SOCIETY FOR TEACHING AND LEARNING IN HIGHER EDUCATION
LA SOCIÉTÉ POUR L'AVANCEMENT DE LA PÉDAGOGIE DANS L'ENSEIGNEMENT SUPÉRIEUR

STLHE
SAPES

The Alan Blizzard Award
Le Prix Alan Blizzard

An Award for Collaborative Projects that Improve Student Learning

Un prix qui récompense les projets en collaboration pour l'amélioration de l'apprentissage des étudiants

The Award Winning Papers

Presented at the University of Alberta, Edmonton, Canada

June 2007

Lauréats du Prix Alan Blizzard

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Table of Contents

Introduction

The Alan Blizzard Award was created by the Society for Teaching and Learning in Higher Education (STLHE) to honour its former President, Alan Blizzard (1987-1995), on his retirement, for his significant contributions to the Society. Designed to stimulate and reward collaborative efforts to enhance the effectiveness of university teaching and learning, the Award encourages and disseminates scholarship and effectiveness in teaching and learning. Each year, the award-winning project is presenting by the team during the Alan Blizzard Plenary at the Society's annual conference. The monograph describing the project is circulated to all Canadian universities.

The concept for the Alan Blizzard Award was developed by a committee including Chris Knapper (President, 1982-1987), Alan Blizzard (President, 1987-1995), Pat Rogers (President, 1995-2000), and Dale Roy (Coordinator, 3M Teaching Fellowships Program). The Award is sponsored by McGraw-Hill Ryerson's Higher Education Division. The Society is particularly grateful to Marlene Luscombe and Joe Saundercook of McGraw-Hill Ryerson, for their advice in the conceptual stages of the design of the Award and for their ongoing support of this project. McGraw-Hill Ryerson supports this Award as part of their focus on student success and faculty support. For more information visit www.mcgrawhill.ca/highereducation/

This year, five applications were received from five Canadian universities. This monograph presents the winning project from the Faculty of Applied Science and Engineering at the University of Toronto. Readers who are intrigued by the possibility of adapting this project to their own institutions are encouraged to contact the authors directly.

For more information and guidelines for submitting a nomination for the 2008 Alan Blizzard Award, visit the STLHE website at www.mcmaster.ca/stlhe/awards/alan.blizzard.award.html

Dr. Aline Germain-Rutherford
Coordinator, Alan Blizzard Award
Associate Professor
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June 2007

Introduction

Le prix Alan Blizzard a été créé par la Société pour l'avancement de la pédagogie dans l'enseignement supérieur (SAPES) en hommage à Alan Blizzard, ancien président (1987-1995), à l'occasion de son départ à la retraite, afin de souligner sa remarquable contribution à la Société. Destiné à stimuler et à récompenser les efforts de collaboration consentis pour améliorer l'efficacité de l'enseignement et de l'apprentissage universitaire, le prix encourage les lauréats en leur accordant des bourses d'études. Chaque année, les lauréats de prix Blizzard présentent une allocution à la séance plénière de la conférence annuelle de la Société. Toutes les universités canadiennes reçoivent une monographie décrivant le projet.

Le concept du prix Blizzard a été développé par les membres d'un comité composé de Chris Knapper (président, 1982-1987), Alan Blizzard (président, 1987-1995), Pat Rogers (présidente, 1995-2000) et Dale Roy (coordonnateur, prix d'excellence et de leadership en enseignement de la compagnie 3M). Le prix Alan Blizzard est parrainé par McGraw-Hill Ryerson (division de l'enseignement supérieur). La Société voue une reconnaissance particulière à Marlene Luscombe et Joe Saundercook de McGraw-Hill Ryerson pour leurs précieux conseils aux différentes étapes de la conception du prix et pour leur appui constant tout au long du projet. McGraw-Hill Ryerson apporte sa contribution au prix Alan Blizzard dans le cadre de l'objectif qu'il s'est donné de favoriser le succès des étudiants et de soutenir les facultés universitaires. Le site www.mcgrawhill.ca/highereducation offre plus d'information à ce sujet.

Cette année, cinq candidatures de cinq universités canadiennes ont été reçues. La présente monographie décrit le projet récipiendaire de la Faculté des Sciences Appliquées et de Génie de l'Université de Toronto. Les lecteurs intéressés à adapter ce projet dans leur propre établissement sont invités à communiquer directement avec les auteurs.

Pour obtenir plus de renseignements et connaître les modalités de candidature pour les prix Blizzard 2008, il est possible de visiter le site SAPES à l'adresse suivante : http://www.mcmaster.ca/stlhe/bienvenue.htm

Dr. Aline Germain-Rutherford
Coordonnatrice du Prix Alan Blizzard
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Juin 2007

2007 Alan Blizzard Award Recipients

Engineering Strategies and Practice:
Team Teaching a Service Learning Course for a Large Class

UNIVERSITY of TORONTO

Back row, left to right—Phil Anderson, Sandy Romas, Kim Woodhouse, Robert Andrews, Mark Kortschot

Front Row—Susan McCahan and Peter Weiss

Section A—Information

Project Title

Engineering Strategies and Practice: Team Teaching a Service Learning Course for a Large Class

Period of Implementation

First piloted in 2003/04, the Engineering Strategies and Practice course sequence is currently in its second year of full implementation.

Contact Person for the Group

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Group Members

All group members work in the Faculty of Applied Science and Engineering at the University of Toronto:

Name	Academic Status	Department
Susan McCahan	Associate Professor	Mechanical & Industrial Engineering
Peter Weiss	Senior Lecturer	Engineering Communication Program
Kimberly Woodhouse	Professor	Chemical Engineering & Applied Chemistry
Robert Andrews	Professor	Civil Engineering
Philip Anderson	Senior Lecturer	Electrical & Computer Engineering
Mark Kortschot	Professor	Chemical Engineering & Applied Chemistry
Sandy Romas	Administrative Assistant	Faculty of Applied Science & Engineering

Section B—Nature of Collaboration

Team work is a fundamental component of Engineering Strategies and Practice, a new cycle of courses teaching design and communication to first year students across the Faculty of Applied Science and Engineering at the University of Toronto. Not only is teamwork taught to, and practiced by, the students, but it has also been fundamental in the course delivery. Indeed, it would not have been possible to implement a course of this scale and complexity without a well-coordinated team effort. Fall enrolment is generally over one thousand, falling to about 850 in the spring semester. The course is delivered by a team of over 50 people, including a course coordinator, communication coordinator, lecturers drawn from the Engineering faculty, tutorial leaders, seminar leaders and project managers drawn from the faculty and alumni of the Faculty, communication instructors and teaching assistants.

Course activities include, in first term, lectures, tutorials in which students work in teams on a designated design project, and seminars in which topics related to design engineering are discussed. The second term includes lectures and tutorials in which the students, in new teams, work on an actual design project for a client drawn from the community of Greater Toronto. Evaluation tools include both individual and team-written documents, a midterm and final examination in first term, quizzes and oral presentations in second term. Finally, students reflect on their work in a portfolio submitted at the end of the year. Moreover, evaluation of documents going to clients is not a straightforward process. They are graded on the basis of course goals, but they must also be approved by the Project Manager and sometimes require a number of revisions after grading, before approval is granted. The entire process requires a high degree of coordination between the members of the teaching team. In spring 2006, there were 117 design teams; in spring 2007, there are over 150 teams.

Section C—Abstract

In 2000, the Dean of the Faculty of Applied Science and Engineering at the University of Toronto put together a task force to recommend the future direction of curriculum development. In the spring of 2001, the Decanal Task Force reported that the existing curriculum was excellent in developing technical and mathematical skills, but did not address other competencies, such as independent learning, communication, design, problem-solving, systems thinking, or team skills in an organized way throughout the Faculty.

