



Engineering Education: Moving toward a Contemplative Service Paradigm

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Ten Steps for Improving Critical and Reflective Thinking Skills in the Engineering Classroom: Moving towards a Contemplative Paradigm

Abstract

The present work seeks to develop and implement a new paradigm for engineering education, one based upon a contemplative pedagogy in conjunction with service learning. The nexus of the two paradigms seems to hold great promise in developing the skills in engineering students the National Academy of Engineering has described. Such a paradigm has been utilized in a combined senior capstone design and engineering ethics sequence.

Introduction

My goal in the present work is to share some teaching tools and resultant impacts on students I have recently experienced. I offer them with complete humility in the same spirit of an opening comment made by the Dalai Lama at a conference on the environment held at Middlebury College in the 1990's.¹ His Holiness began by asserting that he was not very special but rather very ordinary and that his aspiration was to contribute to the world in a small way that was consistent with his values. I too am only seeking to contribute to engineering education in some small way.

The focus then naturally turns towards the students and what is it that I wish for them as they finish a class or their education? The National Academy of Engineering (NAE) suggests the following goals for engineering education:

“To enhance the nation's economic productivity and improve the quality of life worldwide, engineering education in the United States must anticipate and adapt to the dramatic changes of engineering practice. The Engineer of 2020 urges the engineering profession to recognize what engineers can build for the future through a wide range of leadership roles in industry, government, and academia--not just through technical jobs.”

The Academy further adds that:

“The next several decades will offer more opportunities for engineers, with exciting possibilities expected from nanotechnology, information technology, and bioengineering. Other engineering applications, such as transgenic food, technologies that affect personal privacy, and nuclear technologies, raise complex social and ethical challenges. Future engineers must be prepared to help the public consider and resolve these dilemmas along with challenges that will arise from new global competition, requiring thoughtful and

concerted action if engineering in the United States is to retain its vibrancy and strength.”²

The present work documents one approach to meeting the challenge set forth for engineering education by the NAS, one located at the interstitial layer between the service learning and contemplative pedagogies. From service learning, the important notion of engineering by its very nature as a service profession embedded in a community is identified while from contemplative theory, the notions of the trust and the ability to listening to the often muted voices found in a community, to find one’s own voice and to be comfortable with ambiguity and uncertainty are identified and integrated. Further exploring contemplative pedagogy, it involves teaching methods designed to cultivate deepened awareness, concentration, and insight. Contemplation fosters additional ways of knowing that complement the rational methods of traditional higher education. This cultivation is the aim of contemplative pedagogy, a paradigm of teaching that includes methods designed to quiet and shift the habitual chatter of the mind to cultivate a capacity for deepened awareness, concentration, and insight.

Introduction to Service-learning

Service-learning is a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities. Service-learning can be applied in a wide variety of settings, including schools, universities, and community-based and faith-based organizations. It can involve a group of students, a classroom or an entire school.

Jacoby, et al. defined service learning in general, as, “...“a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reciprocity and reflection are key concepts of service-learning.”³ Duffy, et al. stated that service-learning is “... a hands-on learning approach in which students achieve academic objectives in a credit-bearing course by meeting real community needs.”⁴

Astin, et al. performed a study with a national cohort of students and found that service learning had significant impact on student outcomes.⁵ Oakes describes in detail those universities doing service learning in 2004.⁶ Duffy, et al. also reported positive outcomes on many of the ABET (a-k) criteria. They also reported results of a survey showing that, “...79 percent of department chairs had heard of service learning, only 23 percent of departments currently offered it.”

Bringle et al and Totten et al described service-learning as: (1) an educational experience that is course-based and credit-bearing; (2) an organized service activity consisting of an intentional and thought-provoking application of classroom learning to active and engaging work by participating in a group project that meets identified community needs; and (3) a structured reflection on the service activity to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility.⁷

Introduction to Contemplative Inquiry

Two groups that focus on the development of contemplative pedagogy in higher education are the Association for Contemplative Mind in Higher Education (ACMHE) and the Center for Contemplative Mind in Society. ACMHE “promotes the emergence of a broad culture of contemplation in the academy by connecting a network of leading institutions and academics committed to the recovery and development of the contemplative dimension of teaching, learning and knowing.”⁸ According to their website, “The mission of the ACMHE is to advocate for contemplative practice in higher education; to encourage new forms of inquiry and imaginative thinking; and to educate active citizens who will support a more just and compassionate direction for society.”⁹

The Center for Contemplative Mind in Society “transforms higher education by supporting and encouraging the use of contemplative/introspective practices and perspectives to create active learning and research environments that look deeply into experience and meaning for all in service of a more just and compassionate society.”¹⁰ Their website further elaborates that the center, “envisions an education that promotes the exploration of meaning, purpose and values and seeks to serve our common human future...an education that enables and enhances personal introspection and contemplation leads to the realization of our inextricable connection to each other, opening the heart and mind to true community, deeper insight, sustainable living, and a more just society.”

