An Integrated Process Safety Curriculum: It's more than just technical content!

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Outline of Talk

I believe that universities must be an active participant in insuring that chemical engineers have proper process safety instruction to be successful in their careers.

- **What do we need to teach?**
- **Why do we need to do this?**
- **How do we do this?**

What do we need to teach?

There are three major parts to process safety education:

1. Technical part: toxicology; industrial hygiene; toxic, flammable and reactive hazards; source, consequence and dispersion models; overpressure protection; hazards identification, risk assessment, etc.
2. Cultural part: behavior, valuing process safety, "doing the right thing," etc.
3. Psychomotor part: ability to execute procedures related to process safety, i.e. hot work permits, vessel entry, lock-tag-try, etc.

All three parts are essential!

What do we need to teach?

Current undergraduate chemical engineering programs excel at teaching technical topics to chemical engineers, and to a limited extent some psychomotor skills in the Unit Operations laboratory.

However, with the addition of safety content, this is the first time that a substantial cultural part is a necessary part of the student's education.

What should university's do?

Do we really need to teach Safety Culture?

Yes! because:

1. **This is the only place that all chemical engineers receive common instruction, whether they go to a large chemical company, a "mom and pop" company, the military, the government, or any place else.**
2. **It is a lot easier to instruct culture at the typical age of undergraduate students.**
3. **Industry would prefer to have new hires with proper safety culture.**
4. **With safety culture the engineer is inclined to "do the right thing."**

Major Impediment to Teaching Safety Culture

Most chemical engineering faculty do not have any industrial experience and have never been exposed to the application of safety culture in an industrial practice situation.

However, safety culture can be learned in a short period of time.

Bloom's Taxonomy of Learning Domains

Technical Part: → **Cognitive Domain**
B. Bloom, *Taxonomy of Educational Objectives, Handbook 1: The Cognitive Domain*, 1956.

Cultural Part: → **Affective Domain**
Krathwohl, Bloom and Masia, *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook 2: Affective Domain*, 1973.

Psychomotor Domain: → **Psychomotor Domain**
Simpson, *The Classification of Educational Objectives in the Psychomotor Domain*, 1972.

Bloom's Taxonomy of Learning Domains

Additional details on the learning domains:

Lowest → Highest

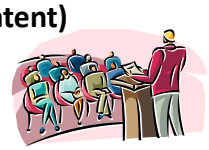
Cognitive Domain: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation.

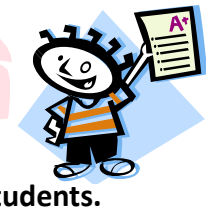
Affective Domain: Receiving, Responding, Valuing, Organization, Internalizing values.

Psychomotor Domain: Perception, Readiness, Guided response, Complex overt response, Adaptation, Origination.

Teaching in the Different Learning Domains

Cognitive Domain: (Technical Content)
Lectures, homework, tests





Affective Domain: (Culture/Values/Behavior)
Instructor must be a role model for the students.
Students must realize desirability of value or behavior.

Psychomotor Domain: (Doing things)
Students must do actual operations.

Teaching Process Safety at Michigan Tech

Some safety content in all courses, including senior design.
All faculty understand importance of process safety.
Minimal safety program in chemistry labs.

1. **Junior transport laboratory**
   - Taught 2nd semester junior year.
   - Mostly "canned" experiments.
   - Safety manual provided.
   - Safety briefing at beginning of lab.
   - Hazards reporting system.
   - Instructor shows value of safety.
   - Beginning of instruction on affective and psychomotor domains.

Teaching Process Safety at Michigan Tech

1. **Junior transport laboratory safety program**
   - **Build on skills introduced in chemistry labs (and for some students while on coop).**
   - **Focus on chemical plant standards (PPE, MSDS).**
   - **Introduce capstone lab safety standards, practices, language (hazard reporting, ladder safety).**
   - **Personal responsibility/professional responsibility emphasized throughout.**
   - **Treat as career skill – must take these skills with you!**

Teaching Process Safety at Michigan Tech

2. **2-credit required safety course:**
   - **Taught first semester senior year.**
   - **Mostly technical content on process safety.**
   - **Mostly cognitive domain thru technical lectures.**
   - **Discussion of simple case histories.**
   - **Includes SACHE certificate program on *Safety in the Process Industries.***
     - **This includes safety procedures and designs for safety.**
   - **Students need to watch a number of CSB accident videos.**
   - **Uses Crowl and Louvar textbook, 3rd ed., Chapters 1 thru 9, 11**
     1. **Introduction, including accident statistics**
     2. **Toxicology**
     3. **Industrial Hygiene**
     4. **Source Models**
     5. **Toxic Release and Dispersion Models**
     6. **Fires and Explosions**
     7. **Concepts to Prevent Fires and Explosions**
     8. **Chemical Reactivity**
     9. **Introduction to Reliefs**
     11. **Hazards Identification**

