"IMPACT OF TECHNOLOGY ON INDIVIDUALS AND SOCIETY": A CRITICAL THINKING AND LIFELONG LEARNING CLASS FOR ENGINEERING STUDENTS

Stephanie Nelson, Ph.D.[1]

Abstract — *This paper presents a rationale, course objectives, and sample exercises for a newly developed general education class that is encouraged especially for engineering and technology students. The class was developed in response to a need to engage students with social and ethical issues related to their disciplines, as well as to empower them as critical thinkers who will be actively involved in democratic decision-making about technical issues. The class has two primary objectives: First, students are provided the opportunity to reflect critically on the merits and drawbacks of technology in their lives and across broad social contexts. Second, to promote life-long learning commitment and skills, the class also focuses on self-assessment of personal learning styles and understanding how new technology information and skills are acquired.*

Index Terms — Critical thinking, ethics, life-long learning, ABET outcome goals.

INTRODUCTION

The various engineering core curricula are challenged enough with heavy technical content, and thus have difficulty fulfilling the following ABET Criterion #3 outcome goals:

- An ability to function on multi-disciplinary teams
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global and societal context
- A recognition of the need for, and an ability to engage in life-long learning
- A knowledge of contemporary issues

As Tad Beckman has recently pointed out, these criteria are "well beyond specific technical training in science, mathematics, or traditional engineering subjects" [1]. Traditionally the purview of the humanities and social sciences, these educational outcomes are indeed important for engineering graduates to possess. In one recent survey, engineering employers placed "capacity for independent and critical thinking" ahead of logical and orderly thinking and academic learning, while at the same time rating recent graduates as poor in problem solving, business communications, and "particularly poor at critical and independent thinking" [2].

In order to meet these outcome goals, the Cal State LA College of Engineering & Technology recently developed an elective general education class that is encouraged for E&T majors. The class has two primary objectives:

- First, the class is focused on technology issues and students are asked to think critically about the impact of technology on their lives and the lives of others. The course reader contains readings around themes—technology & education, technology & fear, technology & uncertainty, technology & capitalism, technology & work, technology & communication, technology & the body, technology & warfare, etc.—and includes texts from Bill Gates, Carl Sagan, and the Unabomber.
- Second, in response to the need to promote life-long learning commitment and skills, the class also focuses on self-assessment of personal learning styles and understanding how new technology skills are acquired. Students commit to a term project of achieving basic competency in a new technology that they believe will enhance their professional or personal lives: e.g., creating a web page, learning to type, snowboard, or drive a car. Students keep a learning journal in which they evaluate their progress against a technology acquisition plan and draw conclusions about the process of acquiring new technology skills.

The class has been taught and revised five times to date. Students almost uniformly assess the class as "outstanding" or "very good." The course enrollment has increased steadily, and for this most recent session, enrollment was near capacity. The course is promoted by word of mouth from former students, by encouraging E&T academic advisors to recommend it for students majoring in their disciplines, and by outreaching to advisors in other academic areas.

RATIONALE

Critical thinking skills have been associated with a range of positive outcomes, including improved problem solving and information processing, as well as mitigation of irrationality, subjectivity, and prejudice [3]. Future engineers must not only be able to define and solve problems, but must also be

[1] Department of Technology, California State University, Los Angeles, Los Angeles, CA 90032-8154, snelson@calstatela.edu.

able to collaborate cross-functionally and communicate cross-culturally. A typical future workplace scenario described by Krivickas involves a virtual multi-national team that might include "systems engineers in the USA, circuit designers in Europe, and production engineers in Asia" [4].

Closely associated with the need for improvement in critical thinking is the need to improve students' ability to "learn how to learn." In introducing a new "process" paradigm into engineering education, Neff et al. state that the "main goal is to empower students to become life-long learners, both capable and eager to learn new concepts on their own" [5]. In the climate of rapid rate-of-change in all engineering fields, Rugarcia et al. warn that it is not possible to equip engineering students with all the technical knowledge they need to succeed in the workplace. They argue for a shift away from "an ever-increasing number of specialty areas to providing a core set of science and engineering fundamentals, helping students integrate knowledge across courses and disciplines, and equipping them with lifelong learning skills" [6]. Indeed, Beder has argued that engineering education is more oriented toward training than education per se. While training develops occupational skills, "ideally education equips people to make their own decisions and to be critical thinkers" [2]. With roughly 6000 scientific articles published every day [6], students must have the drive and the skills to seek out information constantly in order to stay current in their field.

