

THE ENGINEERING DESIGN PROCESS: AN “ENGINEERING PHILOSOPHY” COURSE AT THE GRADUATE LEVEL

Ron Britton, Douglas Ruth, Aidan Topping, Marcia Friesen, William Degagne and Glenys MacLeod
University of Manitoba
Ron.Britton@umanitoba.ca

Abstract - Since 2003, 117 students from all departments in the Faculty, and beyond, have enrolled in a discussion-based graduate course on “engineering philosophy.” The course is non-traditional in both content and process.

Discussions are based on student input. Four books and a series of professional sources set the tone for each of five segments. Three hour long classes are held every second week over two terms. Student input is compiled and shared prior to each class. A technical communications specialist is part of the academic team. The specialist supports students’ growth in communicative competence beyond the undergraduate level.

Since the course falls outside the engineering norm, this paper addresses how a less rigid, more philosophical and wide-ranging, discussion-based course enhances students’ ability to approach engineering as both a functional discipline and social design model.

Keywords: Graduate Studies, Engineering Philosophy, Discussion-based format.

1. INTRODUCTION

The first NSERC Chairs in Design Engineering were awarded in 2001. The program encouraged Chair holders to explore techniques that would broaden student understanding of the full breadth of Engineering. At the University of Manitoba we undertook to address this issue by introducing students to the broader field of Engineering philosophy. Authors like Koen, Florman and Petroski provide a foundation upon which we developed our approach. In the Fall of 2001, a proposal for a course entitled “Engineering Philosophy” was submitted to the appropriate university committee. It was rejected. In 2002, the proposal was edited and resubmitted under the title “The Engineering Design Process”. This proposal was approved, and the course was offered for the first time in 2003. Since then, 117 students from all departments in the Faculty, and beyond, have enrolled.

From its inception, the course has been informed by Clive Dym’s observation that “design is bigger than

technology.” Specifics associated with the delivery of the course changed as we gained experience. Today, it has evolved into a discussion-based course that exposes students to a variety of points of view. The Calendar description, in its usual cryptic manner, defines the content of Engineering 7010 as “Consideration of the Engineering Design Process and the logic upon which it is based. Explore both the history and possible future directions of the process from technical, social and environmental points of view.” This paper will discuss the course as it now exists, specifics of course administration and delivery, and share student reactions.

2.0 THE COURSE

2.1 Course History

For the first number of years, students were required to write, and present, a critique of the book they had read. This created an environment that was typical of a traditional lecture (i.e. someone talking and others “listening”). The quality of the discussion after the critiques were presented varied significantly. From an instructor’s perspective, we had a topic students were interested in, but a delivery technique that didn’t allow that interest to develop into serious discussion. In 2006/2007, the shift to student-based questions rather than critiques began, and it evolved to the present format.

2.2 Course Philosophy

The course examines a multiplicity of perspectives on design in general and engineering design in particular. The concept of “process” is addressed in a general rather than a specific manner. Given that engineering design produces unique solutions that are dependent on input constraints, and given that student background is the prime input constraint associated with this course, we anticipate that each student experience will be unique. Students are encouraged to use the course material to develop their definitions of their personal design philosophies.

2.3 Course Delivery

ENG 7010 is a three-credit course. Class meetings occur every second week over two terms (September thru April). Each meeting is scheduled for a maximum of three (3) hours with a “bio-break”. In order to eliminate lost time while students seek out the closest coffee shop, a Keurig Coffee machine, complete with supplies for both tea and coffee, is available in the classroom.

The first, and last, assignment in the course is the preparation of a personal Design Philosophy. During the first class meeting, students are given one week to prepare, and submit, their Design Philosophy. Two weeks before the end of class, students are reminded that their second Design Philosophy statement is due. This provides us with an assessment of the impact the course has had on individuals and students with an opportunity to reflect on the past year’s experience.

Functionally, the course has six specific components. There are five components that require each student to read a specified book, or set of documents, and then submit two questions that arise from that reading assignment. The questions are submitted to meet a deadline 48 hours prior to class. The questions are compiled, anonymously, and distributed at least 24 hours before the class meeting. Class begins with each student commenting on the questions. Faculty members comment once all students have participated. Discussions that follow function under an adaptation of the aboriginal Eagle Feather tradition in which a person can, and must, speak if they are in possession of the feather. In our case we use a beer mug and/or a foam stress ball. Two weeks later, the process is repeated, but it is now based on Responses to the questions and/or discussions that were featured previously. Note that students provide Responses, not Answers. The objective is to stimulate further discussion, not reach conclusions.

During the 2015/16 academic year the four books that we used were, in order of utilization, Ferguson’s Engineering and the Mind’s Eye, Bucciarelli’s Engineering Philosophy, Petroski’s To Forgive Design: Understanding Failure, and Arthur’s, The Nature of Technology. The fifth reading based component involves a number of documents from Engineers Geoscientists Manitoba and Engineers Canada. Details of both sets of reading material are listed in Appendix A.