To address these competencies, in the 2003/04 academic year, the Faculty piloted a new course sequence entitled "Engineering Strategies and Practice" (ESP). In 2005/2006, the course moved to the full enrolment of students representing eight of the Faculty's nine programs. Enrolment, in first term, is over 1,000 students; in second term, enrolment is approximately 850 students.

Fundamentally, ESP uses the context of design to introduce students to professional communication, team skills, and systems thinking. It sets a framework for the entire technical curriculum using a project based learning approach, with projects drawn from real clients in the community. The very nature of this broad course requires a diversity of talent and its logistics require a team effort.

Section D—Paper

Institutional Context

In 2000, the Dean of the Faculty of Applied Science and Engineering put together a task force to recommend the future direction of curriculum development. In the spring of 2001, the Decanal Task Force on Curriculum Change identified seven key competencies that should be explicitly developed through the curriculum[1]:

1. Technical and Mathematical Skills
2. Independent Learning
3. Communication Skills
4. Design
5. Problem Solving
6. Systems Thinking
7. Team Skills

The Task Force found that the existing curriculum was excellent in developing technical and mathematical skills, but did not address the other competencies in an organized way throughout the Faculty. Rather, technical and mathematical skills were taught through the first three years and it was expected that the other six skills would emerge, without formal instruction, in order to apply the technical and mathematical skills to a capstone design project in fourth year. Shifting from this model represented an enormous change in the way engineering was taught in our institution, and met resistance both from faculty who believed in the traditional approach and from students enrolling in the Faculty, because they too expected a traditional math and sciences approach.

In the fall of 2001, a Working Group on first year was assigned the task of recommending changes to the first year curriculum per the recommendations of the Task Force. The goal was to lay a strong common foundation for all students in the identified competencies. In 2002, the Working Group recommended that the Faculty replace the two existing complementary studies courses, with a two course sequence entitled, “Engineering Strategies and Practice”, that would use design as a context for learning foundational skills, primarily focusing on the six competencies that had been identified as deficient.[2] The added advantage of this approach is that it integrates communication skills, and the other competencies into an engineering activity thus reinforcing the message that these skills are integral aspects of engineering practice.

Goals of the Project

The course was designed to set a framework for the students, using the design process to provide motivation for the other technical courses they were taking in first year and beyond. The specific goals of the course can be compared to the competencies identified by the Task Force on Curriculum Change (see Table 1). It should be noted that, with the exception of technical and mathematical skills, the ESP objectives meet the overall goal of achieving a foundational level of mastery in each competency. The course, as implemented, meets or exceeds all of these original goals.

Project Description

The ESP pilot began in fall 2003 with 100 students from the eight programs that share a common first year. In 2004/05 this number expanded to 150 students. In the two pilot years, students volunteered to take the course and, thus, already had an interest in ESP’s goals and unique approach. In 2005/06 the course moved to full delivery, with enrolment topping 1,000 in September, dropping to 942 in December. Both ESP I and ESP II include five contact hours per week; three hours of lecture and one two-hour tutorial. Not only was the number ten times higher than the original pilot, the students had not chosen the course as an option and many had significant resistance to it.

Table 1

Comparison of Decanal Task Force Competency Definitions and the Original ESP Learning Goals Stated in the Report by the Working Group on First Year

Competency	Decanal Task Force	ESP
Design	• the design process • synthesis from multiple disciplines • thinking outside the box • project management • a holistic approach based on systems thinking	• an introduction to and framework for the design process • introduction to professional practice
Oral and Written Skills	• knowing how people communicate • effectively presenting and writing both technical and non-technical information • English competency	• communication as an integral component of engineering
Independent Learning	• know when, where and who to ask for help and information • self-motivated, curious • ability to survey and extract structure in new area	• foundation for independent learning • reinforce and strengthen enthusiasm for learning
Problem-solving	• problem formulation/identification • search and retrieve relevant information • critical thinking skills • creative thinking techniques • problem resolution • problem-solving methods and techniques	• introduction to and framework for problem-solving • opportunity to practice an iterative approach to problem-solving
Team Skills	• application of the principles of team development to achieve goals in a team setting • team processes for people and tasks • leadership skills • working in and achieving goals in a team environment	• experience working in a team environment
Systems Thinking	• holistic view including technology, people, organizations, and environment • understanding relationships and interactions • methodical, systematic approach	• introduction to and framework for project management • introduction to dealing with the social and environmental impact of technology • introduction to holistic view for examining engineering systems
Basic Math/Tech Competence	• use of models and their limitations • understanding basic science principles • formalisms (for model building) • computer literacy • discipline-specific knowledge	

To maintain the high quality student experience within the available resource base, we have only one lecture section because the lectures, while necessary both pedagogically and from an accreditation viewpoint, are not where this course provides a small class, value-added experience. Thus, resources go primarily into keeping the tutorials sections reasonably small (25 to 35 students). The tutorials are structured sessions in which the students work in teams on their design project. Each tutorial section has its own mentoring staff team composed of a teaching assistant and a tutorial leader in the fall term, or a teaching assistant and Project Manager in the spring term. They provide one-on-one feedback and guidance to five or six teams per tutorial section. (Please refer to typical tutorial agenda in Section E.) Similarly, enrolment in the seminars, which occur during the tutorial time slot later in the second half of ESP I, is kept as close to 20 per section as possible in order to ensure that everyone has an opportunity to participate actively in the discussion.

To support this enterprise, the ESP team has also implemented a set of technology tools. For example, we use *iWrite*. Developed at the University of Toronto, *iWrite,* is an interactive software package for helping students with their writing. It has a number of auto-tutorial features which allow us to set up assignments in a guided way to give students an interactive instructional session as they develop their assignments. There are also software tools available for assigning students to design teams, and other logistical activities that will be implemented to support the course.

ESP I

ESP I (fall semester) is divided into two modules—A and B. In Module A, a combination of lectures and a team project are used to introduce students to three of the major themes in the course: design, communication, and team skills. In the lectures, a basic methodology for engineering design is presented and case studies are discussed. In communication skills, the students are introduced to the concepts of technical and academic writing at a post secondary level. Specifically, the lectures cover how to make a credible statement, how writing in the engineering profession differs from other genres, and how to analyze an audience as a first step in effective communication. Students learn an approach to team organization and productivity. They are presented with the underlying concepts that elaborate the practical issues arising in team work and with strategies for improving the functioning of a team.

Team-delivered lectures in Module A model the interaction between multiple disciplines in engineering. Although the lectures are designed as a cohesive unit, generally the design material has been delivered by the Course Coordinator, Susan McCahan, who has industry experience as a design engineer, and by Kim Woodhouse, who has an active consulting business working with companies on team and management issues. Kim also lectures on team dynamics. Communication material is delivered by Peter Weiss, a professional writer. The teaching team interacts in the lectures, drawing no clear division between design, teaming, and communication to reinforce the concept that these activities work together in the process.

In Module A, the activities in the tutorial sessions give students an opportunity to practice these concepts. The students are put into inter-disciplinary teams and given a model design project from a fictitious client company. Every tutorial session has an agenda, which guides them through tutorial activities and demonstrates how an agenda is used in a business meeting (see appendix for model agenda). Students work through the team formation activities, and the conceptual phase of the design process.[3]

During this phase of the course, students develop several pieces of writing in conjunction with the model design project. The major written assignment for the semester is an iterative document called the Conceptual Design Specification (CDS). The CDS includes a definition of the problem, a complete presentation of the functions, objectives and constraints that any solution must meet, an explanation of the alternative solutions that were generated, a full discussion of the decision-making process that was followed, and, a credible argument supporting the design that the team is proposing. A draft outline is submitted by the team a few weeks into the model design activity.

Using the feedback on the draft, the team develops a preliminary CDS to be submitted at the end of Module A, six weeks into the term. A rubric has been developed[4] to give the students feedback on their writing and a copy of this rubric, along with specific notes from the teaching assistants, is returned to the team (the rubric can be found in the Supporting Documentation section). This formative approach to assessment allows the students to learn how to iteratively revise a document both to improve and deepen it as their understanding of the project grows. The rubric helps to create consistency between the thirty tutorial sections.