The course description excerpt from the class syllabus is shown below, outlining the specific objectives for the course.

METHODS

The strategies and approaches to achieve the desired outcomes for the class are numerous. The following summary of them is keyed to the ABET desired outcomes listed above. Principal class components are discussed in more detail in the following section.

- *Ability to function on multidisciplinary teams*—The fact that this is a General Education class allows engineering students to cross-fertilize with students from other disciplines across campus. Students work in cross-disciplinary teams and perform various team activities that include research, discussion of readings, and peer coaching on term projects.
- *Understanding of professional and ethical responsibility*—Examination of current issues in technology allows students to identify ethical issues and discuss professional and ethical dilemmas as well as democratic responsibilities. Issues discussed include euthanasia, chemical castration, cloning and bioengineering, and equal access to technology and finite resources.
- *Ability to communicate effectively*—Students present written and oral reports, as well as take part in several active learning projects related to technical communication, described in more detail below. Students also develop a learning acquisition plan and schedule, and track progress against plan, as well keep a learning journal.
- *Understanding of the impact of engineering solutions in a global and societal context*—Students study historical background and research trends in technology in a global context, including adoption and migration of technology, resource utilization, impact of technology on the planetary environment, and issues of technology-based exploitation.
- *Ability and desire to engage in lifelong learning*—Considerable time is spent reflecting on the learning process itself, as well as understanding how the brain acquires and retains information. Students take several learning preference assessments. A central component of the class is a "new technology skills acquisition project," in which students commit 20 hours to learning a new technology skill of their choice and reflect upon their learning process in a journal. This is discussed further below.

Course Description

This is a lower-division General Education course in the "Block E" option: Lifelong Understanding and Self-Development. The University's philosophy for this course is that it should "equip students for lifelong understanding and development of themselves in the context of global and multicultural environments and in the context of social and cultural institutions."

Thus the goal of this course from my perspective is twofold: (1) given the phenomenal rate of technological change in our world, one goal is to engage you in reflection about the lifelong process of acquiring new technology skills; (2) an additional goal is to encourage you to think both positively and critically about the role technology plays in our personal and professional lives.

These dual objectives will be pursued through two avenues: first you will develop a technology acquisition plan and commit to learning a new technology of your choice as a term project, reflecting on the knowledge-acquisition process throughout the class term by keeping a project journal. Second, you will explore current issues in technology through reading, discussing, presenting, and writing. Workgroups will also be a part of the class. We will take advantage of the computers in the classroom to do Internet searches that explore technology issues and resources.

Keep in mind our goals for you in your General Education courses—these are also my goals as listed below—tailored specifically for this course:

- Knowledge and skills enhancement for lifelong self-development
- Improved written and oral communication skills
- Improved ability to engage in critical thinking across disciplines, including natural sciences, math, social sciences, and arts and humanities
- Improved quantitative reasoning skills, with a focus on an understanding of statistical information related to technology issues
- Enhanced values and knowledge to enable and promote democratic participation in our society
- Understanding of outstanding achievements in technology
- Understanding of and appreciation for the diversity of global technology (or lack of it) and awareness of social concerns and issues from racial and gendered and multicultural perspectives.

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- *Knowledge of contemporary issues*—Since the students meet in a computer classroom, they are able to take advantage of the Internet to update our knowledge of technology issues and trends. A fair amount of class time is spent teaching students about search engines and advanced search techniques. The classroom computers also have a seamless interface to the University's library database, which provides students with access to many journal articles in their entirety.

DISCUSSION

Critical Thinking and Ethics

Studies have shown that skilled critical thinkers tend to be more objective and fair [3]. The course readings challenge the students' sense of social justice and fairness, and also that ask them to question the intentions of authors. For instance, the students read Bill Gates' laudatory essay on the impact of computers on education [7] "against the grain" by pairing it with Johathan Kozol's essay on the impoverished and forgotten school system in East Saint Louis [8]. Students begin to realize that there are problems that no technology will resolve—racism, unequal access, poverty, ignorance, fear, and anger. Students also read the work several so-called Luddites—notably Neil Postman on the impact of television on American political discourse [9] and excerpts from the Unabomber's Manifesto [10].

In addition, students read conflicting opinions on the issue of global warming, and then do further research in their groups, come to a consensus about whether or not they feel the environment is in imminent danger, and if so, what personal and social sacrifices they would be willing to make to help mitigate the problem. These readings prompt students to consider issues about uncertainty and political agenda in scientific writing. Students are questioned about what the role of the public should be in democratic decision-making as opposed to relying on technical experts. Who gets to decide policy issues for technologies that affect our environment, our health, the security of our lifestyle? What is our responsibility as citizens and technical professionals to inform ourselves and promote public understanding and access to information?

