Using Writing to Address Lifelong Learning, Ethics, and the Global Context of Engineering in Mechanical Engineering Courses

Thomas A. Litzinger

Penn State

Introduction

As a result of EC2000, engineering educators are being challenged more than ever to enhance engineering students' skills and knowledge in a number of non-technical areas such as lifelong learning, ethics, and the global context of engineering. In some instances engineering faculty are responding to this challenge by introducing courses specifically targeted at these topics such as engineering ethics[1] or professional practice.[2] Other faculties are working to integrate across technical and non-technical courses within their curricula to increase student competency in non-technical areas, e.g., the work at Broome Community College[3] and at the University of Hartford.[4] A third approach is to integrate these topics directly into engineering courses. Examples of this approach are the integration of writing about case studies in professional ethics into a Mechanical Engineering design class[5] and the use of writing in a Chemical Engineering fluids and heat transfer course to "jumpstart lifelong learning."[6]

The approach chosen by the author was the third approach of integrating writing assignments directly into engineering courses. This paper describes writing assignments on lifelong learning, the ethical implications of engineering, and the global context of engineering that were integrated into thermal-fluids courses. For each assignment, the learning objectives, the quality of the students' work, and their reactions to the assignments are summarized.

Lifelong Learning

A writing assignment related to lifelong learning was incorporated into Thermodynamics II, a required course for juniors in Mechanical Engineering. The literature on lifelong learning indicates that learning occurs in both formal and informal modes.[7] Formal learning occurs in traditional classes where learning is typically directed by the instructor; whereas informal learning often occurs through the process of self-directed inquiry that is required to complete a challenging task. The writing assignment given to the students focused on the informal mode of lifelong learning, i.e., self-directed learning, because the students spend most of their time as undergraduates in formal learning modes.

The assignment was used during two different semesters, once with 30 students and once with 60 students. It was given early in the semester to help to spark students' interest in

Thermodynamics. The learning objectives for this assignment were discussed with the students when the assignment was handed out; they were:

- Students will practice important skills related to lifelong learning including selecting, locating, and understanding new information.
- Students will apply team and communication skills in carrying out a technical task.
- Students will discover the relationship of the concepts and principles of thermodynamics to an area of personal interest to them.

In the initial part of the task, the students wrote a short essay on the relationship between an area of personal interest and thermodynamics or energy. Topics of the essays ranged from artificial hearts to rocket propulsion. Based upon these essays, student teams were formed around common interests, which set the general area of their papers. The selection of themes based upon students' interests was aimed at increasing the students' motivation to engage in the task, and the use of teams was intended to provide a supportive environment for undertaking the self-directed learning. The teams were charged with selecting a paper topic and writing a single term paper based upon independent research. Three class periods were dedicated to this assignment: one for the initial team meeting and selection of a topic, one for peer review and editing, and one for finalizing their papers.

Upon completion of the paper, the students were asked to reflect on their experience and discuss the most valuable aspect of the assignment and why it was valuable. The results reported here are for the larger class, but are representative of the responses of the small class as well. For the larger class, 50 students provided meaningful input. In describing what was most valuable aspect of the assignment, 18 students wrote that the assignment improved their information retrieval/selection skills and a similar number wrote that the assignment provided them a rare opportunity to learn about something they were truly interested in. Ten students mentioned that the assignment had allowed them to understand new topics related to thermodynamics or enhanced their understanding of topics covered in class. One student wrote that the assignment had been a confidence booster and another wrote that it had affirmed his interest in a career that involved using thermodynamics. As part of an end of the semester course evaluation the students were asked whether the course project had improved their ability to locate information and use it to learn on their own. Approximately 50% of the students agreed or strongly agreed with this statement, and only 10% disagreed or strongly disagreed; the remaining 40% indicated a "neutral" response. Thus, the assignment appeared to be successful for many of the students.

In the two semesters that this assignment has been used the classes wrote a total of 25 papers. Within their papers the students were required to identify the lead author of each section so that individual grades could be given for writing and technical content. Also a group grade was given based on the extent to which the students succeeded in writing a paper that read as one paper rather than a collection of four essays. Overall the quality of the information and the writing was quite good. Only two papers of the 25 were judged to be of marginal quality, primarily based upon the quality of the writing. Only one student used technically incorrect information that he got from a website, even though the danger of using such sites was discussed in class. From the instructor perspective, this assignment achieved all of its objectives.

Engineering and Society/Engineering Ethics

The papers described in this section were integrated into an elective class on internal combustion engines. The class was project-based in that the students worked in teams to design and implement experiments to measure fuel consumption and emissions from lawn mower engines. The class had 42 students, 39 of whom were Mechanical Engineering seniors. Three graduate students were also in the class, two Masters degree students from the Energy and Geo-environmental Engineering and one Ph. D. student from Electrical Engineering.