The final version of the CDS, submitted by each student individually at the end of the term, includes additional sections on environmental impact, economics, and human factors based on the material they learn in Module B. However, this new version of the CDS is the same maximum length as the previous version requiring the student to distil the existing sections to make room for the new material. This type of revision process is common in engineering practice.

Module B occurs during the second half of the fall term. This module expands on the basic concepts introduced in Module A, developing other major themes of the course: the human, social, environmental, ethical and economic factors that play a role in the design process. The lecturer is Robert Andrews who has industry experience in design, and whose present area of research is water treatment. He draws extensively on this experience both as a researcher and as a consultant in his lectures. The content in Module B is taught through case studies and the introduction of more advanced concepts in environmental impact, concepts in human factors, professional ethics, and basic economics. The case studies illustrate that a design is only successful if it works with the human beings, society, and environment in which it is situated. Students begin to learn how to identify stakeholders in the design process, identify the constraints imposed by these additional factors, and how innovative design can result from this challenge.

The tutorial sessions that occur in Module B take an approach to learning unique in engineering: seminars, which are more familiar in upper levels, honours and graduate courses in the humanities. However, this instructional method has proven to be very successful in ESP and the students have given the seminars the highest ratings of any element in the course (see student comments in the attached Supporting Documentation). In this mode of learning, a student is given readings to prepare for the session. There is typically a central question, or problem that acts as the focus of the seminar. Supporting questions are given and the students are expected to formulate preliminary answers in preparation for class. In the session, the group, typically 20 students, is guided through a discussion of the readings.

Topics for the seminars have included stem cell technology, solid waste disposal in Toronto, urban development issues, power generation and climate change, and automated meter reading. Seminar leaders are professors from multiple disciplines, alumni, or staff from organizations such as Engineers without Borders. Readings are drawn from a variety of sources including government documents, the lay press, journal articles, and policy papers. Students learn how to read critically, understand bias in information sources, and begin to develop the skills to evaluate and compare ideas. In every case, the fundamental question is one that requires not only an exploration of the technological solutions, but also an understanding of the context of the problem.

In addition to the marked documents, evaluation in ESP I is based on two exams, participation in the seminar sessions, and evaluation of the student’s engineering notebook. The engineering notebook is a typical method used in industry for documenting daily individual progress on projects and is vital in working through complex problems.

A student who successfully completes ESP I has demonstrated they can apply the design process, concepts of team process, and professional communication skills. It should be noted that the tests in this course require application of the principles, analysis of one or more cases, and include a long answer (writing) question. Students will also have successfully practiced these skills in their model design project. In addition, they will have applied the concepts taught in Module B in their final CDS document, the final exam, and through their participation in the seminar sessions. Successful completion of ESP I is a prerequisite for enrolment in ESP II.

ESP II

The primary focus of the winter term course, ESP II, is a major design project that runs through the entire 13 weeks of the semester. Lectures are divided into two Modules—C and D—which are used to introduce project management and to more deeply examine the design process. In the tutorial sessions the students work in teams on an individual project drawn from a client in the community.

Community service learning has a number of valuable aspects that have been well documented.[5] It has been found that students are highly motivated by “real” projects because their solution to the problem, and documentation of the process, have a purpose beyond the University marking system. Any case study that we could construct would never have this degree of realism and complexity. Yet the technical aspects of the problems are suitable for 1st year students; so the emphasis is really on finding the right solution for the client rather than finding the solution with the most technical complexity. Following the guidelines[5] for this type of instruction, students are marked on the process they follow rather than simply the product of the effort. The clients for ESP represent a variety of organization types. Some are engineering companies, but the majority are non-engineering companies, educational institutions, or charitable organizations, see Table 2. The students meet with the client several times during the semester and provide the client with two intermediate documents leading up to the final design report.

Table 2

Selected Examples of ESP II Design Projects

Client	**Project Description**
YWCA	Design of a backyard facility for a women’s shelter.
Tyndale College	Design of a cooling system for telephone switching equipment
B&R Club	Design of an accessibility system to allow members to go from the front door to the second floor dining room
ING Canada	Design for the ground floor outdoor area to be used as multi-functional space for employees
Wellspring	Website design for an on-line system to provide group and individual support for people living with cancer. (A letter from Wellspring is included in the Supporting Documentation)
Walter’s Forensic Engineering	Design of a system for the measuring the lateral acceleration of a snowmobile going around a tight turn.
Second Harvest	Design of a warehouse sorting, inventory organization, and picking system for redistribution of perishable food donated by restaurants and grocery stores.

Every week each team meets with a faculty project manager who advises them, makes sure the project is on schedule, and that the work load is evenly distributed. The documents that the students prepare are marked by teaching assistants. The team receives written comments on their work and feedback on their writing from the teaching assistant during tutorial. However, any communication with the client, including even the script for the phone call to arrange a first meeting, must receive the approval of the project manager. This quality control system is typical of industry practice for mentoring young engineers. The project manager may require several revisions of a document before approving it. Such revisions do not change the grade that was initially given by the TA, divorcing improvement from the conventional academic reward of a better mark and putting the students in touch with real world time pressures. Teams that fall behind are faced with the problem of having to complete one assignment as the deadline for the next approaches.

As the students work through their projects, the lecture portion of the course teaches concepts they will need. Crucial tools, such as scheduling and resource allocation, are taught in Module C by Phil Anderson.

The lectures in Module D explore the design process in more depth. These lectures are delivered by Mark Kortschot, co-founder and owner of a company which markets one of his inventions. Mark also has experience working with a number of professional inventors. He brings this experience, mistakes and successes, into his lectures. Strategies for gathering information are discussed, as well as intellectual property, marketing and "design for X." The "design for X" lectures elaborate on Module B and include design for human factors; design for safety and reliability; and design for manufacturability and serviceability. The design for human factors lectures are supported by Kim Vicente's award winning book, "The Human Factor"[6], which is required reading for ESP II.

There is no final exam in ESP II. Instead, the final major individual assessment is done through a portfolio compiled by the student at the end of the semester which accounts for 30% of their course grade. There is now a substantial body of literature on this method of evaluation[7]. The portfolio includes the student's engineering notebook and examples of communication documents to which they contributed. They include an introduction which reflects on the work that is included in the portfolio, their individual contribution to it, and explains how this material demonstrates progress in their communication skills. They may choose to include final versions of documents or drafts and may illustrate their roles as writers, revisers and editors.

Because team skills are an essential part of ESP II, students are also assessed on the basis of their team documents, presentations and participation in meetings. The three process documents that the design teams produce during the project mirror those written in Modules A and B: the Project Definition and Project Plan, the Conceptual Design Specification, and the Final Design Report. Individual participation in the project is also evaluated by the project managers based on their meetings with the students and brief status reports that the teams prepare each week. A portion of the evaluation is assigned to the two oral presentations: one during the semester on the project plan, and the final major presentation to the client. In addition, there are two short quizzes to motivate learning of the lecture material.

The course is designed to ultimately provide a learning experience to which each student brings her or his own frame of reference. The challenges of such a goal, especially in a course of this size and complexity, are numerous. Overall, the experience must be compelling because the students decide their own level of engagement. With approximately 30 teaching assistants doing the marking, project managers approving, and communication instructors tutoring, attaining a consistent approach is difficult. While every student will not have the same experience, our team and the system we use ensures that the students' experiences will be congruent. The projects have a scope appropriate for the student's learning needs, and evaluation depends on how well the student achieves the learning objectives of the course, not the type of project they work on. We must also ensure that clients are satisfied with their experience as well.