In a section called technology and capitalism, the class reads a history of the silicon chip industry in the Silicon Valley [11], paired with a look at foreign silicon chip factories in a Malaysian free trade zone [12]. Both studies focus on the impact of a technology-driven market economy on quality of life. Additionally, students read about work life at Microsoft [13], research employee lifestyle and benefits of other high-tech companies, and reflect on what their ideal technology-empowered workplace would be like.

Technical Communication

The class discusses diffusion of technology and resistance to technology as a component of a section on technology and communication. Two group activities focus on problems of issues with communicating technical information. The first is a role-playing activity developed by Heidi Loshbaugh of Colorado School of Mines [14], where students role-play technical consultants investigating a primitive culture with mysterious communication habits and taboos. The exercises focus on problems with cross-cultural communication about technology.

The second group activity asks students to design a "keep-out sign" for a nuclear waste dump; the assignment is shown below.

Group Assignment: Design a "Keep Out" sign for a nuclear waste dump

As the U.S. Department of Energy prepares to store remains from the nuclear weapons program in underground salt chambers near Carlsbad, New Mexico, it faces a communication problem no society has ever confronted before.

How do you warn people for the next 10,000 years that buried in several miles of chambers some 2,000 feet below the scrub desert is a technological tomb that will loose lethal doses of radiation upon anyone who disturbs it? The place must be marked in some way so that it sends the message "pay attention! this place is dangerous and repulsive! stay away!" It needs to communicate that people should not dig or farm or even enter a square mile area.

History teaches us that languages change very quickly. Old English is not understandable today and Latin is no longer spoken. How do you communicate a warning over the next 300 generations when the greatest likelihood is that no language spoken today will still be in existence, and when war or natural calamity may have erased all obvious traces of this era's radioactive waste interment?

The materials the sign is made from need to timelessly withstand weather and erosion. They should also not be so attractive that they may be carried off (the great pyramids originally had marble faces that were subsequently dismantled for other uses). Vandalism and theft are major issues—anything too attractive or portable may be taken away as souvenirs. Also, subsequent regimes tend to tear down the markers of their predecessors.

Your demarcation scheme does not have to be a single sign. It could be a series of elements or barriers, for instance—perhaps your group will decide that redundancy or multiple messages are important. Your design needs to address these communication issues, as well as the durability issues. Decide as a group on your sign concept, then draw it and describe what materials you would use to construct it.

This exercise focuses on the communication of technology over time and encourages students to reflect about the impact of contemporary technical decisions on generations to come. Students also get experience with oral presentation of a graphic and structural design concept.

Lifelong Learning

Early in the class, students take two online learning preference and personality type indicators:

- The Fleming and Mills VARK learning style indicator, www.hcc.hawaii.edu/intranet/committees/FacDevCom/guidebk/teachtip/vark.htm, shows learning

preferences for visual, aural, read/write, or kinesthetic sensory modes of learning information. This test helps students not only to see their own preferences, but to understand that others prefer to learn differently, and that the academic setting is heavily weighted toward read/write. Students are encouraged to take responsibility for structuring their learning experiences in ways that appeal to them personally.

- The Keirsey temperament sorter, www.keirsey.com, is similar to the Meyers-Briggs type indicator, and provides students with a temperament type, defined as a tendency to act in a configured set of habits. These temperament types are loosely coupled to occupations and provide students with a self-assessment tool.

The class investigates how new information is communicated and acquired, as well as how new information may be resisted or may be met with fear and anxiety. They examine who is more likely to acquire new information easily, and they compare their recent adoption of new technologies with their parents.

The class also reflects on previous technology acquisition experiences. The following is a class exercise used to accomplish this.

Mastering Technical Skills Questionnaire

1. What is the most difficult technical you have ever tried to master? I don't mean what was the most *complex* skill you ever mastered, but rather, what took you the longest to learn, or mystified you initially, or caused you to fail either partially or entirely? For instance, I tried and failed to learn to play the flute, although I mastered another wind instrument. And I still have scars from learning to ride both a road bike and a mountain bike. Also, on my second (and final) downhill ski lesson, I fell and cracked my tailbone, and my riding instructor claims I am afraid of my horse, which is why I can't ride him very well. So what was the hardest technical skill *you* ever tried to learn?
2. Why do you think it was so difficult?
3. Was there any way you could have eased your learning process?
4. How did you feel while you were struggling with the learning process? Were you afraid of failure or injury or ???
5. What does the experience say about you as a learner? Do you need to learn at your own pace, be motivated, be rewarded, have a teacher, etc?
6. Do you have a particular learning process that works better for you than others?