The sixth component of the course requires students to select, study, and prepare a 12 minute Power Point presentation on an Engineering failure. Each presentation is followed by two minutes of questioning by a classmate who has been assigned the questioner’s role, and a further three minutes of questions from the class in general. This timing permits six presentations within the 3-hour class. Topics must have prior approval to assure that the

presentation is not a reuse of a previous 7010 presentation.

2.4 Administrative Issues

The class is administered by one academic, but delivered by two. This provides a broader in-class base of experience to facilitate academic response to student questions and discussions. In addition, a Teaching Assistant with a technical communications background provides assistance to those who have difficulty with written communication. This capacity has caused an increase in the number foreign students who are interested in enrolling.

Discussion-based courses are obviously dependent upon student participation. Reacting to this reality, we now impose a limit of 12 students per section in order to provide a “small class” environment in which it is difficult to “hide”. In addition, classes are held in rooms that permit us to rearrange the furniture into a circular format. Each student is provided a “name plate” that soon becomes unnecessary as classmates become more than familiar faces.

Recent copyright law “clarifications” resulted in what some might consider an imposition. Students submit Questions and Responses. Because their submissions are their property, they cannot be reproduced and shared without their permission. As a result, we require students to sign a Copyright Release that is specifically focused on the material they provide for class. The Release entitles the course administrator to reproduce, and distribute, the submissions for in-class use.

2.5 Grading

While it is important to provide an environment that facilitates discussion, the grading scheme motivates participation. The Evaluation summary, reproduced from the course outline, sets the tone. “Course evaluation will be based on the written and oral questions and responses required through the year, as well as a final written statement of the student’s personal design philosophy. Performance characteristics that will influence your final grade include: timeliness of submissions and attendance, grammatical correctness of written submissions; questions that are meaningful, not trivial; responses that go beyond class discussion and/or the specific text under consideration; willing participation. As graduate students and potential Professional Engineers we expect performance well above the medium. We expect written material to meet “draft” thesis standards.”

Once students are registered, they are provided with the following set of performance standards. Each student begins with 100 points. Grades are set at:

A+ = 95 - 100,

A = 88 - 94,
B+ = 80 - 87,
B = 75 - 79.

Potential Deductions include late assignment submission -1 point; bad grammar -2 points; trivial submission -2 points; unexcused absence -1 point per occurrence; non-participation -1 point per occurrence; consistently late for class -1 point.

Since 2003/04, only one B has been assigned.

2.6 Potential expansion

In the fall of 2015, within days of classes beginning, a graduate student in the Faculty of Education asked for permission to enroll in ENG 7010. Faculty of Education graduate courses are all offered in the evening because most students are full-time teachers. We decided to accommodate this student's request and created a second section in the evening. In order to populate the second section at such a late date, we approached students who were registered in the morning section if they were interested in changing sections. Five of the students accepted our offer. Three were part-time engineering graduate students who held full time positions off campus. One had just been offered a TA position at the same time as our morning section and chose to change sections rather than drop the course, and the fifth simply dislikes morning classes. We plan to offer both a morning and an evening section in the coming year. This will allow us to recruit both on campus and off.

3.0 IN SUMMARY

ENG 7010 - The Engineering Design Process has evolved into a discussion-based engineering philosophy course that provides students with a view of engineering beyond the technical details. It has evolved through what can only be called trial and error as we sought a way to make the "soft side" of engineering interesting. Consider the following quote. "I find my mind reflecting on topics we discussed. I do wonder if that course informed me of "how to think" about those topics, or if it just brought up my own suppressed beliefs to the surface and made me aware of "how I think"."

If education is about helping students think, then maybe ENG 7010 is about education.

Acknowledgements

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APPENDIX A: READING MATERIALS

APEGM Act, Bylaws and Code

<<http://www.apegm.mb.ca/ActBylawsCode.html>>

Arthur, W. Brian 2011 *The Nature of Technology*. Free Press, New York, NY

Bucciarelli, Louis L. 2003 *Engineering Philosophy*. Delft University Press, Delft, The Netherlands

Canadian Academy of Engineering. 1994 *The Role of Engineering in Building a National Strategy in Science and Technology in Canada*

<http://www.acad-eng-gen.ca/publis/e/role_an_1.cfm>

Canadian Academy of Engineering. 2002 *Protecting the public and the environment*.

<http://www.acad-eng-gen.ca/publis/e/Protecting_a1.cfm>

Ferguson, Eugene S. 1993 *Engineering and the Mind's Eye*. The MIT Press, Cambridge, MS

Petroski, H. 2012 *To Forgive Design: Understanding Failure*. Belknap Press of Harvard University Press, Cambridge, MA.