2006-2315: SYNTHESIS OF TEACHING AND EVALUATION ACTIVITIES FOR DEVELOPMENT OF PROFESSIONAL SKILLS IN A CAPSTONE DESIGN COURSE

Devdas Pai, North Carolina A&T State University

DEVDAS M. PAI is a Professor of Mechanical Engineering at NC A&T State University and Associate Director of the Center for Advanced Materials and Smart Structures. He teaches manufacturing processes and tribology related courses. A registered Professional Engineer in North Carolina, he serves on the Mechanical PE Exam Committee of the National Council of Examiners for Engineers and Surveyors and is active in several divisions of ASEE and in ASME

Juri Filatovs, North Carolina A&T State University

G. JURI FILATOVS is a Professor of Mechanical Engineering at NC A&T State University. He received his Ph.D. from the University of Missouri-Rolla. He has worked for McDonnell Aircraft and the US Bureau of Mines. His research is in the area of materials and their properties. He teaches materials science and the capstone design courses in mechanical engineering.

Synthesis of Teaching and Evaluation Activities for Development of Professional Skills in a Capstone Design Course

Abstract

ABET's transition from content-based engineering accreditation criteria to an outcomes-based model is now complete. The onus for defining curricular content has shifted from ABET ('one size fits all') to the program's faculty ('stakeholder-driven continuous improvement'). This new-found autonomy in determining curricular content has created varied 'localized' interpretations and implementations. It comes with its own set of challenges. Heightened emphasis has been placed on development and documentation of professional skills (aka 'soft' skills) such as oral and written communication, team work, lifelong learning, and global and societal issues. Teaching, assessing and documenting soft skills necessitates a new synthesis of topics. In this paper, we describe our experiences in a capstone design course for mechanical engineers, our transitivity matrix mapping ABET outcomes to classroom implementation methods, and our approach to capture and document our progress and achievements. We discuss our principal process mechanisms; including the student portfolio, which is useful for defining and demonstrating a number of ABET competencies.

Introduction

The Department of Mechanical and Chemical Engineering at NCA&T State University resulted from the merger of two departments. The combined department has ABET-accredited programs in Mechanical as well as Chemical Engineering. Mechanical Engineering has had an evolving capstone design course for many years. This two-semester course is structured around a team approach and is intended to provide a realistic culminating experience in which many skills are integrated. In addition to the technical skills, we have strived to develop the many other professional attributes and competencies necessary for a successful career. We have based these on primarily industrial interaction and believe they reflect elements identified by other authors[1,2,3]. With the implementation of the Accreditation Board for Engineering and Technology (ABET) Criteria 2000, further modification of the course occurred. Although many of the ABET outcomes were addressed in our capstone course a partial recasting was necessary, particularly in the assessment/grading, required course documentation, and student awareness of our goals. In this paper we describe our experiences and lessons learned in implementing more completely the ABET criteria, focusing on the six outcomes which comprise the Professional or 'soft' skills.

Capstone Course Goals

We present the following set of themes (developed over the years) as lecture topics and incorporate into the design environment; we also give brief arguments for their importance, as we justify them to the students:

1) Intellectual, Professional, and Ethical Stance: Students must understand the characteristics of their profession and their role in it, the tools and characteristics of a qualified, working engineer. Understand the professional standards and the ethics.

2) Resource Skills: The final measure of their success lies in the future in the way they develop their careers and is unforeseeable, and therefore they require skills which will sustain them for a long time. These include the establishment of habits and methods for picking up needed new skills, and remaining current in their profession. They need to understand that there is continual erosion of their worth, driven by the new technology which engineers advance. They must have information gathering skills, how to obtain information on current technology throughout their careers.

3) Management Skills: Professionals must be able to set goals, plan, and deploy, and manage resources. They must understand risk analysis, costing, legal/regulatory issues, and ethics.

4) Technical Communication: There is need to write specifications, reports, proposals, and communications to a wide audience. There is a need to speak and present ideas in a wide range of situations.

5) Interpersonal Skills: The strong trend toward simultaneous engineering requires many interpersonal skills, ISO 9001 specifies many technical interfaces.

6) International and Global Climate: Students are entering a multiplicity of social worlds and subcultures, a globally competitive climate requiring cross-border safety and code compliance.

ABET Linkage

As part of our ABET self- study process, we have mapped our curriculum into the general a-k outcomes of ABET and to the discipline specific outcomes developed by ABET in conjunction with the relevant professional society (in our case, ASME). We have tagged ABET general program outcomes as shown in Table 1 and ASME discipline-specific outcomes as shown Table 2. Table 3 shows how the required mechanical engineering courses in our curriculum (ie excluding the technical elective courses) map into ABET and ASME outcomes.