A student who successfully completes both semesters of ESP will have a strong foundation in the competencies originally identified by the Task Force on Curriculum Change. ESP II gives them the opportunity to work through a full, complex project. They will be well prepared to move into more advanced, discipline specific design courses. Communication skills are practiced in an engineering context and provide a basis for continuing, independent learning in this area. By the end of ESP students have had the experience of working in a team under the direct mentorship of a project manager. And the design documentation they prepare must include consideration of the environment, human factors, and the organization in which the design is to be situated. The combination of learning through a seminar mode of instruction, working with a client, developing a real workable design, and being exposed to experts from different disciplines who are some of the best teachers in the Faculty is unique learning opportunity. It constitutes a pivotal part of the student experience in Engineering at the University of Toronto.

It would impossible to scale-up this course to such a large number of students without a highly effective instructional team. The very nature of this broad course requires a diversity of talent. The logistics of this course require collaboration. While basic compatibility has an enormous influence on the success of any team, in the case of the ESP instructors and administration, we have also developed an approach that can be passed on as course personnel changes. Most people coming into the team-teaching environment of ESP were used to either, on one extreme, a task based approach in which responsibilities were divided up and accomplished independently and, on the other, an entirely collaborative approach. The problem with the first method, also known as "over-the-wall engineering," is that individual components may not match and the key objectives of congruency and consistency may not be met.

The problem with the latter approach is that decisions may get delayed if a reasonable consensus cannot be achieved. Our approach is one of "accountable collaboration." That is, each member of the teaching team has her or his own area of responsibility. Unlike an "over-the-wall" approach, a significant amount of communication and consultation ensures coordination between various course elements. The team meets once a week; more often during planning phases. In addition, lecturers attend one another's lectures. Assignment instructions are passed around for comment; benchmarking sessions with TAs focus on more than just evaluating the students' work. Problems with the assignments themselves are discussed and suggestions are invited. However, in the final analysis, each team member will make the final decision on any matter in her or his jurisdiction, allowing for effectiveness and efficiency.

Over the last three years, we have received highly favourable reports from our clients concerning their interaction with the students. A number reported that they intend to use the designs developed by the students to initiate a project. For example, the YWCA used the facility design developed for them in a proposal to the government for funding. ING Canada asked the student team that worked with them to present their results to a group of company executives. The Wellspring design team presented their final design to the organization's advisory board that includes some of the top oncologists in Toronto. (A letter from Wellspring is included in Section E). The contribution that the students make to the community, and in particular to non-profit organizations in the area, is substantial. Many of these organizations do not have the resources to address, in any other way, the problems that the students are tackling. As a result, not only is a need in the community met, but also people from outside of engineering become better informed about what engineers do and get a view of engineering as a human activity.

Impact on Student Learning

The design and goals of ESP derive from the recommendations of the Task Force on Curriculum Change and, more broadly, the literature they reviewed in constructing those recommendations. One important source for their work was The Boyer Report[8]. This key report includes a series of recommendations for reforming the undergraduate experience. Table 3 shows a comparison of ESP elements to the related recommendations and selected statements made in the Boyer Report. It can be seen from the table that the ESP experience is completely consistent with the goals set by the Boyer Commission.

The design of ESP was also informed by a wide variety of sources on teaching and learning. A few instances include the organization of the tutorials and use of engineering notebooks to role model industrial practice, the use of seminar style instruction, the development and use of rubrics throughout the course, the use of self-reflective assignments and the use of the portfolios for assessment. One very notable example is the way the seminars were designed intentionally to challenge students who are in the dualistic levels according to Perry's model of adolescent development[9]. A university education should, right from the beginning, motivate students toward a deeper evaluative understanding of the world and give them the tools to continue this life long development. ESP is intentionally designed to be an important step in that process.

Table 3

Comparison of ESP Elements and Recommendations Made in the Boyer Report[8]

ESP Element	Boyer Report Recommendations and Principles
Development of effective written and oral communication skills are an essential and integrated component in the course.	• Beginning in freshman year, students must learn how to convey the results of their work effectively both orally and in writing. • All student grades should reflect both mastery of content and ability to convey content. • The freshman composition course should relate to other classes taken simultaneously and be given serious intellectual content or it should be abolished in favour of an integrated writing program… • The course should emphasize explanation, analysis, and persuasion, and should develop the skills of brevity and clarity. • Writing courses need to emphasize writing 'down' to an audience who needs information, to prepare students directly for professional work.
The inter-relationship between engineering, people, society and the environment is explored in Module B, the seminars in ESP I, and the design projects.	• …the freshman and sophomore years need to open intellectual avenues that will stimulate original thought and independent effort, and reveal the relationships among sciences, social sciences, and humanities.
The students work on design projects in teams both in the Fall and Spring semester.	• Inquiry-based courses should allow for joint projects and collaborative efforts. • Learning is based on discovery guided by mentoring rather than on the transmission of information. • In every discipline, field work and internships should be fostered to provide opportunities for original work. • Every freshman experience needs to include opportunities for learning through collaborative efforts, such as joint projects and mutual critiques of oral and written work.
Seminars in ESP I, Module B, give students an opportunity to learn through a small group, inquiry based system guided by a mentor.	• All first-year students should have a freshman seminar, limited in size, taught by experienced faculty…
Each major theme in ESP is taught by an expert in the field who is actively engaged in related professional work and/or research.	• In a research university, students should be taught by those who discover, create, and apply, as well as transmit, insights about the subjects in which the teacher is expert.
ESP is designed to provide an overall framework that motivates the technical curriculum and development of professional skills. The design projects integrate multiple skills and material from a variety of disciplines.	• The freshman experience needs to be an intellectually integrated one, so that the student will not learn to think of the academic program as a set of disparate and unconnected requirements. • The freshman program should be carefully constructed as an integrated, interdisciplinary, inquiry-based experience…

Students consider the course challenging. Entering the faculty in first year, they expect lectures, labs, problem sets and exams. They do not expect a course which includes discussion, writing that is more business-like than essayistic, design problems with multiple solutions. However, by any measure, the deliverables for ESP are commensurate with the other courses in the student's program, and with courses they will take later in the curriculum. This implies that students are putting more time into the preparation of the delivered material. From a teaching perspective this is a terrific outcome because we know that students actually learn the material primarily when they engage with it outside of the lecture hall. Numerical outcomes and sample comments are given in Section E.

Many of the negative comments we receive appear to reflect a discomfort with the open-ended nature of the course material. This may be a result of a conflict between the student's perception of the way the educational process "should" occur and the intentional design of the ESP program, i.e. a dualistic student (in Perry's model) will be highly frustrated by the inquiry based methodology used in ESP in which there is no one perfectly correct answer. Dualistic thinking is common in students at this level and common for anyone beginning a new task. In order to help students make the leap from dualism to the multiplicity necessary for successful design, we strive to give them a sense that there is a purpose to this approach by explaining the course goals as clearly as possible. While we work to improve the course, it is important that we continue to challenge students with open-ended problems so that they learn how to evaluate, compare, and contrast solutions in an informed and credible way.

Some impacts are difficult to assess. Faculty who supervise fourth year design projects may be more aware of changes in student attitude and ability than are the students themselves, but even these changes will be mitigated by the particular characteristics of years and student groups. Other likely places to look for evidence of impact, albeit anecdotal, are in student internships and experience in entry-level positions upon graduation. Given the shift in curriculum emphasis represented by this course, it is difficult to compare current and past experience, but one indication of changing awareness is in the improvement of student evaluations of the course between ESP I and ESP II. As students apply what they have learned in first term to their real design problem in second term, they develop an increased appreciation of the value of the course and its pedagogical goals.

Future Developments

As we follow the ESP pilot students through their respective programs we will begin to accumulate data on impact. Already we have approval from the University Ethics Board to carry out a longitudinal study that will look at the efficacy of different ESP elements in the long term, and the relationship that this efficacy has to the student's learning style. For example, as a first area of focus, Peter Weiss is leading an investigation of the rubrics developed for the course.[4] Investigation on how students use rubrics and methods for creating increasingly effective feedback and self-reflective systems for development in writing will continue as part of ESP. We will also be looking at whether, and how, students make use of the skills learned in ESP in their subsequent courses.

