Session 1161

The Communications-centered Senior Design Class at Virginia Tech

Eric Pappas, Jack Lesko
Virginia Tech

I. Introduction

In "Engineering and Art," our 2000 ASEE presentation in St. Louis, we noted that the non-technical Accreditation Board for Engineering and Technology (ABET) 2000 "a-k" requirements appeared to describe more than the typical technical skills necessary for students to become competent engineering professionals. We suggested that these requirements described many of the characteristics of a well-balanced, productive, and creative individual, rather than simply those of a highly technically educated individual. These characteristics include the following:

1) good communication skills, oral and written (ABET "g")
2) the ability to work well with a variety of individuals (ABET "d")
3) a sense of values (ABET "f")
4) a variety of educational experiences and training to understand the interdependence among disciplines (ABET "h")
5) the desire and ability to continue to educate oneself (ABET "i")
6) a knowledge of contemporary issues (ABET "j")

There is a natural progression from these characteristics and the "added four attributes" noted by the Task Force on Engineering Education that suggest students develop leadership and diversity skills, and understand and commit to quality. Nationwide, industry is requiring a greater number of communication and interpersonal skills from entry-level engineers. These facts signal a need to change the way we teach engineering in order to respond to rapidly escalating technology and its effects on the individual, family, and society, and to be more in accord with the increasingly complex nature of life and work in the Twenty-first Century.

As engineering faculty members, we must prepare our students for a significant challenge they face: the speed at which technological advances are changing our society and the workplace requires students to possess a greater number of personal skills with which they can effectively cope with the increasing demands placed upon them in the workplace. Such rapid growth is new to those now living, but during other periods of intense growth and change, most notably the Renaissance and the Industrial Revolution, technological changes resulted in challenges to existing values and social, economic, and cultural practices. Currently, changes in the nature of work, methods of communication, lifestyle, and demands on time and

commitment force us to reconsider how we will live in a technological society. Individuals need to grow in concert with these technological changes in order to adjust to, and have some influence on, what may well be a new social order. It seems likely that we are at the threshold of yet another period of unparalleled growth and change, and our engineering curricula need to prepare students not simply for the technical work they will do, but for the engineering lifestyle they will live.

For some time now, engineering educators have recognized the practicalities of teaching personal skills that allow young engineers to practice their craft in a complex work environment. Instruction in ethics, [1,2] management skills,[3] critical writing skills, [4,5] problem solving,[5] and values clarification[6] have begun to take their legitimate place in engineering curricula. Unfortunately, many of these topics have not yet been woven into the technical curricula and may have students wondering why they are learning these skills, and how they are supposed to apply them in an academic or professional setting.

Some educators have begun to study and write about integrating into the curriculum personal development topics such as perception,[7] interpersonal skills and creativity, [8,9] and reflection.[10] These more esoteric topics, however, are not yet uniformly considered valuable enough to include in many university engineering curricula. One recent effort to teach personal skills is taking place at Sherbrooke University in Quebec.[11] Sherbrooke has completely rethought and revised its mechanical engineering curriculum to integrate and balance instruction in technical topics, writing and communications, teamwork, creativity, and design methodology. The school's focus is on engineering practice, which means that these technical and non-technical skills must be taught in concert with each other, rather than in isolation.

A natural step beyond teaching these topics in some degree of isolation leads to a more holistic approach to instruction, which is what we suggest in this article. Engineering educators need to become aware of and responsive to the more humanistic needs and desires of students. It has become a near cliché these days to say that engineering students are often ill-prepared for the career and, more importantly, the life they will lead, especially considering the importance, and the sometimes dehumanizing effects, of the highly technical work they will do.

What we offer in this paper is mostly philosophical. The new skills ABET and industry expect us to teach our students suggest a natural evolution: synthesizing instruction in these skills and attributes to create a comprehensive approach to engineering education that might require students to demonstrate a greater understanding of one's self and society. More specifically, this approach may help us teach students to focus as much on how they carry on their personal lives as they do on their career and material goals. Engineering educators might call this approach "educating the whole student" while philosophers might term it "the art of living."

