual noise or vibration.
22. Rotate spindle clockwise for right-hand tools, counterclockwise for left-hand tools. Use the correct tool for the job.
23. Never start the machine when the cutter is in contact with the work piece.
24. Never work alone in the machine shop.
25. Do not leave machine unattended while it is running.
26. Report all injuries and near misses, no matter how small, to departmental staff.
27. Prevention is better than cure! Be safe rather than sorry!