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## ***Benefits of a Cross-Functional Safety Curriculum***

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# Benefits of a Cross-Functional Safety Curriculum

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of a safety technician, but also possess the knowledge to understand the “why” of those activities and the capability to pursue life-long learning as safety professionals.

The American Society of Safety Engineers (1998) defines the primary functions of a safety professional as:

- anticipate, identify, and evaluate hazardous conditions and practices;
- develop hazard control designs, methods, procedures, and programs;
- implement, administer, and advise others on hazard controls and hazard control programs; and
- measure, audit, and evaluate the effectiveness of hazard controls and hazard control programs.

Practicing safety professionals are one component of the multidisciplinary management organization found in industry. These functions cannot be accomplished in isolation. They are interdependent or cross-functional with other functions of the management structure as well as the functions of labor and their unions. Therefore, curricular activities that require the cooperation of multiple functional groups within an educational setting to accomplish the desired outcomes will more adequately prepare safety professionals for a cross-functional working environment.

University and college faculty charged with the responsibility to develop safety graduates with the requisite knowledge and skills must also be cognizant of the wide variety of learning styles that students bring to the classroom. The traditional lecture format accompanied by practice problems may not produce the kind of academically oriented “hands-on”

practitioner desired in new graduates of safety programs. One promising option involves the use of learning in context. The concept of contextual learning has been gaining support for a number of years. It has been suggested that curricula are strengthened when content emphasis and thinking skills are joined, as is accomplished through experiential learning (Resnick & Klopfer, 1989). The 1991 Secretary’s Commission on Achieving Necessary Skills (SCANS) also makes the point, based on a review of the findings of cognitive science, that “the most effective way of learning skills is ‘in context,’ placing learning objectives within a real environment rather than insisting that students first learn in the abstract what they will be expected to apply” (SCANS, 1991, p. xv). Keif and Stewart (1996, p. 33) reiterate the argument that context improves the learning process, and suggest that “an emphasis on context as it relates to facilitating student learning is supported by cognitive theory.” Collins, Brown, and Newman have also suggested that cognitive apprenticeships in schools may be one way of implementing contextual learning (as cited in Resnick & Klopfer, 1989). A cognitive apprenticeship in higher education would include real tasks; contextualized practice of tasks, not exercises on component skills that have been lifted out of the contexts in which they are to be used; and the opportunity to observe others doing the kind of work they are expected to learn to do.

This manuscript describes an effort to incorporate the concepts of contextual learning and cognitive apprenticeships into a cross-functional safety curriculum within industrial technology.

## Introduction

As a profession, the practice of safety and health is still in its infancy. Thus, there is a recognized need for trained safety and health professionals. Many safety professionals start in other technical areas and receive their safety education on the job and through continuing education programs (Kedjidian, 1998). It has been estimated that currently only 25-35% of individuals entering the safety profession are academically trained for safety (Kohn, 1997). Acceptance of safety as a true technical-based profession by industry is unlikely to occur until the majority of the people practicing the profession are academically trained. This depends on the ability of faculty to produce graduates who are able to not only perform the required activities

## **Cross-Functional Curriculum Components**

Industrial technology at Iowa State University encompasses the disciplines of manufacturing technology, safety, and training and development (see Figure 1). The cross-functional curriculum development is currently focussing on the interaction between the safety and manufacturing curriculum options.

Below are the catalog descriptions for the courses involved in this curricula integration effort.

### **Introduction to Metallic Materials and Processes**

This course introduces the chemical, electrical, mechanical, and thermal properties of metallic materials, as well as an introduction to select industrial manufacturing processes. Lecture and laboratory activities focus on understanding and applying process parameters. This is a sophomore-level course required for students in all three undergraduate options (that is, manufacturing, safety, and training and development). Course components specific to aspects of the cross-functional curriculum include: the safe utilization of manufacturing materials and equipment, understanding of how safety policies and procedures impact the manufacturing environment, and an appreciation for the expertise and responsibilities of skilled workers and the role they play in ensuring a safe manufacturing environment.

### **Introduction to Occupational Safety**

This course covers an introduction to industrial accident prevention as it relates to safety and health, and the administration and management of safety and health programs. This is also a sophomore-level course required for students in the safety option. The course components involved in the cross-function curriculum include hazard identification, injury prevention, regulatory requirements, safety audits/inspections, and job safety analysis.

