Teaching "A-K" Skills

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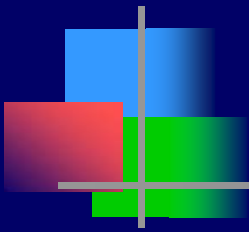
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References

- **D. Woods et al, Developing Problem Solving Skills: The McMaster Problem Solving Program, *J. Eng. Ed.* 86:75-91, 1997.**

- **D. Woods, R. Felder, A Rugarcia and J. Stice, Future of Engineering Education III – Developing Critical Skills, *Chem. Eng. Ed.* 34:108-117, 2000.**

- **E. Seat and S. Lord, Enabling Effective Engineering Teams: A Program For Teaching Interaction Skills, *J. Eng. Ed.* 88:385-390, 1999.**

What Is a Skill?

Team Exercise – Definition of a "skill"

- **Work as a team to write a one-sentence definition of a "skill"**
  - **1 or 2 minutes thinking**
  - **1 or 2 minutes discussing**
- **Prepare a transparency**

Definition of a "skill"

- **Dictionary definition:**
  - **Discernment; knowledge**
  - **Great ability or proficiency; expertness**
  - **Ability in an art, craft, or science**
  - **Knowledge; understanding; judgment**

Our Definition of a "skill"

- **Our definition: a skill is knowledge, ability, and expertness in a process**
  - **E.g., design skill is knowledge, ability, and expertness in the design process.**
- **Thus, teaching a skill implies the development of**
  - **Knowledge, awareness of the process**
  - **Ability, proficiency, experience with the process**
  - **Expertness, judgment in using the process**

EC2000 CRITERIA 3 (a) – (k)

Engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of math, science, and engineering

(b) an ability to design and conduct experiments, as well as analyze and interpret data

(c) an ability to design a system, component, or process

(d) an ability to function on a multidisciplinary team

(e) an ability to identify, formulate and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) a broad education to understand the impact of engineering solutions in a global/societal context

(i) a recognition of the need and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills and tools of engineering practice

Who? Why? When? Where? How?

- **The workshop will address these questions**
  - **Why should we teach "A-K" skills?**
  - **Where and when should we teach "A-K" skills?**
  - **Who should teach "A-K" skills?**
  - **How should we teach "A-K" skills?**

Workshop Objective

- **After the workshop, participants will be able to discuss the "Who? Why? When? Where? How?" questions about teaching skills**

Why Teach "A-K" Skills?

Team Exercise -- Why Question

- **Work as a team to answer the question**
  - **Why Teach "A-K" Skills?**
- **Prepare a transparency**

EC2000 Criteria 2

Engineering programs must have:

- (a) educational objectives
- (b) process to determine and periodically evaluate objectives
- (c) curriculum & process to achieve these objectives
- (d) system to demonstrate achievement of objectives

Requirements on Curriculum and Processes

- **Curriculum and process must teach content and skills defined in EC2000**
  - **Content -- The traditional knowledge of the discipline**
  - **Skills -- The processes needed to use the knowledge**
- **Required skills defined in Criteria 3 (a)-(k)**

McMAster's Study -- Observation on Student's Problem Solving Skills

- **In 60's McMaster's ChE Faculty observed that students could not solve problems**
  - **If wording and context changed**
    - **i.e., out-of-context problems**
  - **Requiring ideas from different courses to**
- **In short, students could not solve realistic problems**

Woods et al, *J. Eng. Ed*., 86:75

McMAster's Study -- Observation on Student's Problem Solving Skills

- **McMaster's observations:** **Students seemed to solve problems using "pattern matching" approaches**
  - **Collecting sample solutions**
  - **Patching together previous solution**

Woods et al, *J. Eng. Ed*., 86:75

McMaster's Research Projects

- **Conducted 4 research projects over a number of years**
- **Research questions**
  - **What is problem solving?**
  - **Can problem solving and group skills be taught?**
  - **Is what we currently do in the classroom sufficient?**

Woods et al, *J. Eng. Ed.*, 86:75

McMaster's Research Conclusions

- **Students lacked content-independent problem solving skill**

- **Skills did not improve over four years**
  - **Worked over 3000 homework problems**
  - **Observed over 1000 solutions by faculty and peers**
  - **Worked open-ended problems**

Woods et al, *J. Eng. Ed*., 86:75

McMaster's Research Conclusions (cont.)