II. Engineering and Philosophy

Human productivity and quality of life, we know, grow from a balance of time, physical energy, and mental effort. All life exists in some form of balance...life that does not ceases to exist. We see a rapidly growing imbalance: our world is growing disproportionally and more rapidly technologically than our students are prepared for. They have been sheltered from real experiences by the presence of technology (e.g. the reliance on computers, computer games, and the internet) to the detriment of more active experiences like artistic pursuits, reading, and physical activities. Relying on technological pastimes breeds a further inability to communicate and interact with others, and to understand themselves.

In order to make more useful and relevant what we teach, we need to respond to this imbalance and teach our students the professional and social skills they need to balance their understanding of engineering to make sure they can effectively and appropriately apply what they learn. Well-adjusted, open-minded people make the best decisions for their lives; those who balance work, family, leisure, and personal time successfully are most always excellent colleagues who are successful in their careers and personal lives.

Our philosophy of engineering education (as especially represented in our capstone design class) guides our teaching more than do industry trends or ABET requirements. At the center of this philosophy is our contention that students must develop a personal and professional learning process—a method of "intentional growth" that includes learning and employing such skills as critical and creative thinking, reflection, brainstorming, and effective conversation. In addition, students need to learn the discipline and motivation with which to apply these skills in order to create their own lives, and find work and a lifestyle that are in harmony with their goals, interests (and dreams), and obligations. We educate our students to understand that successful careers and productive lives grow from a combination of personal skills and technical education.

In our class, we present our students with challenges to the way they think and what they believe, and opportunities from which to choose or create a career and lifestyle based their personal and professional interests. We help our students become open-minded and mature decision makers who are not overly influenced by the dictates of society, industry, peers, or parents. In short, we want them to understand their own growth process and become more reflective and philosophical about their lives and careers.

Traditionally, engineering curricula have marginalized the value of interpersonal skills and growth for the acquisition of an ever-increasing amount of technical knowledge and skill. While this approach may have been appropriate prior to the technological groundswell that has befallen us, no amount of purely technical knowledge will provide the understanding students need to bring that knowledge appropriately to our rapidly changing and often alienating technological society. Engineering programs need to recognize that, if the point of engineering education, implicitly or unintentionally, is to train students to perform technical work at a sophisticated level, we graduate young professionals who are deficient in some essential personal and worldly skills.

Ultimately, as engineering faculty members, we are educating students to become good people, not simply good engineers. We hope that our efforts will help students know how to apply what they have learned in such a manner as to make a contribution to their families, communities, and themselves (not simply their superiors) without sacrificing an inordinate amount of time, energy, and commitment to their work. We do not want our students to sacrifice a sense of personal well-being simply to improve the bottom line. To this end, we are listening to our students more carefully, challenging them on issues they will soon confront, and integrating more philosophical issues into class discussions, activities, and writing assignments. More importantly, we hope to help them figure out what they want their lives to be like, rather than simply what they want their careers to be.

We have learned over the past few years that we have been educating a number of students who are not planning to pursue an engineering career, perhaps due to a growing lack of interest in engineering fields or due to a discontent with the discipline. This fact, we believe, has important implications: 1) that we may not be doing a good job of educating some students because they do not find engineering interesting, and 2) that we need to educate students to be effective critical and creative thinkers, not simply well-trained engineers.

While the progressive engineering trends we find in ABET requirements and current industry practices are influencing engineering programs, engineering educators need to continue to explore instructional topics and methods that will empower students personally, offer them a greater understanding of the world, and help them develop the interpersonal and professional "tools" with which to put their learning to work. Individuals whose skills, interests, and understanding of world are narrow, or whose only tools to understanding life and work is through technology or technical pursuits may well fall short of making their desired contribution to the world.

III. Engineering Science and Mechanics Senior Design Class

We have been rethinking our senior design class over the last few years, not only to align ourselves with well-stated ABET requirements and industry trends, but to respond to the needs our students express. Students evaluating our teaching over the past three years have made it clear that they feel they do not have all the tools necessary to make their next adult transition: to begin living on their own and doing well in their careers. Most students consider the progressive subjects we present in class important to their lives, essential to their careers, and a challenge intellectually.

We conduct our classes informally and teach these non-technical skills in a context relevant to students' design projects. We try to create an atmosphere that lies realistically within the context of the professional workplace. The topics we have added to our curriculum move towards a central point...to educate an individual who knows how to have a good career and a good life, and who is aware of the difference.