### **Safety in Manufacturing**

This course identifies safety and health risks in industrial work environments, particularly to workers in manufacturing industries. Topics

include the prevention of hazardous workplace exposures and the safe use of equipment for materials handling and production operations. This is a junior-level course required for students in all three undergraduate options (manufacturing, safety, and training and development). Cross-functional curriculum components include hazard identification, injury prevention, safe work procedures, appropriate personal protective equipment, and regulatory requirements.

### ***Current Interactions***

#### **Introduction to Metallic Materials and Processes**

The students in the *Introduction to Metallic Materials and Processes* class interact with the safety students by experiencing safety audits and inspections of their working environment and operating procedures. Student acceptance and understanding of safety and health principles are encouraged by receiving safety information from multiple faculty sources and their own peers.

#### **Introduction to Occupational Safety**

The students in the *Introduction to Occupational Safety* class interact with the students in the *Introduction to Metallic Materials and Processes* class to complete one of their semester projects—conducting a job safety analysis (JSA) in a work-like setting. Completing the JSA is the capstone effort evolving from the targeted outcomes listed in the previous section. The manufacturing faculty, in consultation with safety faculty, identify activities (for the JSAs) that are appropriately challenging and which involve current course-specific safety issues.

#### **Safety in Manufacturing**

The students in the *Safety in Manufacturing* class interact with the curriculum and students in the *Introduction to Metallic Materials and Processes* class to gain hands-on experience while accomplishing the targeted outcomes listed in the previous section. By way of illustration, students are required to review safe operating practices for specific laboratory activities. Semester projects are

assigned addressing topics of concern identified by manufacturing faculty. These topics offer students the opportunity to examine actual issues in a manufacturing environment, such as machine guarding, dust and chemical exposure, and implementation of written safety policies and procedures. Students are expected to explore the issues, assess the potential risks, and offer realistic solutions that include a cost/benefit analysis.

### ***Evolution of the Cross-Functional Curriculum***

Outcomes assessment is an ongoing effort within the Industrial Technology program at Iowa State University. This process of outcomes assessment is energized by three primary motivators. The first motivator is simply the desire on the part of the faculty to continually improve the curriculum; the second is curricular review by the department's Industrial Advisory Council; and the third is curricular review as an element of the department's accreditation process (R. A. Smith, personal communication, March 2, 1998). One by-product of the overall assessment process is a listing of tasks which graduates of the occupational safety track are expected to be able to take on. A sample of the 42 tasks currently tracked by the department is:

1. Detect hazardous conditions and operations.
2. Compare the risk of a work task.
3. Apply scientific principles to waste disposal.
4. Identify the appropriate personal protective equipment.
5. Understand the philosophy of safety.
6. Recognize the components of a laboratory safety program.
7. Perform a safety inspection and audit.
8. Apply accident prevention procedures.
9. Apply the theories of industrial hygiene practices.
10. Identify the toxicological effects of chemicals as found in typical manufacturing settings.
11. Understand the principles of process safety management.

12. Write safety policies and rules.
13. List the steps in conducting a job safety analysis.
14. Develop and write safety programs.
15. Choose and administer the appropriate safety training program.

The cross-functional curriculum evolved out of efforts by faculty members to implement the concepts of cognitive apprenticeship—providing real tasks, not exercises on component skills that have been lifted out of the contexts in which they are to be used—between the manufacturing technology and occupational safety tracks within the Department of Industrial Education and Technology.

Example cross-functional activities assigned to the safety students that address the targeted outcomes listed in previous sections and identified in the above task list are shown in Table 1. In addition to the types of homework assignments shown in Table 1, safety students were also assigned realistic, open-ended problems as semester projects that relied on the activities of other courses for completion. Examples of semester projects are included in Table 2.

Initially, the cross-functional aspects of the curricula were very informal. However, the process has become more formalized with each semester. Current curricular interactions between are discussed and formalized prior to the start of the semester.

## Benefits

### Occupational Safety Students

The most significant benefit for the safety students is the ability to practice their profession in a work-like environment while they are learning safety and health principles in the safety curriculum. This practical application of their discipline under typical manufacturing constraints (budget and training requirements, as well as production pressures) promotes realistic solutions to safety and health issues. The process of interacting with the *Introduction to Metallic Materials and Processes* students and faculty provides the safety students with practical examples of

how the various industrial technology disciplines interact (e.g., training, safety, and manufacturing disciplines all influence the manner in which the students perform the manufacturing processes that are incorporated into laboratory activities).