Once students have assessed themselves as learners, as well as their typical responses to their environments, students are asked to develop a "new technology acquisition project plan." This is a term project where students commit to learning a new technology of their choice, spending 20 hours acquiring this new technology skill in a structured manner according to a written schedule and action plan. "New technology" is loosely defined, and students are encouraged to pursue a project that will enhance the quality of their personal life rather than just their professional life, so the project is not necessarily an academic or career-based one. About half the class typically decides to learn how to build a Web site. Common "new technology projects" undertaken by past students include the following:

Learn how to:

- Build a web site for personal use or to share information (display poems, show off a car collection, describe how to build a computer, provide information about women's soccer, etc.)
- Build a Web server, assemble a computer, design a circuit
- Write a program in a new computer programming language or use a new software program to produce a product
- Type, scuba dive, golf, play chess or golf
- Drive a car
- Play a musical instrument

Students keep a journal of each learning session, in which they assess their progress against schedule, as well as analyze the quality of the experience and reflect on the emotions or attitudes evoked by the experience. At the end, they give an oral presentation and present a report with the following guidelines.

Final Report and Presentation

Your report should contain the information below. Your presentation should summarize the contents of your report and be no longer than 10 minutes. You should plan to demonstrate a product or a technical skill as a part of your presentation.

Address the following in your final report and presentation:

- What was your project?
- Why did you decide on it?
- What was your plan?
- How did your accomplishments measure up to your plan?
- What kind of schedule did you keep?
- Did life intervene with your plan?
- What accomplishment are you most proud of?
- What would you still like to improve?
- What was the best thing about doing your project?
- What was the most frustrating thing?
- **What did you learn about yourself as a learner during this process?** Note: Spend some time on this one—it is the most important element of your project.

Attach your journal as an appendix to your report.

CONCLUSION

One additional good outcome of the class is that students really bond with each other, perhaps due to the self-disclosure sharing that goes on about personal learning experiences and the personal nature of many class projects. Students who are developing Web sites in particular often help each other outside of class, although some class time is used for "user group" information-sharing for projects that are similar. This works well also with students who are learning musical skills or the similar recreational activity skills.

Because the class is cross-listed as a general education theme course, students with diverse backgrounds and career aspirations have a chance to work together in "multi-disciplinary teams." The 1998 Global Congress on Engineering Education has noted the need for engineering students to work with students from other disciplines "in order to get a broader perspective on how their technology interacts with society" [15]. The diverse academic perspectives of cross-disciplinary students bring about enriched classroom discussions. It is highly recommended that engineering students be offered greater opportunity to collaborate across disciplines.

Students in this course enjoy learning about new technologies and technology trends, and they embrace new technologies for the improvements they enable in their lives and careers. Rarely is a student overtly critical of the impact of technology on his or her life. They tend not to be worried about self-destruction of our race of the planet via technology. However, they do appreciate the opportunity to examine the impact of technology on their lives from a critical perspective, and they admit that some technologies have made us over-dependent on them, can steal or structure time in ways that are detrimental, have affected our lifestyles and the ways we communicate, and can blind us to alternative ways of thinking or living. They also are aware that technologies can't solve all our problems, and that equal access to technologies and utilization of finite resources as well as environmental degradation continue to be problems associated with technology. It is hoped that the class will encourage them to think about their own actions and decisions from a broader social justice grounding.

Importantly, the E&T College believes that this class directly meets ABET- and NSF-driven outcome goals by addressing noted areas of weakness in the engineering curricula, specifically by developing student skills in the following areas:

- Understanding of impact of technology from a global and social context
- Life-long learning skills and commitment
- Written, oral, cross-cultural, and technical communication skills
- Multi-disciplinary collaboration
- Ethical, social, and professional responsibility
- Knowledge of contemporary issues

Engineering curriculum decision-makers are encourage to consider integrating a similar class into their programs.

FUTURE PLANS

The E&T College at Cal State LA is planning to add an additional service-learning component to the class. Rather than requiring students to acquire a new technology skill as a term project, they can choose to teach a new technology skill to community members in a structured setting. The CSULA campus has an active community outreach service-learning initiative, and an after-school computer literacy program in the community has been identified as a good fit for E&T students. This element in the class will be incorporated starting in the fall of 2002.

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