Table 1. Tags for ABET Outcomes under its Criterion 3

a.1	Ability to apply knowledge of mathematics
a.2	Ability to apply knowledge of science and engineering.
b	Ability to design and conduct experiments, and to analyze and interpret data
c	Ability to design a system, component and process to meet desired needs.
d.	Ability to function on multidisciplinary teams.
e	Ability to identify, formulate and solve engineering problems.
f	An understanding of professional and ethical responsibility.
g	Ability to effectively communicate orally and in writing.
h	Understanding of engineering solutions in a global and societal context.
i	Recognition of need for and ability to engage in life-long learning.
j	Knowledge of contemporary issues.
k	Ability to use engineering techniques, skills and modern engineering tools for engineering practice.

Table 2. Tags for Discipline-specific (ASME) Outcomes

me1	Ability to apply multivariate calculus.
me2	Ability to apply differential equations.
me3	Ability to apply statistics.
me4	Ability to apply linear algebra.
me5	Ability to work professionally in thermal systems.
me6	Ability to work professionally in mechanical systems

Table 3. Mapping of required MEEN courses into ABET & ASME Outcomes

	110/120	104	210	260	335	336	337	402	403	416/415	440	441	442/576	446	460	474	501	502	503	562	565	572	573	574
a.1		I	I	I	I	R	R	I	I	I	R	I	R	I		R	R	R	R	R	R		R	
a.2		I	I	I	I	I	I	I	I	I	R	I	R	R	R	R	R	R	R	R	R		R	
b								I	I									R	R				R	R
c		I		I		I				I	I	R	R	I		R			R	R	R		R	R
d.											I				R	I				R	R		R	R
e		I			I	I	I			I	I	I	I	I	I	R	R			R	R		R	R
f	I			I				I	I							R	R	R	R	R	R	R	R	R
g		I		I				I	I	I	I			I	I	R		R	R	R	R	R	R	R
h				I									I	I	I	R		R	R	R	R	R	R	
i								I	I		I		I	I	I	R	R	R	R	R	R	R	R	
j				I							I	I	I	I	I	R				R	R	R	R	
k		I	I		I	I	I			I	R	I	R	I	I	R				R	R		R	R
me1							I	I		I		I	R							R				
me2			I			I	I			I	R		R							R				
me3			I					I						I				R			R		R	
me4			I		I	I	I	I			I							R		R				
me5									I	I		I	I				R		R	R			R	R
me6		I									I			I	I	R	R				R		R	R

Table 3 clearly shows that while ABET outcomes are covered throughout our curriculum, the capstone course (MEEN 573 & 574) carries many of the professional skill outcome obligations. We believe that the above themes are a substratum for transitivity to ABET, and the following rough correlation (Table 4) can be extracted, although there are overlaps:

Table 4. Mapping of capstone design course goals into ABET & ASME Outcomes

ABET Outcome #	Description	Capstone Design Course Goal/s That Map/s into Outcome
d	Ability to function on multidisciplinary teams.	5
f	An understanding of professional and ethical responsibility.	1, 3
g	Ability to effectively communicate orally and in writing.	4
h	Understanding of engineering solutions in a global and societal context.	3, 6
i	Recognition of need for and ability to engage in life-long learning.	2
j	Knowledge of contemporary issues.	1, 2, 3, 6

Implementation and Assessment

It is always difficult to convince engineering students of the value of non-technical topics. Additional to lectures in which we emphasize that these are legitimate topics for a capstone design course we also incorporate them into the course structure in a formal way. The principal deliverables are interim and final reports, individual portfolios, and (if applicable) a prototype or working device; presentations are also made throughout the course. Along with technical details about the design, we incorporate the addressing of the ABET outcomes as a portion of the documentation and in formal presentations. These are gradable requirements, and the students are made aware of the goals and expectations. We are careful to build awareness into the process by detailed explanations of the ABET objectives, how they overlay the course content, and we provide a template of the outcomes to be addressed. The response and evidence of consideration of these is included in separate sections in the reports and portfolios, which are graded for content and the seriousness with which they are approached.

As an example, for ABET outcome 3d, an ability to function of multi-disciplinary teams, student responses have included descriptions of how the team environment affected the design process, how the design was enhanced or hindered by the team structure, the strengths and weaknesses of the individual members, and analysis of the group dynamics. This is done monthly, in light of which the team subgroups and individual tasks are modified.

Summary

In the first cycle addressing ABET objectives specifically in our capstone course, our experience with strongly involving students in the process has been positive. We feel by making the means more closely and obviously serve the end we have a duality of showing evidence of an ABET-mandated skill set and encouraging an increased knowledge base.

References

1. Society of Manufacturing Engineers, “Manufacturing Education Plan: 1999 Critical Competency Gaps,” Dearborn , MI, 1999.
2. Mathematical Association of America, “Assessment Practices in Undergraduate Mathematics,” MAA Notes 49, 1999.
3. American Society for Engineering Education, “The Green Report: Engineering education for a Changing World, 1994.