- **Skill not learned by**
  - **Watching faculty work problems**
  - **Watching other students work problems**
  - **Working many problems themselves**
    - **Even open-ended problems**
- **Skills were learned in a workshop environment**

Woods et al, *J. Eng. Ed.*, 86:75

Another View -- Teaching Interaction Skills

- **Interaction skills cannot be learned by**
  - **Osmosis**
  - **Simply working in groups**
- **Interaction skills must be taught *explicitly***

Seat and Lord, *J. Eng. Ed.,* 88:385

Why?

Why teach "A-K" skills?

- **Because EC2000 requires that our students learn them**

- **Because students do not learn processing skills unless they are explicitly taught**

Team Exercise – Teaching Skills

- **Work as a team to answer the questions**
  - What is the most compelling reason for explicitly teaching traditional skills (e.g., design, problem-solving) in an engineering curriculum?
  - Repeat for non-traditional skills (e.g., communication, ethics, lifelong learning).
    - Note "explicitly" implies that the skill is actually taught in class and not just demonstrated & the instructor has learning objectives, instructional material, assignments, etc.
- **Prepare a transparency**

Where and When Should We Teach "A-K" Skills?

Team Exercise – Where and When Questions

- **Work as a team to answer the question**
  - **"Where and when should we teach 'A-K' skills?"**
- **Prepare a transparency**

Possible Locations for Teaching Professional Skills

- **First-year engineering courses**
- **Capstone design courses**
- **Specialty courses (e.g., technical writing)**
  - **Usually taught outside the engineering college**
- **In core engineering discipline courses**
  - **Integrate instruction in skills with traditional content**

Pfatteicher's Lecture on Teaching Ethics -- Necessary Characteristics

- **Instruction in ethics must**
  - **Be provided to all students**
  - **Appear more than once in curriculum**
  - **Allow sufficient time for reflection**
  - **Be integrated with technical courses**

Sarah Pfatteicher, U. of Wisconsin

Teaching Skills -- Necessary Characteristics

- **Instruction in** ~~*ethics*~~ *each professional skill* **must**
  - **Be provided to all students**
  - **Appear more than once in curriculum**
  - **Allow sufficient time for reflection**
  - **Be integrated with technical courses**

Teaching Interaction Skills - Where in the Curriculum

- **Start in first year**
- **Develop during rest of program**
  - **Cannot be accomplished in a single-step**
- **Don't leave to capstone course**
  - **Competes with design problem**
  - **Becomes a distraction to design problem**
  - **Devalued**
- **Teach as part of engineering courses**
  - **Part of the class material**

Seat and Lord, *J. Eng. Ed.,* 88:385

McMaster's Three Step Approach

- **Build** the skill in stress-free exercise
  - (context-independent)
- **Bridge** the skill
  - Use simplified problem in target subject domain
  - Reflect on the process used to solve this problem
- **Extend** the skill to any type problem situation
  - Reflect on the skill in
    - Subject courses
    - Everyday life

Woods et al, *J. Eng. Ed.*, 86:75

Where and When?

- **Where and when should we teach "A-K" skills?**
  - **Need to be taught at all levels (1st through 4th year)**
  - **Need to be taught in engineering courses**
  - **Need to be integrated with traditional engineering content**
- **Use McMasters's build-bridge-extend model**

Team Exercise – Integrated in Engineering Courses or Not

- **Work as a team to answer the questions**
  - **What is the most compelling reason for teaching skills as an integrated component in a traditional engineering course?**
  - **What is the most compelling reason for teaching skills outside traditional engineering course?**
    - **"Teaching skills as an integrated component" means taking time in traditional courses (e.g., statics, circuits, controls) to teach skills (e.g., design, problem-solving, communications, lifelong learning).**
- **Prepare a transparency**
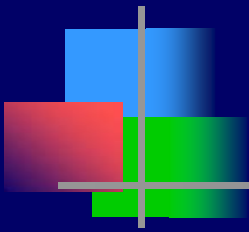
Who Should Teach "A-K" Skills?