Our departmental communications program has, for seven years now, integrated into the technical curriculum instruction in technical and scientific writing, presentation skills, teamwork, engineering ethics, and professionalism. We offer below a sampling of some of the additional activities we have integrated into our design class. The methods we use to address these topics include in-class small and large group discussions, in-class writing and collaborative activities, homework response papers, and occasional lectures. Some examples of our discussion and activity topics include the following:

"A Good Life vs. a Good Career" (Students discuss their thoughts on what constitutes a good career versus what constitutes a good life; includes goal clarification and definitions of personal success)
"Taking Control of Your Life" (This personal empowerment discussion helps students learn some decision making skills, and recognize that they alone are responsible for creating their own lives and careers)
"Discussion and Argumentation" (In this discussion, we explore the nature and benefits of engaging in intellectual discussions rather than arguments)
"Open Topic Discussions" (Students bring to the discussion topics they find relevant to their careers and lives)
"Introspection / Brainstorming" (Using lectures, discussions, and occasional role plays, we focus on the relevance that effective and directed thinking play in one's life and work)
"Critical and Creative Thinking" (Students deconstruct, in writing, current engineering articles to determine the authors' intents and writing strategies; discussion follows)
"Listening Skills" (Students complete questionnaires evaluating how well they listen; a discussion of improving listening skills follows)
"Engineering Design Process" (Students describe in writing the process they use to work collaboratively as well as how they generate ideas, methods, and procedures for continuing work on their design projects)
"Engineering and Personal Ethics" (Instruction in these topics takes the form of responding to articles on current and classic topics related to engineering and workplace ethics, including diversity issues)
"Myers-Briggs Test" (This test and the discussion that follows assess self awareness, personal process, and team interaction)

IV. Student and Faculty Response

Since we began seriously revising our approach to teaching senior design, responses have been generally positive. The changes we have made each year have been moderate, and it has required that we "market" the changes so that students and faculty long used to the more traditional "research approach" to teaching design were not confused or threatened by our instructional methods or topical changes. Many students have welcomed the changes as essential to having a successful career. Faculty members directly involved with the class (generally as advisors to senior projects) have supported our efforts philosophically.

There has been little time to assess the class longitudinally, and we rely on positive anecdotal evidence to support our continued revision of the class. Student evaluations from the 1998-1999 and 1999-2000 were largely supportive and sometimes overwhelmingly enthusiastic. Typical responses include the following:

"The class provided a forum for discussing issues about our future plans. I reevaluated my plans for after graduation."

"Very refreshing to discuss relevant topics that are very important to our personal and professional lives...and taught me droves more than many of my other classes."

"Inspired discussions."

"Enjoyed talking about issues about real life, rather than always engineering topics."

"Showed us the importance of communications and [we]engaged in meaningful topics."

Responses from recent graduates are beginning to come in:

"I didn't always agree with your approach to teaching Senior Design, but I am using the skills we learned in class every day at my job."

"Some of the "off beat" topics you covered in class were right on the mark. I am using some of your material to teach my students." (from a graduate student in Utah)

"Don't change Senior Design."

Faculty responses to the class have been supportive of our efforts to help our students with their communication skills, critical thinking skills, and approach to creative design. Most responses note how our students are "much more prepared for professional life and engineering careers" than they were even a few years ago.

V. Conclusion / Summary

We recognize that adding non-technical topics to the engineering curriculum will require sacrificing some time we use to teach essential technical topics. This curriculum shift has, understandably, bothered some engineering faculty members, yet we find that industry has been unusually supportive of this change. In addition, this approach may mean continuing our own education in order to teach these new topics. It is our belief, however, that engineering faculty members know much about these issues and need only develop instructional methods to use in the classroom. Clearly, providing instruction in these non-technical topics is now essential if we are to graduate engineers who can respond productively to the global changes we face in our discipline as well as the challenges these changes force us to confront in our personal lives. We will leave a more detailed and specific description of our methods to future papers, presentations, and personal inquiries.

Bibliography

1) Fledderman, C. Engineering Ethics Cases for Electrical Engineering and Computer Engineering Students. IDDD Transactions in Education, vol. 43, no. 3, August 2000.

2) Santi, P.M. Ethics Exercises for Civil, Environmental, and Geological Engineers. Journal of Engineering Education, vol. 89, no. 2, April 2000.