In the first part of the assignment, the students were asked to write individual essays that explained their personal definitions of engineering and also their personal views on the roles and responsibilities of engineers in society. To emphasize the need for students to reflect on these questions and come up with their own thoughts, the essays were to be written without reference to any materials and without discussion with others. The students were given one week to write the essay, and it was due on the day that discussion of these topics began in class. Some quotes from the essays that capture the main themes are presented in Table 1.

The sophistication and clarity of the students' definitions of engineering were pleasantly surprising. This assignment elicited some interesting responses from several students. One questioned why no one asked him to write such an essay prior to his senior year, and he suggested that this type of essay be required of students prior to the selection of a major. Another was grateful for the assignment because a family picnic was coming up, and now he would be able to explain what it is that engineers do. With respect to the goals of engineering, and the roles and responsibilities of engineers in society, nearly all of the students expressed their belief that the role of engineers is to create products and processes that would improve the lives of individuals in society. One student suggested that engineers should take something like a Hippocratic oath. This statement led to a discussion of the Order of the Engineer and also statements on professional practice from several engineering societies.

After the essays were returned and discussed in class, two classes were spent discussing interactions of engineers and society. Topics discussed included the different ways in which the interaction occurs, the different types of justice as tools for considering effects of technology on society, and the difficulties inherent in cost-benefit analyses. One particularly provocative issue discussed was the fact that typical costing methodology places a lower value on the life of a woman than on the life of a man, based upon estimates of lost wages.

The students then received the second part of the assignment that that was done in teams. This part of the assignment asked students to consider four options for regulations of emissions from lawn mowers:

i) no regulations,
ii) limits attainable by modification of engine design,
iii) limits attainable with use of catalytic converters, and
iv) zero emission limits, requiring use of electric mowers.

Table 1: Quotes from Essays on Engineering

Definitions of Engineering • *Ability to design something that does not already exist.* • *In short – engineers are problem solvers.* • *Engineers develop new technologies to make life better or more enjoyable.* • *Engineers transform natural resources into valuable products.* • *Engineering seems to blend technical knowledge with creativity.* • *Engineering is the practical application of accumulated scientific knowledge. … I consider it to be as much of an art form as it is a science.* • *Engineers push society in new directions by applying the knowledge and technology at their fingertips.*
Goals of Engineering – Why do engineers do what they do? • *To make life in general easier for the client (not necessarily society), whether that means designing a better ballistic missile or making a better airbag.* • *The goal of engineering can be summed up in four words, "to make life better."* • *Engineers have a social responsibility to provide safe solutions.* • *In short, engineering is devoted to making new, better, simpler, safer, easier to use solutions within a society with an endless need for such solutions.* • *Produce a better product for consumers; meanwhile, increasing profitability for your company.*
Roles and Responsibilities in Society • *The public puts a great deal of trust into the designers and manufacturers of the products they use. It is the engineer's duty to live up to this trust and constantly have the consumers safety in mind …* • *The role of the engineer in a society is to translate technical and complex ideas into a language that the non-engineer can understand.* • *The role of the engineer in society is a totally individual matter, different for each engineer.* • *The engineer must have an active role in the positive advancement of society.*

The students were required to describe the costs and benefits of each of these four options, considering the point of view of justice, i.e., distributive, intergenerational, and ecological. They were asked to discuss the kinds of information that they would need to make a decision on which option to use and to describe the decision making process. They were not asked to gather the data and make a decision, as that would have been well beyond the scope of the course. The learning objectives for this assignment were:

- Students will apply the concepts of justice to a concrete set of options to address a technical problem.
- Students will demonstrate an understanding of the complexity and impact of decisions made by engineers.

As structured, the assignment caused some difficulty for the students, because the suggested format was quite repetitive in that each option had to be considered for cost/benefits and justice. However, they still succeeded in doing a lot of good thinking and learning. Some of the costs that they discussed were costs to the consumer in terms of money, time and freedom of choice, costs to the manufacturers, possible loss of jobs, and even destruction of companies. Benefits included improved health in society as a whole, reduced ecological impact, and the possible creation of new jobs. Some of the weaker portions of the papers related to the process of how to reach a decision. Overall, however, the class did well, receiving grades of 88 and above.

The students were given a post-assignment survey to gauge their reactions to this assignment. One question asked them to describe what was most valuable about the assignment. Some typical responses were:

"Deep thinking is something we tend to miss out on as engineering students."

"This part of the project forced me to think about things that I never had before, or to think about things from a different angle. This part of the project reinforced for me that there are no ideal solutions that are best for everyone. There will always be trade-offs."

"Seeing how hard it is to make decisions that affect many people and the environment. I knew that making a product analysis has to be done, but I had no idea it was so in depth and unquantifiable."

"Being forced to analyze the impact of a seemingly simple change on all parties involved. I never would have given it as much thought if we didn't have to do this assignment."

Another question on the post-assignment survey asked whether ethics and the related part of the project should be kept in the class in the future. The students were overwhelmingly supportive of keeping the topic and the project, with some noting that this topic is rarely, if ever, addressed in other classes.

