EC 2000 a–k Instructional Modules

http://www.foundationcoalition.org

The Foundation Coalition (FC) has developed modules to assist faculty members in teaching skills, particularly nontraditional skills such as communication skills, ethics, and lifelong learning, associated with the EC 2000 Criterion 3a–k. Faculty may download the modules from the FC web site, http://foundationcoalition.org, and use them in their classes. The Coalition is particularly interested in working with faculty who will review the modules, use the modules in their classes, or provide feedback and improvements to the modules.

What Is a Skill?

- Knowledge or understanding
- Ability in an art, craft, or science
- Proficiency, expertness, or judgment

In the context of an engineering curriculum, a skill requires knowledge, ability, and expertness in a process. For example, design skill is knowledge, ability, and expertness in the design process. Thus, a skill implies

- **Knowledge**—an awareness of the process,
- **Ability**—experience with the process, and
- **Expertness**—judgment in using the process.

Why Should Engineering Programs Teach Skills?

Engineering curriculum must teach the material defined in EC 2000, particularly Criterion 3a–k. This includes **content** (traditional knowledge of the discipline) and **skills** (processes needed to use the content).

Furthermore, engineering programs must demonstrate that their graduates have learned **traditional skills** (design, problem solving, computational) and **nontraditional skills** (communication, ethics, and lifelong learning).

Students do **not** learn processing skills by observing the instructor use them, by watching other students use them, or by using them repeatedly in homework assignments.[1] Since interactive skills cannot be learned by osmosis, instructors must explicitly teach them and provide considerable supervised practice in their use.[2]

When Should Skills Be Taught?

In discussing the teaching of engineering ethics, Pfatteicher[3] suggested that instruction must

- Be provided to all students,
- Appear more than once in the curriculum,
- Allow sufficient time for reflection, and
- Be integrated with technical courses.

These constraints apply to all skills.

Instruction in skills is best started in the first year and continued throughout the program. It cannot be accomplished in a single step and should not be left to the capstone course.

Where Should Skills Be Taught?

Students have difficulty transferring skills from stand-alone courses to other areas, e.g., transferring writing skills from English composition or even technical writing to engineering lab courses. They cannot apply the skills in other contexts.[1] Teaching skills as a part of a conventional engineering course circumvents the transference problem, but learning new skills concurrently with new content, e.g., teaching design methodology along with electronics confuses students, so they learn neither well.

Research at McMaster University on problem-solving skills showed that students did not acquire this skill by watching faculty and other students work problems or by working many problems (even open-ended problems) themselves.[1] This research showed that problem-solving skills can be taught and learned in a workshop environment where the process is taught separately and then integrated with the course content. The researchers developed a three-step approach.

- Build the skill using context-independent exercises;
- Bridge the skill using simplified problem in target subject domain; and
- Extend the skill to any complicated problems in subject courses.

Seat and Lord[2] in discussing interactive skills said that they should be taught in engineering courses as a part of the class material and that the involvement of engineering faculty legitimizes the importance of learning the skill.

How Should Skills Be Taught?

In teaching skills the instructor should

- Explicitly **identify the skill** and explicitly **teach it**;
- **Use a workshop** or cooperative learning format;
- Include several **opportunities to practice** the skill;
- Provide **feedback**—serve as a coach;
- Encourage students to **monitor** and **reflect on learning**;
- Include **discussion** activities.

Woods and his colleagues[4] present a good set of guidelines for teaching skills.

Why Instructional Modules?

Engineering instructors who decide to teach processing skills confront four problems:

- Lack of experience and training in teaching skills;
- Need for an interactive teaching style;
- Limited availability of instructional material; and
- Need to integrate the instruction into an existing engineering course.

Short instructional modules organized in a workshop format can meet this need. Faculty members working in the FC have created a set of instructional modules aimed at the skills required in EC 2000 Criterion 3a–k.

What Modules Are Available?

Technical Skill Areas
Computational design
Experimental modeling
Problem solving

Professional Skill Areas
Project management
Lifelong learning
Teaming
Time management

Ethical–Social Skill Areas
Contemporary issues
Ethics
Global & societal impact

Communication Skill Areas
Graphical
Oral
Written

What Do the Modules Look Like?

The FC instructional modules

- Fit into a week of classes,
- Are discipline independent,
- Utilize standard classroom facilities,
- Require limited up-front instructor investment,
- Fit into major upper-level courses,
- Have a standard form,
- Use active/cooperative learning, and
- Utilize web-based resources.

The FC instructional modules contain

- A clear **justification**,
- A set of **measurable learning objectives**,
- An **assessment process** to measure improvement,
- Multiple **student exercises and assignments**, and
- An **instructor's guide** discussing the use of the material and the grading of student work.

References

1. Woods, D.R., et al, "Developing Problem Solving Skills: The McMaster Problem Solving Program," *J. Eng. Ed.* 86:75–91, 1997.
2. Seat, E., and Lord, S.M., "Enabling Effective Engineering Teams: A Program for Teaching Interactive Skills," *J. Eng. Ed.* 88:385–390, 1999.
3. Pfatteicher, S., "Teaching vs. Preaching: EC 2000 and the Reengineering Ethics Dilemma," *J. Eng. Ed.* 90:137–142, 2001.
4. Woods, D.R., et al, "The Future of Engineering Education: Part 3 Developing Critical Skills," *Chem. Eng. Ed.* 34:108–117, 2000.

Have the FC Instructional Modules Been Tested?

An evaluation program was implemented to test all modules in a classroom setting with faculty members who did not develop the material serving as teachers and observers. Student survey data indicate a positive reaction to the instructional material. For example, this table shows the average of the students' approval scores on the objectives, justification, classroom material, and homework for three of the modules.

Module	Approval score
Global and societal impact	3.7
Ethical	4.3
Contemporary issues	3.6

Note: Approval scores range from 1 to 5, with the highest being 5.

The data also suggested a strong improvement in the students' confidence to perform tasks related to the learning objectives. For example, the following table shows the data from the problem-solving modules:

Objectives	Confidence Score	
	Premodule	Postmodule
Describe the problem-solving process	3.9	4.5
Discuss problem-solving approaches	4.2	4.4
Solve routine problems	4.3	4.5
Solve novel, out-of-context problems	3.6	4.1
Critique the problem-solving process	3.7	4.2

Note: Approval scores range from 1 to 5, with the highest being 5.

Since the initial evaluation testing of the modules, module developers have revised their material based on comments from the instructors, observers, and students participating in the evaluation study.

If you would be interested in trying one or more of the module, you can visit the Foundation Coalition web site at http://www.foundationcoalition.org or contact Jeffrey Froyd at froyd@ee.tamu.edu or 979.845.7574.