Teaching Process Safety at Michigan Tech

3. **Senior Unit Operations Laboratory:**

Full senior year course – 2 semesters.
6,500 sq. ft. multistory facility. 3 full time staff (one engineer).
First semester, smaller experiments: heat exchangers, membrane separation, kinetics, ARSST, liquid extraction, vacuum drying, flow measurements, others.
Second semester, larger process experiments.
Larger process experiments:
- 30 gallon batch reactor
- 3 story distillation column with structured packing

Both experiments have Emerson DeltaV and PI-Processbook software
Student run safety program (more later).
Heavy into safety culture (affective domain) and process operations (psychomotor domain).

Teaching Process Safety at Michigan Tech




1946 → 1980

Autocratic style of Accident Prevention:

Lab supervision made rules, set the example, expected students to follow

- ***Bad behavior***
  - **-Resulted in a grade penalty and threat of removal from course**
- ***Result***
  - **-Sets up a "police state" with respect to safety and does nothing to create a mature, professional, responsible Chemical Engineer**

15

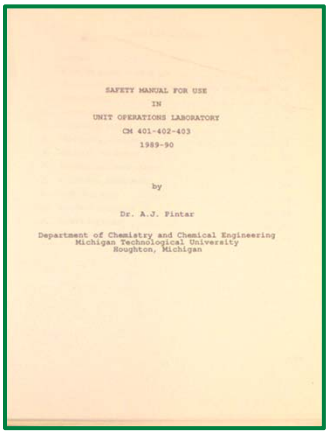
1980 → 1989

Beginning of the Safety Program

1982 – "Safety" Experiment added to Unit Operations Lab

Typical assignments:

- **Students serve as safety officers**
- **Study catastrophic event at a chemical plant**
- **Federal mandates toward worker or environmental safety**
- **Produce a safety training video**
- **Conduct safety inspections**


SAFETY MANUAL FOR USE
IN
UNIT OPERATIONS LABORATORY
CM 401-402-403
1989-90

by

Dr. A.J. Pintar

Department of Chemistry and Chemical Engineering
Michigan Technological University
Houghton, Michigan

1983 – Students write first *Safety Manual for Use in Unit Operations Laboratory* under direction of Dr. A. Pintar

16

1980 → 1989

Process Safety education gains a foothold, late 1980's:

- **Chemical Process Safety course is offered as an elective**
  - -Lecture and video based course with substantial industrial content
  - -Collaborative effort of Wayne State University, Michigan Technological University, BASF Wyandotte, and NSF
- **Students are tasked with developing a student-run hazard id program for UO Lab**
  - -*Praise Positive* from Dow Chemical Company and
  - -*SOAR* from BASF used as models
- **Student contest names new lab hazard identification program: *Prevent Accidents With Safety (PAWS)***
  - -Name fits with MTU Husky mascot

17

1990 → Present

Faculty expertise is strengthened:

1990 - *Chemical Process Safety* course becomes a required course for BSChE at Michigan Tech

1993 – Crowl joins MTU faculty as *Herbert H. Dow Professor for Chemical Process Safety*

1994 - UO Lab Safety program enhancements:

- Course syllabus lists safety as the first learning objective: "*Students will develop a constant awareness of safety so that all work is performed in a safe manner*"
- Job Safety Assessment (JSA) required for all UO Lab experiments
- Required safety meetings held after every "UO lab run day"
- Pre and Post laboratory inspections by students
- Safety meetings organized and run by students

18

UO Lab Process Safety Program at MTU

1. Student team meets with instructor and receives experiment objectives.
2. Team completes Job Safety Assessment (JSA), which includes detailed experimental procedure.
3. Team meets with instructor to review JSA.
4. One member of each team serves on UO Lab Safety Committee.
5. Safety Committee performs pre-lab inspection.
6. Lab operates and students complete experiments. PAWS forms are submitted during operation of lab.
7. Safety Committee performs post-lab inspection.
8. Required Safety Meeting is held:
   - Review and resolve all PAWS forms.
   - Review and resolve all inspection issues.
   - Safety topic presentation by Safety Committee
   - Discussion of safety topic – resolve any lab issues related to topic.
8. Faculty / staff continuously audit safety program to insure effectiveness.

Conclusions

1. Process safety education requires education using all three learning domains: cognitive, affective and psychomotor.
2. Traditional university instruction involves mostly the cognitive domain with some psychomotor content via laboratory courses.
3. With careful integration of lecture and laboratory content all three learning domains can be successfully achieved.