Team Exercise – Who Question

- **Work as a team to answer the question**
  - **Who should teach "A-K" skills?**
- **Prepare a transparency**

Who Should Teach Skills – Possible Answers

- **Engineering faculty**

- **Faculty from other departments**
  - **(e.g, English, Communications, Psychology)**

- **Non-engineering faculty/instructors (area specialists) hired by college of engineering**

Difficulty Of Teaching Process Skills

- **Process skills**
  - **Hard to define, develop, and assess**
  - **Deal with attitudes and values as much as knowledge**
- **Engineering instructors**
  - **Lack formal training in them**
  - **Have limited experience teaching them**
  - **Have difficulty giving feedback**
  - **Lack knowledge of research on developing skills**

Woods et al, *Ch. Eng. Ed.*, 34:108

Teaching Interaction Skills -- Coaching and Facilitation

- **Requires personal interaction with students**
- **Faculty need to be able to**
  - **Lead discussion**
  - **Monitor and evaluate performance**
  - **Provide feedback**
- **Faculty need**
  - **Coaching skills**
  - **Facilitation skills**

Seat and Lord, *J. Eng. Ed.,* 88:385

Problems With Transference Of Skills

- **Skills taught in content-independent, stand-alone courses**
  - **Not transferred to other areas**
  - **Students cannot apply the skills in other contexts**

Woods et al, *J. Eng. Ed.*, 86:75

Increased Relevance

- **Importance (relevance) of skill increases when taught**
  - **During engineering courses as a part of the class material**
 - **By engineering faculty**

Seat and Lord, *J. Eng. Ed.,* 88:385

Who?

- **Who should teach "A-K" skills?**
  - **Engineering faculty need to be involved**
  - **Perhaps assisted by non engineering faculty (are specialists)**
- **Engineering faculty need support in teaching skills**
  - **Instructional material**
  - **Training in facilitation and coaching**

Team Exercise – Engineering or Non-Engineering Instructors

- **Work as a team to answer the questions**
  - **What is the most compelling reason for having <u>engineering</u> faculty teach non-traditional skills (e.g., communications, ethics, lifelong learning)?**
  - **Repeat for for <u>non-engineering</u> faculty.**
- **Prepare a transparency**
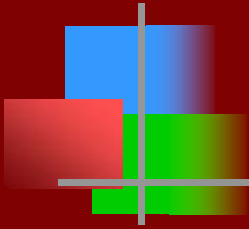
How do we teach "A-K" skills?

Team Exercise – How Questions

- **Work as a team to answer the question**
  - **How do we teach "A-K" skills?**
- **Prepare a transparency**

Skills Best Developed By Practice With Feedback

- **Talking about the skill don't work**

- **Demonstrating the skill don't work**

- **Students must practice skill**

- **Instructor must provide feedback**

  - **Instructor serves as "coach"**

Woods et al, *Ch. Eng. Ed.*, 34:108

Activities To Promote Process Skill Development

- **Identify the skill**
  - **Include in course syllabus and all official descriptions**
  - **Allocate time for activities that provide practice**
  - **Emphasize relevance of the skill in professional success**
  - **Treat seriously and enthusiastically as technical content**

Woods et al, *Ch. Eng. Ed.*, 34:108

Activities To Promote Process Skill Development (Cont.)

- **Make explicit the implicit behavior associated with the skill**
  - **Discover what's really important**
  - **Communicate this to students as goals and criteria**

Woods et al, *Ch. Eng. Ed.*, 34:108

Activities To Promote Process Skill Development (Cont.)

- **Provide extensive practice in application of skill**
  - **Carefully constructed activities -- repeated**
  - **Prompt feedback using evidence-based targets**
- **Skills rarely developed by demonstrations**

Woods et al, *Ch. Eng. Ed.*, **34:108**

McMaster's Research Conclusions

- **Workshop-type intervention made a difference in problem-solving skills**
  - **Define skill and indicate importance**
  - **Put in context of other skills being developed**
  - **Give learning objectives**
  - **Provide activities**
  - **Have students summarize change and growth and times they could use the skill in journal**
    - **Reflection**

Woods et al, *J. Eng. Ed.*, 86:75

Teaching Interaction Skills -- Importance of Modules

- **Engineering professors uncomfortable with teaching skills**
  - **Lack formal training in these skills**
  - **Available resources inappropriate**
- **Instructional modules provide one solution**
  - **Enable integration into engineering courses**
  - **Eliminate need for creating new courses**

Seat and Lord, *J. Eng. Ed.,* 88:385

Teaching Interaction Skills -- Use of Instructional Modules

- **Modules should**
  - **Include supervised interactions to practice with others**
  - **Emphasizes that there are no single right answer**
  - **Provide experiential activities in a group**
    - **Learning by watching**
      - **Observe other's mistakes**
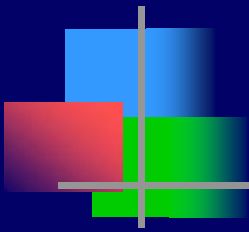   - **Observe instructor coaching others**

Seat and Lord, *J. Eng. Ed.,* 88:385

How?