### Other Industrial Technology Students

While taking the *Introduction to Metallic Materials and Processes* course, students' primary focus is on the completion of their laboratory projects—the pressure to complete their projects in a timely manner can relegate the principles of safe operation to a level of secondary importance in the minds of students. These students benefit by having their peers in the safety curriculum reinforce safety guidelines and operating procedures taught by the instructor. *Introduction to Metallic Materials and Processes* students also gain a better understanding of the interrelationships between technical disciplines and the process of involving support functions in the manufacturing environment to address specific issues. Additionally, activities in the *Safety in Manufacturing* course provide those students with the opportunity to reevaluate the use of the manufacturing equipment focussing on the safety aspects of the processes.

### Faculty

The faculty involved in these interactions benefit by the opportunity to further their students' understanding of the interrelationships of various technical disciplines that are encompassed by Industrial Technology at Iowa State University. This process of interaction also helps faculty reduce duplication of effort, reminds them of common goals across curricula, and promotes collegiality among those participating. In addition to helping to meet Industrial Technology curricula goals, the faculty involved also receive benefits directly related to accomplishing the targeted outcomes of the individual courses. For example, safety faculty are presented with a convenient location that allows them to easily incorporate practical hands-on experiences for safety students and manufacturing faculty efforts to help students

learn production processes, with an eye toward safety, are significantly enhanced by the process of student peer reinforcement.

## Observations

Manuele (1997) summarized the practice of safety as one which:

- serves the societal need to prevent harm or damage to people, property, and the environment;
- is based on knowledge and skill in a variety of technical fields (applied engineering, applied sciences, applied management, and legal, regulatory, and professional affairs);
- is accomplished through
  - a) anticipating, identifying, and evaluating hazards; and
  - b) taking actions to eliminate, control, or avoid those hazards; and
- attains a state for which risks are judged acceptable.

The cross-functional safety curriculum within the Industrial Technology degree program at Iowa State University supports the preparation of students who, upon graduation, will be able to enter the safety profession and start practicing the discipline as defined above and promote the advancement of safety as a true technical-based profession.

In addition to helping to accomplish the broad-based goal of developing safety professionals, the following general observations (drawn from student comments on course evaluations and from appraisal of course content and delivery by the faculty as part of a continuous improvement process) have also been realized by the current cross-curriculum interaction:

- The *Introduction to Occupational Safety* students consider the JSA assignment to be one of the highlights of the course, one in which they are able to apply many of the concepts introduced during the semester.
- Many of the *Safety in Manufacturing* students are already familiar with the use of the manufacturing equipment. This

facilitates their discussion of hazard identification, and suggesting both engineering changes and the correct operating procedures to prevent injuries.

- The safety students take the real-life challenges seriously because manufacturing faculty are interested in their suggestions and recommendations for improving the safety of the lab operations. The students realize they can have a significant impact on the safety of themselves and their peers.

### Continued Interaction

Current interaction between the safety and manufacturing curricula will continue to expand during forthcoming semesters. In addition to the interactions described above, the following interactions are also planned for upcoming semesters:

- Faculty will develop a more formalized process for Occupational Safety students to perform safety audits and inspections in the Metallic Materials laboratory.
- Faculty will implement a more formalized process for the review and implementation of recommendations resulting from safety student projects and assignments.
- Faculty will implement a formalized process for manufacturing students to request a review of materials, processes, or

equipment for which they have safety concerns.

- Faculty will explore interaction between the safety curriculum and other manufacturing laboratory courses.
- Faculty will attempt to put in place financial resources for students to implement safety changes that they recommend.
- Faculty will explore a means of documenting the results and benefits of the cross-functional safety curriculum.

### Recommendations

The primary recommendation to Industrial Technology faculty resulting from the authors' experience is to review course outcomes for opportunities to develop cross-curricula interactions. Interactions between Industrial Technology disciplines can lead to a more efficient use of departmental resources across a larger number of classes, while at the same time improving the performance and capabilities of those classes. Successful cross-curricula interactions can also lead to experiences that are more realistic for the students and heightens interest level among students for content outside of their area of focus. Given a working intradepartmental model for cross-functional curricula interactions, the next step is to expand the model to incorporate industrial partnerships. By involving students with industry projects, the students receive additional benefits associated with having indus-

trial partners (mangers, supervisors, etc.) and industrial partners benefit by having faculty and students advance the land-grant university mission of serving constituents across the state.