Global Context of Engineering

This assignment was given in an introductory Thermodynamics class that is taught to Honors students in Engineering Science. The class was small, with only 20 students. The learning objectives for this assignment were:

- Students will demonstrate that they have read and understood selected references on global energy consumption by using material from those references in their papers.
- Students will demonstrate an understanding of the implications of the global patterns of energy usage by linking them to future business opportunities for a company, preferably, one for which they might like to work.

The specific assignment given to the students asked them to have two major sections in their papers:

i) A summary of the current and projected patterns of energy supply and demand along with their implications, both technical and ethical, for developed and developing countries.
ii) A discussion of the implications of these global patterns for a company that they hoped to work for upon graduation, including both negative and positive effects, like decreased market share, higher energy costs, or the opening of new markets.

Initially the assignment also included a review of the literature on global energy consumption patterns. However, this search was more difficult than anticipated, so a set of selected references were provided to the students. The students were provided with seven papers ranging from an overview article from Science to more detailed articles from the International Journal of Global Energy Issues.

The assignment was successful in terms of the quality of the thinking and writing done by the students; the grades for the assignment were 85 and above. However, a number of students had difficulty applying what they read in the articles to a company they wanted to work for. All students were encouraged to visit company websites and to go to the business library on campus where they could read annual reports to better understand the company they were interested in. Unfortunately, two types of difficulties were encountered that made application of global energy patterns to their company difficult. Some of the students had no idea of companies that they might want to work for and others had difficulty making connections to energy related issues. The latter problem was particularly true of students who were interested in the semi-conductor industry. In a post assignment survey the students were asked what were the most significant things that they had learned from reading the references and writing their papers. One student who found the assignment very useful wrote:

"*The term paper was an excellent idea. I have an interview with the company on which I based my term paper, and the info I learned will be extremely helpful.*"

Others comments included:

"It helped my global view of energy usage. I was also surprised where most of our energy comes from."

"Took too much time but interesting. Learned how to use materials at libraries."

One student in the class found the assignment to be overly simplistic. He felt that the selected references were biased to certain points of view, and to some extent, he was correct. The following comment is probably his:

"*Personally I did not really gain much out of the term paper. I thought it was a neat idea but too simplistic.*"

For most of the class, however, the assignment appeared to be successful. It opened up their thinking, allowed them to learn more about companies of interest to them and to see the potential impact of global patterns of energy usage.

Summary

This paper has summarized writing assignments that were integrated into thermal-fluids courses to enable engineering students to develop their skills and knowledge related to lifelong learning, ethical aspects of engineering, and the global context of engineering. All three assignments appeared to be successful in achieving the related learning objectives based upon the quality of the student work and their feedback on the assignments. Thus, the work summarized here adds to the body of work that supports the integration of writing into engineering courses in order to enhance critical non-technical skills and knowledge for engineering students.

References

1. Yokomoto, C., "Using Small Groups to Promote Active Learning and Student Satisfaction in a Required Engineering Ethics Course," *Proceedings of the ASEE Annual Conference and Exposition,* 1998.
2. Turns, J. and Atman, C. "Preparing Students for Professional Practice: Course Evaluation and Implications," *Proceedings - Frontiers in Education Conference,"* v.2, 2000.
3. Bennet, R., Beston, W., Dickson, M, Gerty, J. and Ruggier, P., "Integrated Learning: Engineering Science, English, and Orientation," *Proceedings - Frontiers in Education Conference,"* v.1, 1998.
4. Richards, B., Alnajjar, H., Ader, A., Adrezin, R., Isaacs, B, and Tempel, P., "Integrating Critical Thinking and Writing Curriculum into Freshmen Engineering," *Proceedings of the Annual ASEE Conference and Exposition,* 2001.
5. Layton, R., "Creating and Measuring an Awareness of Professional Ethics," *Proceedings of the Annual ASEE Conference and Exposition,* 2001.
6. Breidis, D., "Jump Starting Lifelong Learning," *Proceedings of the Annual ASEE Conference and Exposition,* 1998.
7. Cervero, R. M. , Miller, J. D., and Dimmock, K. H., "The formal and informal learning activities of practicing engineers," *Engineering Education*, vol. November, pp. 112-116, 1986.

THOMAS A. LITZINGER

Thomas A. Litzinger is currently Director of the Leonhard Center for the Enhancement of Engineering Education and a Professor of Mechanical Engineering at Penn State, where he has been on the faculty for 16 years. Prior to his appointment as Director of the Leonhard Center, he was ECSEL local principal investigator and the Coalition-PI for Student and Faculty Development. His work in engineering education involves curricular reform, teaching and learning innovations, faculty development, and assessment. He has received the Eisenhower Award for Distinguished Teaching at Penn State as well as the Premier and Outstanding Teaching Awards from the Penn State Engineering Society (PSES). He has also received an Outstanding Research Award from PSES and an NSF Young Investigator Award. Prior to joining Penn State, Dr. Litzinger had four years of industrial experience with General Electric in power systems, and completed his Ph. D. studies at Princeton.