The Importance of Work Practice Tools and Standards in Chemical Engineering

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Abstract:

A set of work practice standards for the basic tasks which students must perform has been developed for chemical engineering. These work practice standards are for writing, problem solving, library use/information retrieval, and laboratory safety. They have been assembled as guides to these tasks which have been adopted as departmental standards by the faculty. A single set of standards makes it easier for both the faculty and students to focus on the content of the work and not on differences in mechanics. This reduces frustrations on both sides. These work practice standards are utilized every course throughout the curriculum. In particular the writing and problem solving guide and the library guide are introduced in the first course (ChE 101) and the methodologies are employed throughout the curriculum. The laboratory safety guide is introduced in the first chemical engineering laboratory course (ChE 345) and these standards are employed in all of our laboratory courses. Furthermore, a design guide has been provided for our capstone design courses. A final tool is the departmental reading room, which contains a collection of important professional references accessible to both faculty and students. When combined with online library tools, this is a real time saver for everyone. This reading room was established with corporate and private donations.

One measure of success of the undergraduate curriculum is the fact that 1988 and 1992 graduates have won in the AIChE National Design Competition for seniors. This competition has been held annually for more than sixty years and competition is intense. Recruiting of undergraduates in strong and their employment prospects are bright. The national reputation of the undergraduate program is good. The work practice standards went a long way towards rationalizing earlier problems and have enabled our students to compete in national level competitions. One further unexpected result is that the library guide, originally prepared for undergraduate students, has proven helpful to graduate students as well. Furthermore, because graduate students TA laboratories, the laboratory safety guide has proven helpful to them as well. At the request of the administration, the chemical engineering safety guide has been expanded to cover the entire university and has been issued to all department heads required to maintain a chemical hygiene plan and to all deans.

Introduction:

The educational process has two principal objectives:

(1) Conveying factual content of a subject to the student;
(2) Developing student learning, communication and thinking skills.

Traditionally, engineering education has emphasized technical content of subject matter and to some extent assumed the existence of learning, communication, and thinking skills. Since engineering is by its nature problem solving activity, it develops student ability to solve problems in content areas. However, because the factual content of an engineering education is so large, less emphasis than is perhaps wanted has been allocated to development of communication skills and styles of learning.

We have all seen expressions of concern in the national media regarding aptitude and kill performance levels of American students versus other national groups, or even versus ourselves in previous decades. Perhaps the time has come for significant reemphasis on basic skill development at all levels of education.

Background:

An article titled "Putting College Back on Course" appeared in the September 19, 1983 issue of Chemical Engineering. A nationwide survey of 3599 graduates of U.S. chemical engineering programs in the preceding decade revealed that waiting skills were rated second in importance after material and energy balance calculations by the graduates themselves. Yet only 4% of the students had formal training in these skills in college while 62% took additional formal training in writing after graduation. Clearly, a skill deficiency gap was identified.

The above mentioned article led me to consideration of what skill deficiencies could be identified in our students. Further, it led to consideration of what would be appropriate remedies. This led to a set of skill guides in writing and problem solving, library resource use, laboratory safety, and a set of general rules of thumb for grass roots design. Furthermore, it was clear that our students were in need of an on-site set of professional level references while they are doing work in the department. This latter need led to implementing a reading room, for which funds were raised from corporate donations.

One comment from a survey participant in the above-mentioned article is relevant to all persons interested in education:

"It is unreasonable, even cruel, to send people into a real world unprepared for reality."(Dennis Stewart, McKees Rocks, PA)

Elements of an Engineering Education:

Engineering education results from the interaction among three elements: the faculty, the students, and the curriculum. This is illustrated in Figure 1. For this reason, each element is essential to the process. In addition, some specialized equipment and materials are required(computers, laboratories, and library resources).

The faculty each develop individual styles suited to our personalities. This can lead to a wide range of methods to develop student skills. This is done in the context of organizing the course around a syllabus.

The students entering an engineering program are usually students with an interest in technical subjects and they are high school graduates with problem solving skills that are strong relative to their peers. However, they usually have only a vague notion of what engineering is.

Consider the curriculum. Figure 2 illustrates the structure of the undergraduate chemical engineering curriculum. It consists basically of lecture courses and laboratory courses. Lecture courses are interactive between teacher and student through question and answer and demonstration of solution methods to problems. The laboratory courses are interactive again by question and answer and also by illustration of how to use equipment. The tasks which must be performed by engineering students in lecture courses are primarily a series of homework exercises. These are usually groups of highly structured problems to be solved and they require the student to apply his knowledge of the subject matter in combination with more general problem solving methods. This develops the student's ability to solve such highly structured problems. The introduction of unstructured or less well structured problems is useful to education of the student, but is generally left to higher level courses where the student will have acquired some technical knowledge. In chemical engineering a senior level design project is required for graduation.