The approach is implemented in a senior level capstone design two course sequence which is held concurrently with a course in engineering ethics. Projects undertaken by student design teams are primarily suggested by members of local and regional non-profit and not for profit agencies that focus on meeting the needs of residents with various physical, mental and emotional challenges. The engineering ethics course is held during the fall semester while the capstone design course sequence begins in the fall and ends in the spring. The ethics course is 3 credit hours and qualifies as a general education elective course while each semester of the design course sequence is 4 credit hours.

The focus of the present paper is to describe a wide array of techniques that were utilized in the combined courses. Feedback from the students was obtained using several different assessment tools including standardized student surveys as well as reflection essays and exit interviews. This article will focus on the exit interviews as they document students’ reactions more richly.

The Techniques

- “Now I become myself”

Let me state at the outset that I have tried countless techniques in my efforts to improve the learning experiences of my students as well as increase my enjoyment of my profession. Some of my efforts have been a success while others not so much. I am reminded of a few verses from a poem, “Now I become myself”, by May Sarton:

“Now I become myself. It's taken
Time, many years and places;

I have been dissolved and shaken,
Worn other people's faces,..."¹¹

Yes, I have worn others' faces. That was not much fun nor do I think it particularly effective. Throughout the semesters, I shared with students information about who I am, how I came to be the person I am in 2016. For me it was not about becoming friends or colleagues in any way but rather for students to have at least a glimpse of who I am in three dimensions, what I valued and what concerned me. Perhaps the most important learning objective herein was a recognition that each of us operates from the perspective of our own life experiences, our own story or movie. We live our lives based on what we "know" to be the "truths" in that movie. One particularly effective video which sheds light on this notion of starring in one's own movie is Serling's "I Shot an Arrow into the Air."¹² The episode relates the experiences of three astronauts who believe they are lost in space, on a distant asteroid with limited supplies only to discover that in fact they had never left the earth. Each of the three was operating within an environment that did not even exist. Their worlds were in fact totally made up.

- A morning meditation and a few more rules

In the effort to make a distinct and definite separation from the outside world and its attendant Age of Information, each class was begun with a very simple meditation. Students were asked to close their books, notes and electronic gadgetry and sit in silence. A meditation chime was used for this part of the class. After three rings, the formal class was begun.

Students are requested to keep their communication devices turned off for the entirety of the class. If any feel the need to electronically connect with the outside world, students are free to leave the classroom at any time. In addition, eating is not allowed.

After the first class, some time is spent on dispelling the myth of multitasking and its supposed efficiency.¹³ According to recent developments in neuroscience, the brain does not really do tasks simultaneously, as we thought (hoped) it might. In fact, we just switch tasks quickly. Each time we move from hearing music to writing a text or talking to someone, there is a stop/start process that goes on in the brain. That start/stop/start process is a difficult task: rather than saving time, it costs time (even very small micro seconds), it is less efficient, we make more mistakes, and over time it can be energy sapping.

- Good, bad and maybe

A Zen Buddhist fable concerning good and bad goes like this:

There is a Taoist story of an old farmer who had worked his crops for many years. One day his horse ran away. Upon hearing the news, his neighbors came to visit. "Such bad luck," they said sympathetically.

"Maybe," the farmer replied. The next morning the horse returned, bringing with it three other wild horses. "How wonderful," the neighbors exclaimed.

"Maybe," replied the old man. The following day, his son tried to ride one of the untamed horses, was thrown, and broke his leg. The neighbors again came to offer their sympathy on his misfortune. "Maybe," answered the farmer. The day after, military officials came to the village to draft young men into the army. Seeing that the son's leg was broken, they passed him by. The neighbors congratulated the farmer on how well things had turned out. "Maybe," said the farmer.¹⁴

Students are then challenged to write about the meaning of good and bad and to answer questions such as is there a time scale associated with such judgments? How far into the future or the past must be considered? Do such notions of good and bad even exist? After writing, students are then asked to share their thoughts with the rest of the class.

- Cherokee "Talking Stick"⁷

The talking stick has been used for centuries by many American Indian tribes as a means of just and impartial hearing. The talking stick was commonly used in council circles to designate who had the right to speak. When matters of great concern came before the council, the leading elder would hold the talking stick and begin the discussion.¹⁵ When he finished what he had to say he would hold out the talking stick, and whoever wished to speak after him would take it. In this manner the stick was passed from one individual to another until all who wished to speak had done so. The stick was then passed back to the leading elder for safe keeping.