In the future the Faculty is considering a plan to open ESP to students in other Faculties, notably Arts and Science. This would give non-engineering students an exposure to the engineering design process. It would also allow us to make our design teams truly interdisciplinary. The total enrolment would be capped, but we could see as many as 100 students from outside the Faculty enrolled in ESP over the next few years.

The ultimate goal is to use ESP not only to impact student learning at the University of Toronto, but to use what we learn to inform engineering education more broadly[10]. As this project continues, we will continue to use ESP to deepen our understanding of effective methods and factors that influence learning in engineering education. Part of this mission is to share what we find with the professional community.

Bibliography

1. R. Bonert, K.J. Vicente, and K. Woodhouse "Decanal Task Force Report on Curriculum Change," Internal Report, Faculty of Applied Science and Engineering, University of Toronto, 2001.

2. D. Bagley, D. Kuhn, S. McCahan, S. Pasupathy, and S. McCahan, "Report of the Working Group on 1st Year," Internal Report, Faculty of Applied Science and Engineering, University of Toronto, 2003.

   Models examined by the working group include several examples of first year design courses which integrate communication objectives such as the EDC program begun nine years ago at Northwestern University.

3. *Engineering Strategies & Practice,* custom text published for University of Toronto, McGraw-Hill. The material in this custom text is drawn from two sources: Engineering Design by G.E. Dieter, McGraw-Hill, 2000; and A Beginners Guide to Technical Communication by A. Eisenberg, McGraw Hill, 1998.

4. P.E. Weiss, M. Hundleby, S. McCahan, and K. Woodhouse. "Making a Little Theory Go a Long Way: Situating Rubrics For Learning and Assessing," Proceedings of the International Professional Communication Conference, Limerick, 2005.

   This paper discusses the design and use of rubrics not only as a tool for summative assessment, but also as a component in developing self-directed learning.

5. There are numerous sources of information on Community Service Learning. Sources that we have used include: discussions with the Office of Community Partnership at the University of Toronto; J. Howard. Service-Learning Course Design Workbook. Michigan Journal of Community Service Learning, 2001; Lima and Oakes. Service-Learning Engineering in Your Community. Great Lakes Press, 2005.

6. K. Vicente. The Human Factor. New York: Routledge, 2004.

7. L. D. Fink. Creating Significant Learning Experiences. San Francisco: Jossey-Bass, 2003. This book gives an excellent review of the current literature on teaching methods, including the use of portfolios as part of an assessment plan.

8. "Reinventing Undergraduate Education: A Blueprint for America's Research Universities" (commonly referred to as The Boyer Report), Boyer Commission on Educating Undergraduates in the Research University, 1998.

9. Perry's model was originally published in the 1950's. Its development is outlined in W.G. Perry, Jr. "Cognitive and ethical growth: The Making of Meaning.," in The Modern American College. A.W. Chickering, Ed. San Francisco: Jossey-Bass, 1981, pp. 76-116.

   An excellent discussion of the model, and particularly how it informs current engineering education practices, can be found in Teaching Engineering by Wankat and Oreovicz (out of print) available online: http://depts.washington.edu/cidrweb/resources/engrtools.html

   Additional discussions can be found in M.J. Pavelich and W.S. Moore, "Measuring the Effect of Experiential Education Using the Perry Model," in Journal of Engineering Education, Oct. pp. 287-292, 1996.

   R. Irish, "Engineering Thinking: Using Benjamin Bloom and William Perry to Design Assignments," Language and Learning Across the Disciplines, Vol. 3, no. 2, pp. 83-102, 1999.

10. S. McCahan, D. Bagley, P.E. Weiss, K. Woodhouse and W. Cluett "Teaching Design, Synthesis and Communication for First Year Engineering Students at the University of Toronto", Proceedings of the 2004 ASEE Annual Conference, Salt Lake City, June 20-23, 2004.

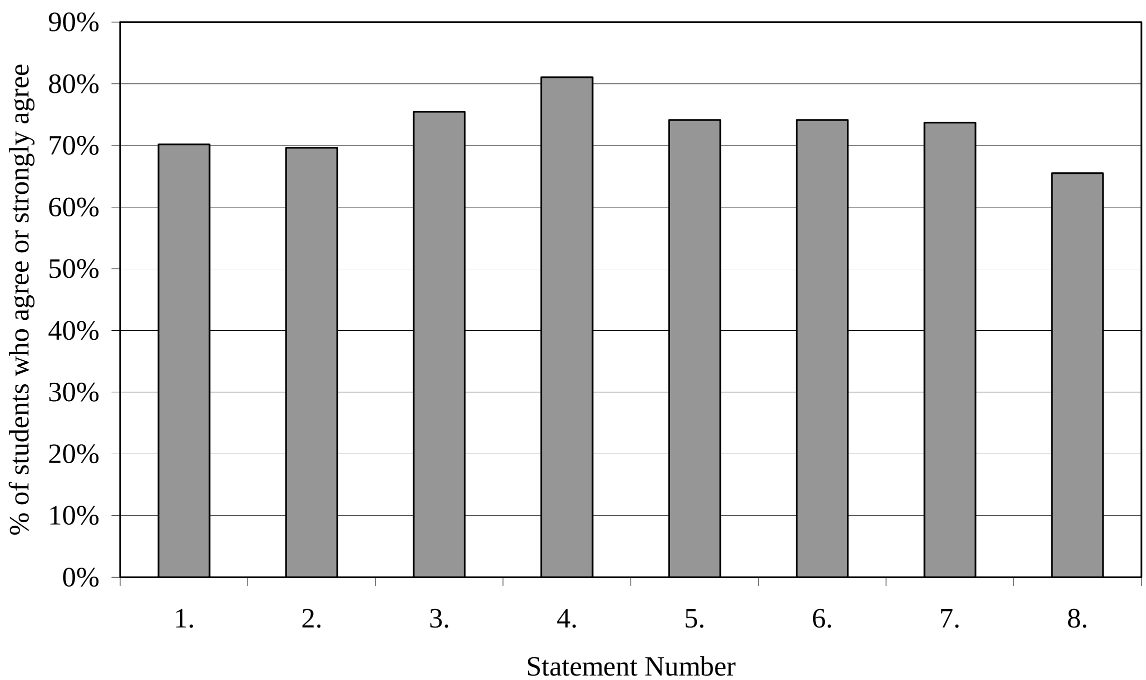
Section E—Supporting Documentation

Survey Data

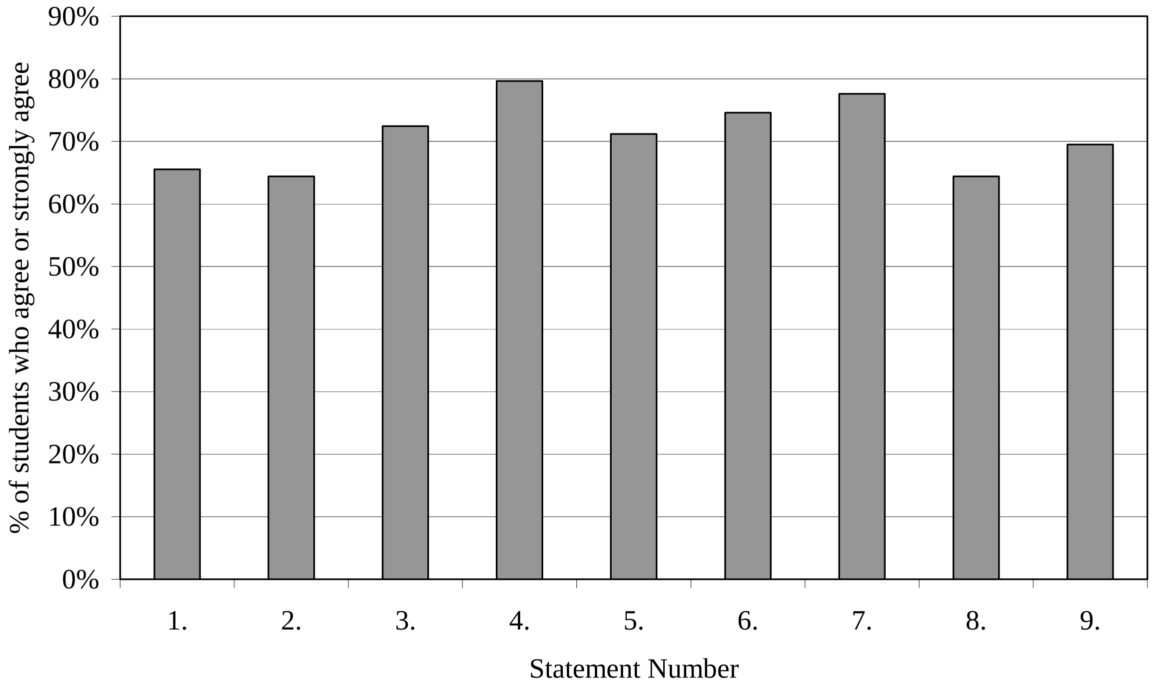
Upon completion of ESP, students were asked to respond to the following statements:

1. The major design project was a good opportunity to apply the skills I learned in this course.
2. The major design project I worked on in ESP was at a good technical level to be challenging while still fitting my skill level.
3. After completing the major design project, I am better prepared to approach professional communication assignments.
4. After completing Engineering Strategies and Practice, I can apply what I've learned to approach a client's need, plan a project, and work with a team to successfully complete a design.
5. After completing Engineering Strategies and Practice, I can identify what I need to learn to address a problem, and independently find the information I need.
6. After completing Engineering Strategies and Practice, I understand how human factors, social systems, environmental issues, and economics are part of the engineering process.
7. The experience of participating in Engineering Strategies and Practice, overall, has had a positive impact on my professional development.
8. The experience of participating in Engineering Strategies and Practice, overall, has had a positive impact on my personal development.
9. My understanding of the engineering process and what an engineer does has changed because of this course.

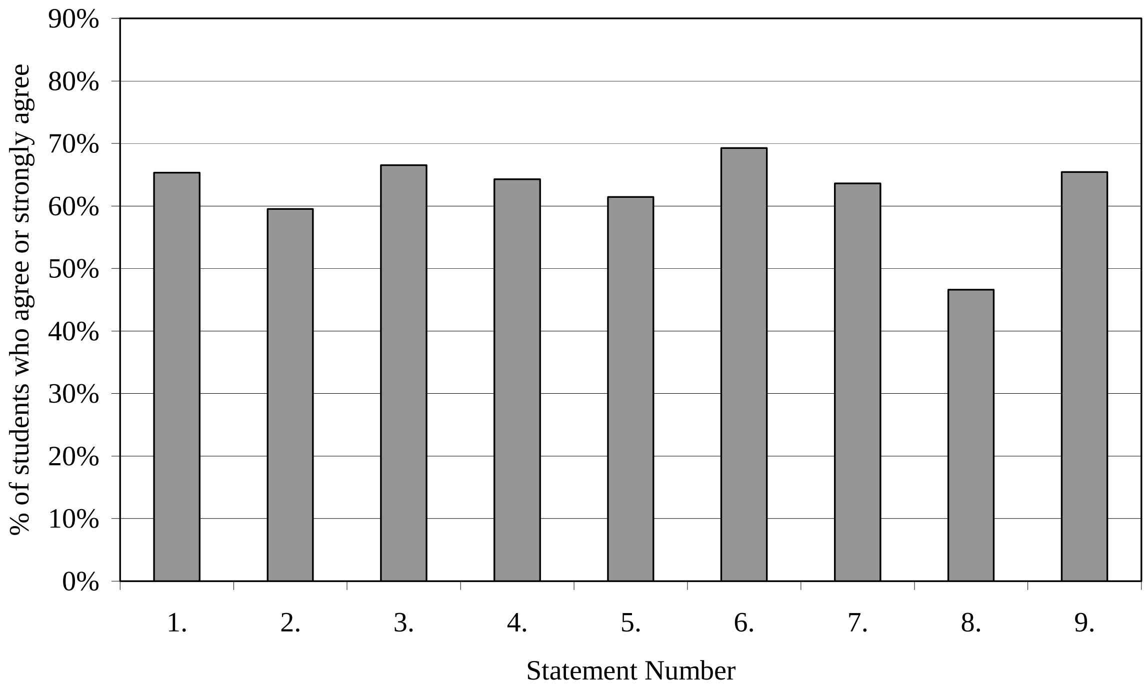
Survey Data for the 2003/04 Academic Year collected in April/May 2004
Enrolment in 2003/04 was elective: first year of the pilot
Note: statement 9 was not part of the survey in 2004



Survey Data for the 2004/05 Academic Year collected in April/May 2005
Enrolment in 2004/05 was elective: second year of the pilot

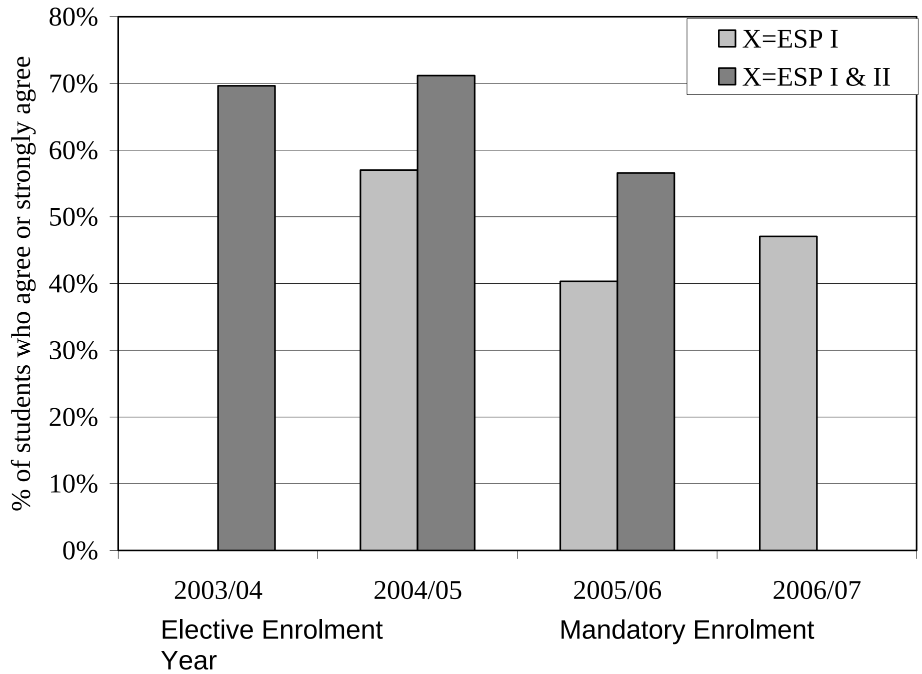


Survey Data for the 2005/06 Academic Year collected in April/ May 2006
Enrolment in 2005/06 was mandatory: first year of the full scale rollout