Discussion:

The tasks that must be performed by chemical engineering students can be summarized as:

1) homework(written and software based)
2) laboratory manipulations
3) accessing, collecting, and reviewing library resources to obtain key technical and economic data
4) preparing laboratory notebooks
5) preparing laboratory reports
6) preparing design reports

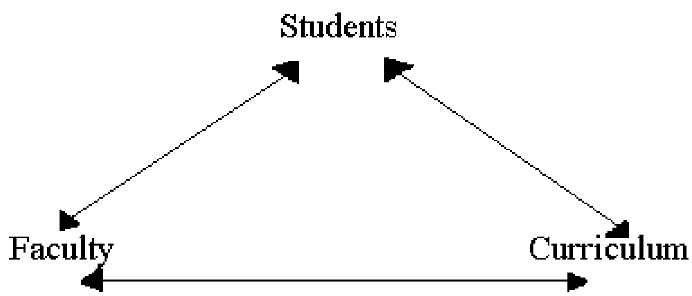
Thus, it is apparent that the opportunity exists within the curriculum to develop writing skills, problem solving skills, library research skills, and laboratory equipment handling skills. By setting departmental standards for such perennial student difficulties as organization, format, and mechanics, we can help the student focus his/her attention on the task at hand in doing written work. By providing overview information on library resources and groupings of key references with call numbers and a short description of each we make accessing non textbook technical data easier. By providing detailed guidance on safe practices in the laboratory setting we provide untrained people guidance on how to work safely and we further emphasize that safety is an important value for chemical engineers. This allows us to also consider professional ethics issues.

By providing design students with some general rules of thumb, we introduce the concept that design constraints are not only a result of physical laws and regulations but also a consequence of the other social and economic factors(such as capacity to move equipment by road or rail).

Departmental standards reduce disputes and excuses for not following guidance. Furthermore, once established, they allow relatively more attention to be focused on the actual work. The workload is intense and some people look for excuses to be disruptive. We cannot eliminate all such cases, but by attention to mechanics we can reduce disputes and expose needless disruption for what it is.

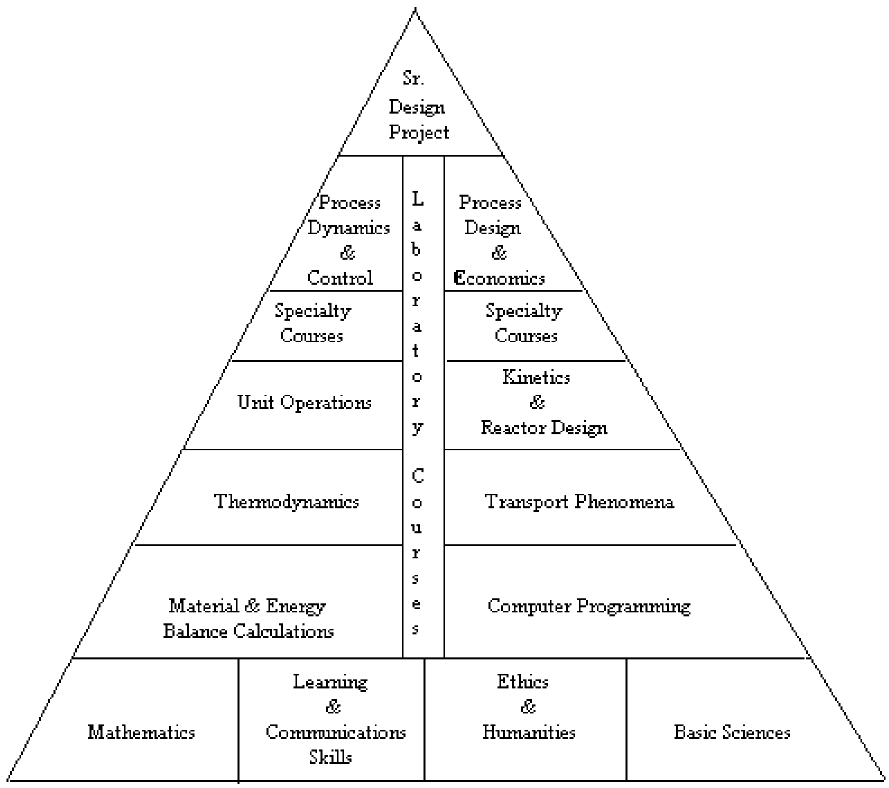
Conclusions:

We have come a long way towards rationalizing and automating work and administrative processes. These are largely thankless jobs which, however, make possible rational functioning. Students enter the program with a wide variation in background and skill in basic tasks. By providing detailed guidance we make it possible for all students who are willing and able to devote sufficient effort to succeed. We cannot compel students to work, but we can provide them directions to a sound path. Eventually the student learns to have what Kipling might call, “a full and Proper fit.”



Key Elements of an Engineering Education

Figure 1



An Undergraduate Chemical Engineering Curriculum Model

Figure 2