My observations in this class were not much different than other engineering classes. A few students typically dominate the classroom with the majority extremely reluctant to speak. The "talking stick" seems a perfect tool for encouraging everyone to speak but even more importantly it demands that everyone listen to the voices of others. This particular class had 58 students enrolled so the circle for the "talking stick" was large and filled the room. Rather than being a drawback, the large number of students actually engaged in the discussions helped reinforce the need to pay attention to the ideas and the views of others, that is, to listen carefully

- Ethical debates

"Those are my views. If you don't like them I'll change them..." so said former Congressman Morris Udall commenting on the strengths of conviction of his opponents in the 1976 Presidential primaries. Yet arguing both positions in an ethical debate is an extremely effective learning technique. Usually, ethical debates focus on topics that involve *moral dilemmas*.¹⁶ Recall, in a moral dilemma, there are two or more moral positions that support contradictory judgments or decisions. In a debate, one is expected to support one of these moral positions over the other. Thus, in general, preparing for an ethical debate can be divided into the following steps:

- An analysis of each moral position. What are the relevant moral principles that support each position and why?
- An analysis of the ethical theories, if any, which support your position.
- An analysis and explanation of the ethical arguments that support your position. What are these arguments? How do they support your position?

- Anticipated objections and responses
- Your chief arguments against the opposition. What are the flaws in their arguments? Why is their ethical position weaker than yours?

Students were presented with a wide range of ethical cases from synthetic biology to performance enhancing drugs in sports to germline engineering. Typically a short video clip is presented and then students are given approximately 15 minutes to write their responses. Afterwards, students are asked to share their views with other members of the class.

- Animals in the laboratory

One of the most contentious issues in biomedical engineering design centers on the use of animal models. Bovine models and porcine models find use in a wide range of research and development settings. Rather than consider the questions associated with animal use in biomedical engineering from a purely academic perspective alone, Students were afforded the opportunity to visit the Farm Sanctuary.¹⁷ Farm Sanctuary is an American animal protection organization, founded in 1986 as an advocate for farm animals. It was America's first shelter for farm animals. It promotes laws and policies that support animal welfare, animal protection, and vegetarianism/veganism through rescue, education, and advocacy. Farm Sanctuary houses over 800 cows, chickens, ducks, geese, turkeys, pigs, sheep, rabbits, and goats at a 175-acre animal sanctuary in Watkins Glen, New York. After the visit, students were asked to reflect upon the use of animals in biomedical research and explore further their attitudes about the relationship between humankind and the natural world.

An episode again from Twilight Zone does an exceptional job of positing the many issues involved in using animal models is “People Are Alike All Over.”¹⁸ A rocket piloted by two astronauts heads out on a mission to Mars. One soon dies after the crash, the other continues to live and soon realizes that he has become a caged exhibit in a Martian alien zoo.

- Ambiguity and uncertainty

Students are challenged to consider the fact that ambiguity and uncertainty exist and nearly always surround our lives. In an effort to promote a deeper understanding of these concepts, I rely on Dante. Dante wrote on the nature of interpretation in his early work *Il Convivio* (The Banquet).¹⁹ In this work, he reflected the traditional medieval understanding that interpretation can take place on four levels: the literal, the allegorical, the moral, and the anagogical. The literal represents the most obvious reading. The allegorical tends to understand the literal set of actions as being symbolic of certain other principles. The moral draws ethical principles from the literal action. The anagogical applies the principle to the final state of the believer. I ask students to read annotated excerpts and then discuss the notion of levels of meaning in a classroom discussion.

In addition, a more recent American author who seems more accessible concerning the concept of multiple levels of meaning is Jack London who has written a wonderful short story later was made into a short BBC film entitled “To Build a Fire.”²⁰ London’s short story is the tragic tale of a man who decides to travel alone through the hostile environment of the Yukon in sub-freezing

temperatures and falls victim to the unrelenting and unforgiving power of nature. The story's central theme is one portrayed by many existentialist writers—that man lives a solitary existence which is subject to the relentless, unforgiving forces of nature; an ever so subtle part of this theme is that it is man's goal to find meaning in his existence.

The goal here is to help break students out of the box of single minded, literal interpretation, that multiple perspectives exist and offer different insights no matter the subject matter. Students are then challenged to connect these ideas to their own senior design project and to examine their work in a broader context.

- Devil's advocate

According to Human, "A devil's advocate role is typically played by an individual who provides alternative perspectives and solutions to problems, frequently challenging group assumptions."²¹ Applied to the classroom, playing devil's advocate means takes the opposing side of an argument. It may not change the students' minds, but using the devil's advocate approach challenges them to expand their analysis, perspective, and understanding of an issue. As Gose writes, "The utility of such teaching strategies is measured by their contribution to the overall goals of helping students learn to analyze logic and assumptions, to critique the validity and soundness of arguments, and to come to true understanding"¹⁴

For this technique, the students were instructed to stand in two lines facing each other. An engineering design decision or ethical argument was presented by one line while the opposing decision/view was offered by students in the second line. This continued for 5 minutes and then the roles were reversed. Afterwards the students were asked to process the experience first orally and then write a reflective essay on the entire process. These were then shared with the entire class.