- **How do we teach "A-K" skills?**

  - **Explicitly identify the skills and provide instruction**

  - **Use workshop or cooperative learning format**

  - **Require practice**

  - **Provide feedback -- instructor serves as a "coach"**

  - **Encourage monitoring and reflection**

Team Exercise – Teaching Content and Skills

- **Work as a team to answer the question**
  - **What is the most important difference in the methodology used to teach content and skills?**
- **Prepare a transparency**

Foundation Coalition (FC) Instructional Modules Based on "A-K" Skills

FC Instructional Modules on Skills

- **Technical Area**
  - **Computational Skills**
  - **Design Skills**
  - **Experimental Skills**
  - **Modeling Skills**
  - **Problem-solving Skills**
- **Ethical-Social Area**
  - **Analysis of Contemporary Issues Skills**
  - **Ethical Interpretation Skills**
  - **Assessing Global & Societal Impact Skills**

- **Communication Area**
  - **Graphical Communication Skills**
  - **Oral Communication Skills**
  - **Written Communication Skills**
- **Professional Area**
  - **Project-management Skills**
  - **Lifelong Learning Skills**
  - **Teaming Skills**
  - **Time Management Skills**

Team Exercise – Instructional Module Specifications

- **Work as a team to develop a set of specifications for a group of instructional modules on these skills**
  - **What should they look like**
  - **What common characteristics should they have**
- **Prepare a transparency**

FC Module Specifications – General Requirements

- **Modules should:**
  - **Fit into a week of classes**
  - **Serve several curricula**
  - **Not require special classroom facilities**
  - **Not require extensive up-front instructor investment**
  - **Fit into major upper-level courses**

FC Module Specifications -- Format

- **Module format should**
  - **Be consistent with a standard form**
    - **Instructor guide**
    - **PowerPoint slides**
    - **Workbook, student exercises and activities**
    - **Student reading material**
  - **Use active/cooperative learning**
  - **Utilize web resources when possible/appropriate**

FC Module Specifications -- Content

- **Module material should contain**
  - **Clear justification & measurable objectives**
  - **Assessment process to measure improvement**
  - **Multiple student exercises**
  - **Activities that provide a progressive instruction**
    - **Build it in a discipline-free context**
    - **Bridge the skill into the discipline,**
    - **Expand the skill into problem areas in the discipline**
  - **Instructor's guide on using of the material**

Workshop Conclusions

- **Engineering curriculum must include instruction in skills**
  - **Traditional skills (e.g., design, problem-solving)**
  - **Non-traditional skills (e.g., teaming, ethics)**
- **Engineering programs should teach these skills**
  - **Throughout the four years**
  - **As an integrated part of traditional engineering courses**

Workshop Conclusions – Part 2

- **Engineering faculty should teach these skills**
- **Teaching these skills requires interactive methodologies**
- **Effective instructional modules will help engineering faculty in this task.**

Lecture on Teaching Ethics -- The Dilemma

- **How do we provide <u>meaningful</u> instruction in ethics to <u>all</u> engineering students**
  - **Without overburdening the faculty**
  - **Without increasing graduation requirements**
  - **Without removing essential technical material from the curriculum**

Sarah Pfatteicher, U. of Wisconsin

Teaching Skills -- The Dilemma

- **How do we provide <u>meaningful</u> instruction in ~~ethics~~ *all professional skills* to <u>all</u> engineering students**
  - **Without overburdening the faculty**
  - **Without increasing graduation requirements or removing essential technical material from the curriculum**

Teaching Skills -- The Dilemma

- **How do we provide <u>meaningful</u> instruction in *all professional skills* to <u>all</u> engineering students**
  - **Without overburdening the faculty**
    - *Cannot -- Need some additional effort*
  - **Without increasing graduation requirements or removing essential technical material from the curriculum**
    - *Cannot -- Need to add credits or delete some material*

Questions?