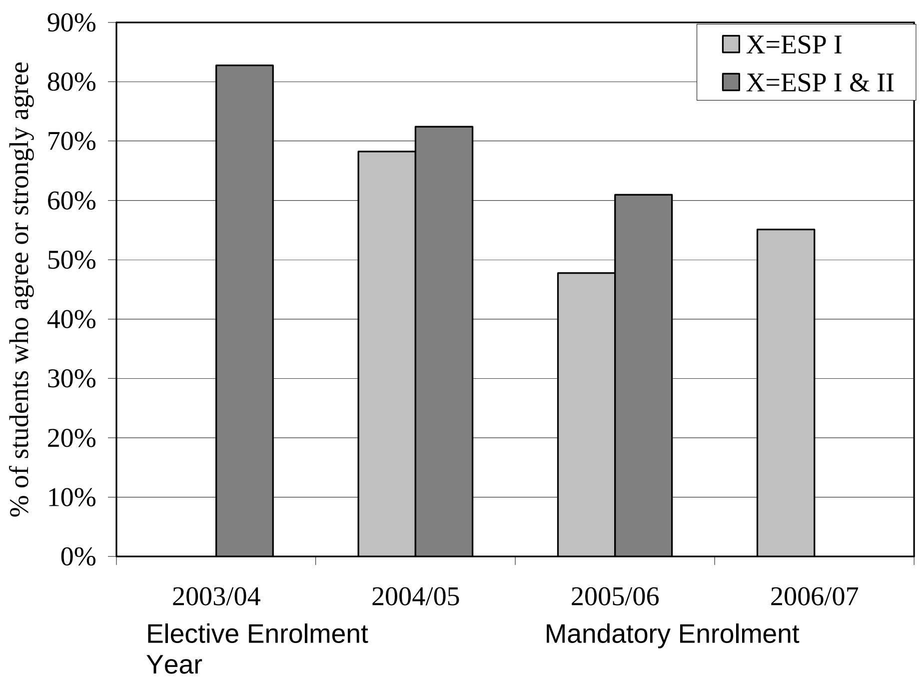


The following data compare the students' response at the end of ESP I in the Fall to the same, or similar, statement at the end of ESP II in the Spring. Data is not available for Fall 2003.

Statement: After completing X, there is an improvement in my professional communication skills.



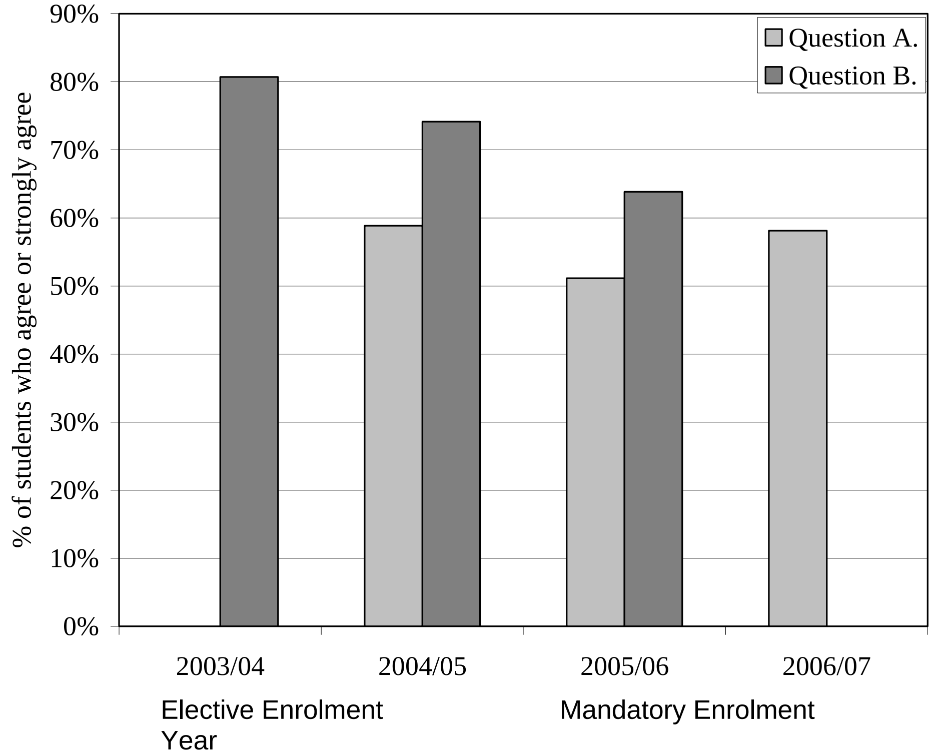
Statement: The material I learned in X is important to my academic and professional success.



Statements:

Question A. After completing ESP I, I believe I can apply my understanding of team dynamics to improve group productivity in real team situations.

Question B. After completing Engineering Strategies and Practice, I can work effectively with a team to tackle a project and I have some understanding of how to overcome problems that arise in a team situation.



The trends in the data are two-fold. First, there was a decrease in the positive responses as the enrolment increased and became mandatory. Some of the issues identified with the large enrolment have been addressed and the percentage of positive responses this year has rebounded from a low last year which was the first year of full scale implementation. Second, the students are clearly more positive about the experience after completing the full ESP course sequence than they are mid-way through the year when they have only completed ESP I. This appears to be a function, in part, of the expectation gap between what they expected from a university level course in engineering (i.e. a technical course) and the experience of ESP. Going into ESP II they are in a position to expect the kind of experience they will have in the course, and the major design project fulfills their expectations as a relevant application of the material they learned in ESP.

Grading Rubric

The following table shows qualities that were taken into account when grading your assignment. However, the grade is based on an overall assessment; therefore, the qualities do not represent individual mark values. Your grade, plus further comments, can be found on the back of this sheet.

Quality	Exceeds Requirements	Achieves Requirements	Requires Revision to Meet Requirements
Credibility of Design Process	1. Document ready for client. 2. All statements supported with persuasive evidence. 3. Comprehensive. 4. Shows considerable skill at applying the design process. 5. Work is highly original.	6. Document requires minor revision before sending to client. 7. Statements supported with adequate evidence. 8. All minimum requirements met. 9. All format requirements are met 10. Shows understanding of design process. 11. Solution introduced appropriately. 12. Original work.	13. Document requires significant revision. 14. Statements not supported. 15. Inappropriate use of emotive, or narrative language. 16. Lack of credible and logical development of ideas. 17. Fails to meet one or more assignment requirements. 18. Format requirements not met correctly. 19. Technical terms used w/o evidence of understanding. 20. Little evidence of ability to apply design process. 21. Solution driven: solution introduced prematurely. 22. Lacks originality.
Drafting issues, including research	23. Clearly thought out. 24. Well detailed, impressive depth of thought. 25. Well researched – reference sources well selected.	26. Reasonable sense of overall project. 27. Choices of reference material satisfactory but more or better research may be advised. 28. Needs more detail in section(s).	29. Thinking is superficial and sketchy. 30. Reader must read "between the lines" to understand information given. 31. Missing significant information. 32. Irrelevant information included. 33. References lack credibility. 34. Requires much more credible research.
Revision issues, including content	35. Clear, focused and logically organized. 36. Consistent section to section, though different writers contribute. 37. New material has been incorporated seamlessly.	38. Clearly lays out and fulfills purpose specific to document. 39. Organized correctly according to instructions. 40. Information in each section appropriate to that section. 41. Incorporation of new material with previous work is sufficient.	42. Sections out of order, compared to instructions or logic. 43. Inconsistent writing/formatting from section to section. 44. Information inappropriately placed within document; content placed in the wrong section. 45. New material not integrated; lacks transitions to relate it to previous material. 46. No new material. 47. Redundancies (material repeated in two or more sections), or gaps left as a result of poor revision.
Editing issues	48. Bullet lists organized meaningfully. 49. Each paragraph clearly develops a main idea. 50. Appropriate use of varied sentence structures.	51. All acronyms written out in complete words at least once. 52. Bullet lists and paragraphs are used appropriately. 53. Correct sentence structure.	54. Acronyms not given in compete words or over-used. 55. Bullet lists over or under used; meaningful relationships between ideas not set up. 56. Paragraphs are rambling, lack unity. 57. Sentences lack verbs or have disconnected elements. 58. Passive tense over-used. 59. Simple sentence elements lost in disorganized sentence structure.
Proof-reading issues	60. Level of language and tone appropriate to the intended reader. 61. Careful proof-reading has ensured few errors in grammar or spelling.	62. Good attempt at professional language. 63. Competent proof-reading has ensured that errors in grammar or spelling do not compromise basic readability. 64. In-text citations and reference list have been carefully checked. and are correct and complete.	65. Language is unprofessional in places. 66. Difficult to read due to many errors in formatting, grammar or spelling. 67. Missing in-text citations or entries on reference list.