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Table 1. Examples of Cross-Functional Activities

Activity	Description
Review of manufacturing activities which involves components of hazard identification, safe work procedures, appropriate personal protective equipment, and regulatory requirements.	Attached are two subjects/projects (metal lathe; twist drill) out of the ITEC 231 laboratory manual. We will of course in this class be focussing on the safety information (under item 9) in each lab subject. Procedure: <ol style="list-style-type: none"> <li>1. Review each lab subject. (Visit the metals lab as necessary to familiarize, or reacquaint, yourself with the equipment and processes involved.)</li> <li>2. Re-write the safety section of each subject to include all pertinent safety information. This may include (but not limited to) the following:                             <ul style="list-style-type: none"> <li>• safety regulations, standards, guidelines, etc.</li> <li>• required personal protective equipment</li> </ul> </li> </ol>

*Table 1. Examples of Cross-Functional Activities (continued)*

Activity	Description
Development of a required safety program which involves components of hazard identification, safe work procedures, and regulatory requirements.	<ul style="list-style-type: none"> <li>• safe operating procedures (Do not include just a list of dos and don'ts. Wherever possible explain the reasoning behind recommended procedures.)</li> </ul> <p>Develop a lockout/tagout program for the lathes in the I TEC 231 Metals lab. The program should include:</p> <ul style="list-style-type: none"> <li>• Lockout/tagout procedures</li> <li>• Suggested training materials</li> <li>• Suggested lockout/tagout equipment</li> <li>• Lockout/tagout placard to be placed on each machine identifying all energy sources and the lockout/tagout procedure.</li> </ul>
Conducting a job safety analysis.	<p>Complete a Job Safety Analysis (JSA) as assigned.</p> <p>After receiving your assigned task, schedule a meeting time with Dr. Field to discuss when students in the ITEC 231 class will be performing your assigned task. Use the example JSA form distributed in class. Consider video taping the job. You may check out video cameras free of charge from the Instructional Technology Center. This will make step 3.2.2 much easier and convenient. However, be sure to get permission before video taping anyone. The following steps are an outline of what you will need to do:</p> <ol style="list-style-type: none"> <li>1. Meet with Dr. Field to discuss your task and schedule your JSA.</li> <li>2. Do background work to familiarize yourself with regulations, standards, safe operating procedures associate with the task you will be analyzing.</li> <li>3. Conduct your JSA as discussed in class.             <ol style="list-style-type: none"> <li>3.1 Break the job down into successive steps.                 <ol style="list-style-type: none"> <li>3.1.1. Observe the job.</li> <li>3.1.2. Identify and describe each step (what is done, not how).</li> <li>3.1.3. Review results with the worker you are observing.</li> </ol> </li> <li>3.2. Identify each potential hazard.                 <ol style="list-style-type: none"> <li>3.2.1. Identify all environmental, physical, mechanical, and procedural hazards.</li> <li>3.2.2. Repeat the observation as many times as necessary to be sure.</li> <li>3.2.3. Review results with the worker/student you are observing.</li> </ol> </li> <li>3.3. Develop safe procedures for eliminating each hazard.                 <ol style="list-style-type: none"> <li>3.3.1. Consider changing the procedures or the physical conditions (tools, materials, equipment, etc.) to eliminate each identified hazard.</li> <li>3.3.2. Discuss potential changes with the workers/students.</li> <li>3.3.3. Re-observe the job incorporating the changes and discuss with the worker/student before finalizing your recommended solutions.</li> </ol> </li> </ol> </li> </ol>

**Table 2. Examples of Cross-Functional Semester Projects**

**General Guidelines**

The first thing you will need to do is to clearly define your problem. Schedule a time to meet with the appropriate faculty members to obtain additional background information about the problem. You may also need to revisit the lab as part of the process of defining the problem. After you have a clear understanding of the problem, start conducting a hazard assessment and documenting relevant background information (e.g., OSHA regulations, ANSI standards, ACGIH recommendations, EPA regulations, etc.) addressing the hazards. Once you have accumulated the background information and finished the hazard assessment you can begin to develop possible solutions. Your solutions need to be realistic accounting for standard industrial constraints (time, money, continued production, etc.). The final step in the process will be to analyze your possible solutions and make a recommendation to correct or mitigate the problem. The documentation of your work will be written-up as a project report.

The Project report should be 15-20 pages in length and include documentation of the hazards, relevant safety and health regulations or guidelines, at least two alternatives for elimination or mitigation of the hazards, and a final recommended solution that includes a cost benefit analysis.

**Example Topics**

In addition to the written report, each group will also make a short presentation to a panel of safety, manufacturing, and training faculty summarizing your project and justifying your recommended solution.

Fluxes used in the foundry processes.

Shielding on the lathes.

Plan and procedures for conducting safety audits in the metals lab.

Plans and procedures for conducting safety training associated with the processes and equipment in the metals lab.

**Figure 1. Industrial Technology at Iowa State University**