- The last word

Though it shares the same title as a current MSNBC evening news show, the term and idea actually goes back to Professor Bernie Roth at Stanford University. At a NSF sponsored workshop on integrating creativity into mechanical engineering, I was attending, after the day's events, we would go around the room to each of the participants and ask them to sum up their reactions to the day's activities in one word.

There are at least two important purposes for this exercise. First, each student is forced to quickly sort through his/her reactions and identify one word that best captures that which they are thinking and/or feeling. Secondly it forces everyone to speak. As the semester went on, the angst that came over some students as their time to speak approached slowly but inexorably decreased.

- The hero's journey

The Hero's Journey is a pattern of narrative identified by the American scholar Joseph Campbell that appears in drama, storytelling, myth, religious ritual, and psychological development.²² It describes the typical adventure of the archetype known as The Hero, the person who goes out and achieves great deeds on behalf of the group, tribe, or civilization.

Its stages are:

- Living in the ordinary world
- The call to adventure
- Refusal of the call
- Meeting with mentor
- Crossing the threshold
- Tests, allies and enemies
- Approach
- Ordeal
- Reward
- Road back
- Resurrection
- Return

Students are then asked to examine their lives in light of the ideas presented in the Hero's Journey, to write about it and finally to share with the rest of the class. As their instructor, I share my particular hero's journey pointing to the many obstacles and rewards, enemies and friends that I encountered along the way.

Several purposes are motivating this exercise. First, students have to pause, take a step back and reflect on their own particular journeys—where they came from, where they are and where they are going. Secondly with the sharing of these stories in class, once again the need to listen quietly to others without judging or planning counter arguments is reinforced.

Assessment of the Approach

During the last week of the semester, students were asked to reflect upon the experiences they had in the combined design and ethics course and identify what they would actually take away from the semester's effort. Several of their comments are included here.

Student 1. "I think that have exercised my brain in this class. I will take away a stronger inclination to critical question my actions. It is far too easy to feel suffocated by the large volume of information we are bombarded with in engineering."

Student 2. "From this class I am taking away the ability to think for myself. This class taught me the only way to formulate my own opinion is to think freely.

Student 3. I was applying everywhere for almost any related science or engineering job. However I decided to pause and then terminate these applications due to the potential benefits of war related efforts. I want no part of war, especially no part of benefitting from it.

Student 4. What I got from this class was the ability to reflect upon myself, to put myself in the positions of others. Often I would leave class very perplexed and even troubled. The course forced me to breakdown my values, what I wanted to be my values and what I showed to be my values. I realized they are not separate entities.

Student 5. From this class I am taking away the confidence to think critically. It is important when reaching decisions to know all sides, all perspectives. It is the differences and listening and respecting that allow for the most meaningful discussions.

Student 6. This class has enabled me to recognize that I filter the world through my own set of experiences and beliefs. I found that most of the time the way I think is from sheer convenience.

Student 7. This class has taught me how to think. Before coming to this class, I didn't know how to do much more than solve a math problem. In a way I was like a computer or a robot. We all were. Usually in engineering there is one answer and you are either right or wrong. To enable us to formulate our ideas though very uncomfortable at first is incredibly important in our profession. I also learned it is okay to be different as long as you are okay with the differences in others.

Though only seven responses are shown herein, the students were unanimous in their feedback on these important points:

- Developed confidence to speak and articulate a perspective/opinion
- Welcomed opportunity to be something other than a robot or math problem solver
- Recognized the importance of listening to others
- Recognized that each of us plays the starring role in the movie of our own creation
- Perhaps most importantly, it is not simply ok to change one's position. Rather it is a sign of wisdom.

Final Thoughts

As indicated earlier in this article, on the last day of the semester I asked each student to write for 15 minutes on identifying what they will take from this experience. Afterwards I spoke to the issue of what I hoped they take away from this time shared together. My goals were for each student to know they have a voice and they always have a choice. Each can choose to say the following, "No, I cannot do that now" or "I have changed my mind." Concurrent with a recognition that each has a voice then also each student must listen to the voices of others, no matter how soft or inarticulate that those voices are. With the quiet listening, the reflection upon any conflict between one's own set of values and what one is being asked to perform, there will begin to be a different kind of knowing, a contemplative knowing, and a mindfulness.

Mindfulness and contemplation fosters additional ways of knowing that complement the rational methods of traditional higher education. As Tobin Hart states, "Inviting the contemplative simply includes the natural human capacity for knowing through silence, looking inward, pondering deeply, beholding, and witnessing the contents of our consciousness.... These approaches cultivate an inner technology of knowing...."²³

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