Grade **Comment on Grade**

Greatest strength of document

Suggested improvement(s)

Comments on the Rubric

This rubric is handed back to the students with every marked assignment. The rubric achieves several goals. First, it creates consistency in marking by allowing the TA's to benchmark their grades against each other to make sure that the marks are consistent across sections. Second, it creates a consistency of commenting. The TA's use the numbering system (i.e. numbers next to the comments) to tag spots in the document where the specific comment applies. In addition, the rubric ensures that every student receives detailed feedback on their work. The rubric has evolved over the last several years and this latest version has been highly successful.

Sample Agenda—ESP I, Tutorial Week 5

1. Engineering Notebook—date a new entry.
2. TA—Introduction to tutorial.
3. Team—Decide how you will handle a team member who does not complete work in a timely fashion. Decide how you will handle a team member who does not respond to email or phone calls.
4. Pre-work for Conceptual Design Specification
5. Finalize design problem statement.
6. Identify the objectives and use a pair-wise comparison (described in class) to prioritize them.
7. Identify constraints.
8. Identify the functions from your problem statement.
9. Make sure this section is well documented to save you time when you are writing the Conceptual Design Specification.
10. Determine if you need to do any additional background work during the week to finalize this section.
11. Team Process—Brainstorming
12. In this part of the tutorial you will use one type of brainstorming. The TA will let you know which. You should end up with between 20 and 40 ideas. Duplicates are okay. Any idea is good.
13. KEEP NOTES OF THE IDEAS OR KEEP THE FLIP CHART PAGES.

Action Items for next week:

14. Create a schedule of tasks to the end of week 7. Everyone should know who is doing what by when. This schedule should include:
15. Dates for future team meetings to work on the draft.
16. Who is responsible for the final proofreading and compiling of the draft, and when they need to get submissions from the team to do this.
17. Who is responsible for handing in the hard copy on the submission date.

Comments on the Agenda

This document is an example of the type of agenda the students have for each week of tutorial in ESP. The agendas are included in the course package the students get at the beginning of the semester. This sample agenda is for week 5 of the semester, which is the third week the students have been working in teams on their design project. Each tutorial effectively operates as a mandatory team meeting, although teams may certainly elect to meet outside of the tutorial time as well. During this third team meeting, the team is still working through some of the “team rules” that will become important as the assignment deadlines approach. They are also doing design activities that give them practice stepping through a formal design methodology. This agenda was developed by the instructor team, and we go over the agenda with the TA’s prior to the tutorial sessions. The TA’s also receive facilitator notes for each week to help them facilitate the team activities.

Student Comments

Student comments in December at the end of ESP I:

- Above all, the seminars were most interesting. They were informative and educational.
- The seminars were quite interesting, and applied quite well to my engineering discipline.
- Overall, the course was an interesting experience.
- The hardest part of the course for me was getting my mind aligned with was required. I really had a hard time trying to convince myself that it was necessary.
- I found a lot of the material very interesting. It also prompted me to realize that there was a lot to learn about engineering that is not taught in science and math.
- Great course and departure from the math!
- Although this course may not be one of those conventional writing courses, I found it to be very useful and have learned a lot from it. In my previous experience of doing professional projects and working with higher authorities to plan out activities, there were some things that I did not do. However, I have learnt much from this course and shall use my knowledge in practical use.
- In general, this course is very special in terms of its content. I think it is a very professional course and will in deed help us in our later academic and engineering career.

Student comments in April/May at the end of ESP II:

- I prefer the difficulty of the ESP course sequence. It was not too difficult and it was not too easy.
- It is a lot of work at times, but it’s an amazing course.
- It feels great completing ESP 1 and 2. As of now I have good sense of professional communication and my writing has improved as well.
- Looking back, this course and APS111 were absolutely spectacular. I'm surprised the staff was able to coordinate so many people in such a smooth manner. I believe I learned more during these two semesters than all of high school.
- Very fascinating course. I would not hesitate to recommend it to anyone else. With the help of this course, I was able to obtain my summer internship as an Engineering student.
- I was on the subway the other day and I happen to sit beside management types that worked with engineers in design. I was listening in on their conversation while doing Sudoku and realized that the things they talked about were part of the information presented in this course. They spoke of functionality, constraints, requirements, objectives and human factors.
- The practical experience of ESP (i.e. the seminar, the group projects) was very important to my professional development, because people learn best by doing. Actually meeting with real clients was also a very rewarding experience, as I got to see how businesses work from the inside.
- An excellent beginning to understanding my career and what to expect in my future endeavours. I would like to thank all the staff involved for providing me with this opportunity.
- I found the amount of assistance from the course staff truly exceptional.
- Overall I felt that the course was and is very well designed and an important tool for engineering. The skills learned in the class were useful to the real world, and helpful in my personal growth as a student.
- The practicality of this course is simply fantastic. Working with a real client in the very first year of engineering was an amazing experience
- This is a great course, and the time commitment that is required is a lot, but honestly worth it!
- The experience that we have received from this course and the professional development gained is truly an asset. There was so much effort put into creating and organizing the course, and it is executed very well.
- After taking this course I felt that I have improved on many levels of personal development aside from the academic level. This course was a great experience, on dealing with real people and real problems.

27 Wellington Heights Court
Aurora, ON L4G 5C9

January 8, 2007

Professor Susan McCahan
Chair, First Year
Faculty of Applied Sciences and Engineering
University of Toronto
35 St. George Street
Toronto, ON M5S 1A4

Re: Engineering Strategies and Practices

As an alumnus of SKULE, I have been pleased to lead seminars for the innovative Engineering Strategies and Practices course for the past 4 years. This first year course is designed to foster excitement for engineering through seminars and projects that challenge students to evaluate the role of engineering in society, our relationship with the environment and the potential social impact of technology.

The course use the engineering design process as the context for introducing students to professional communication skills; problem solving; independent learning; systems thinking and teamwork. The seminar format is an excellent forum for two-way communication and learning through participation which sets the students up for the design portion of the course. Comments from students have been very positive considering the contrast with their normal lecture format, which is traditional in style and often involves large numbers of students. As these seminars are designed for 25 students, and students are able to choose from a wide range of topics of interest, participation is excellent. The diverse background of the student body at SKULE also contributes to lively and interesting views on seminar topics as students rely on their personal experience to frame the discussions.

In enlisting the help of alumni in presenting these seminars, the Faculty also takes advantage of the diverse working backgrounds of their former students. As this course has developed through the past 4 years, the school has institutionalized the systems that support this relatively new curriculum. They offer guidelines on conducting seminars, templates for seminar leaders on presentation of materials, and access to library resources. This is all in an effort to provide seminar leaders and students with consistently high standards of excellence.
I look forward to continuing to lead Engineering Strategies and Design seminars in the future.

Yours sincerely,

Mary T. Roy, PEng, MBA

WELLSPRING

March 23, 2004

Professor S. McCahan
Engineering Strategies and Practice, Course Coordinator
Department of Mechanical and Industrial Engineering
University of Toronto
5 King's College Road
Toronto, Ontario
M5S 3G8

Dear Susan:

As you know, the student team of I has been working on the design of an Online Support System for Wellspring as part of your ESP program.

I am writing to commend these students to you for the outstanding work they have been doing on this project and to express our appreciation for the thoroughness, professionalism and enthusiasm they have brought to the project. They have come to every meeting well-prepared, with pertinent questions, and innovative solutions to propose. The proposal they have produced is notable not only for its clarity and creativity, but for its sensitivity to the work that we do at Wellspring and the resource constraints under which we operate as a charitable organization. Moreover, it is extremely well-written.

It has been a pleasure to work with this talented team and to participate in the ESP program.

Sincerely,

Lynda Morrison
Chief Executive Officer

A lifeline to cancer support

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