3) Raju, P.K. & Sankar, C.S. Teaching Real-world Issues through Case Studies. Journal of Engineering Education, vol. 88, no. 4, October 1999.

4) Boyd, G. & Hassett, M. Developing Critical Writing Skills in Engineering and Technology Students. Journal of Engineering Education, vol. 89, no. 4, October 2000.

5) Maskell, D. Student-based Assessment in a Multi-disciplinary Problem-based Learning Environment. Journal of Engineering Education, vol. 88, no. 2, April 1999.

6) Pantaziduo, M. & Nair, I. Ethic of Care: Guiding Principles for Engineering Teaching & Practice. Journal of Engineering Education, vol. 88, no. 2, April 1999.

7) Deek, F.P.; Hiltz, S.R.; Kimmel, H. & Rotter, N. Cognitive Assessment of Students' Problem Solving Skills & Program Development Skills. Journal of Engineering Education, vol. 88, no. 3, July 1999.

8) Bhavnani, S.H. & Aldridge, M.D. Teamwork across Disciplinary Borders: A Bridge between College and the Work Place. Journal of Engineering Education, vol. 89, no. 1, January 2000.

9) Seat, Elain & Lord, Susan M. Enabling Effective Engineering Teams: A Program for Teaching Interaction Skills. Journal of Engineering Education, vol. 88, no. 4, October 1999.

10) Mourtos, N.J. Portfolio Assessment in Aerodynamics. Journal of Engineering Education, vol. 88, no. 2, April 1999.

11) Grose, G.K. Starting Over at Sherbrooke. Prism, vol. 10, no. 4, December 2000.

ERIC PAPPAS
Dr. Eric Pappas is currently the director of the Materials Science and Engineering / Engineering Science and Mechanics Advanced Writing and Communications Program in the College of Engineering at Virginia Polytechnic Institute and State University (Virginia Tech). The program, developed by Professor Robert Hendricks and Dr. Pappas in 1993, maintains individual programs for faculty and students in two engineering departments, and includes instruction in writing, public speaking, interpersonal and professional communications, management and leadership skills, engineering ethics, professional development, creative and conceptual thinking, and engineering design. Dr. Pappas is currently on the Virginia Tech Honors Program faculty and is a faculty fellow in the Center for Excellence in Undergraduate Teaching.

Dr. Pappas received a B.S. in Business and Economic Theory from Wagner College in New York City in 1972. In 1987, he received an M.A. in English and in 1990 an Ed.D. in English Education, both from Virginia Tech. He has been on the faculty of Virginia Tech since 1987 and has taught classes in technical writing, creative writing, literature, interpersonal communications and public speaking, creative thinking, engineering design, management skills, gender issues, and professional ethics.

Materials Science and Engineering Department
Engineering Science and Mechanics Department
12 Holden Hall
Virginia Tech
Blacksburg, Virginia 24061

Telephone: 540-231-5305
E-mail: epappas@vt.edu
Fax: 540-231-8909

JOHN J. "JACK" LESKO

Dr. Lesko joined the ESM faculty as an Assistant Professor in the fall of 1995. His interdisciplinary research focuses on the nature of the fiber-matrix interphase, their effect on damage mechanics and their influence on composite strength and durability. His investigations include the coupled kinetic effects of time, temperature and environment on the durability of high performance aerospace and low cost polymer ground transportation/infrastructure composites. He is also conducting research in the field of polymer composite materials, mechanics, and structures as applied to the civil infrastructure. Dr. Lesko lead an effort to implement one of the first composite bridges in the U.S. (The Tom's Creek Bridge) and has established a focus on the implementation and durability of composites in the infrastructure[1].

In 1997, Dr. Lesko received the National Science Foundation CAREER Award, and the Virginia Tech College of Engineering, Certificate of Teaching Excellence. Presently, he serves as the Secretary for the American Society of Engineering Education, Mechanics Division and as a member to the International Editorial Boards for the ASCE Journal of Composites for Construction and the International Journal of Fatigue.

Dr. Lesko received an M.S. and a Ph.D. in Engineering Science & Mechanics at Virginia Polytechnic Institute & State University, in 1991 and 1994, respectively; and a B.S. in Mechanical Engineering at University of Maryland in 1987.

Engineering Science & Mechanics Dept., Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061-0219 jlesko@vt.edu (540) 231-5259, Fax: (540) 231-9187