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# An Experiment in Integrating Communication into the Biosystems Engineering Design Trilogy*

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*Technical communication is recognized as a fundamental and necessary skill for engineers of all disciplines in all types of careers. As a result, it is firmly entrenched as a mandatory course in Canadian faculties of engineering. Technical communication, however, has not always been palatable for engineering students because it emphasizes the 'softer' skills which students tend to devalue in comparison to the seemingly more objective, 'harder' engineering skills. Engineering faculties generally offer technical communications as a separate distinct course. This results in students viewing these courses as separate from the engineering curriculum and placing them in with their other elective obligations. Opportunities for innovative ideas to stress the importance of technical communications while incorporating this skill set into the engineering students' toolbox are being welcomed. The Department of Biosystems Engineering at the University of Manitoba has integrated technical communication instruction into a capstone design course. A trained technical communication expert teaches the course together with professional engineers. Because the technical communication instruction relates to the design projects being completed, the students see the value of technical communication in the overall design process; thus it is not regarded as a separate or unrelated activity.*

**Keywords:** capstone design; technical communications; engineering design education; engineering communication

## WHY INCORPORATE COMMUNICATION SKILLS?

A WELL-RECOGNIZED GIVEN is that the quality of interpersonal, communication and teaming skills in engineering graduates, also known as 'performance skills', is of concern to both industry employers and engineering educators. Increasingly, American and Canadian Engineering Accreditation Boards have encouraged programmes to integrate communication skills into the engineering curricula [1]. However, the means to integrate communication skills into the curriculum is still open to debate.

Traditionally, technical writing, which was the first communication skill that engineering schools sought help with developing, has been considered the province of English departments. Some engineering schools have developed cross-disciplinary team teaching to address the need; others have formed partnerships with writing consultants. Less common has been the creation of writing centres located within an engineering faculty to, uniquely, meet the needs of communicating communication skills to engineering students by providing instruction in and out of class.

Located within this continuum of teaching practices is the technical communication course offered in the University of Manitoba's Faculty of Engineering. Created over twenty years ago in response to the faculty's demand by employers for engineers with communication skills relevant to their discipline, the course is a stand-alone mandatory offering taught to all engineering students officially within the second year of their programme. The two professors who teach the multi-sectioned course are non-engineers. Nonetheless, they hold academic appointments in the Faculty of Engineering and, as a result, give the course a measure of 'in-house' credibility. The course concentrates on developing writing, public speaking and team-based skills as students collaborate on project teams to research and write a technical report. The course also exposes students to peer editing and revision strategies within a larger framework of audience analysis.

Although this stand-alone course can be applauded for its in-depth focus on cultivating skills that many engineering students have not traditionally excelled at, it has often been regarded by students as an unnecessary 'add-on' course. While student dislike of a subject should not be allowed to drive changes to the curriculum, it is important to understand why the course is disliked. It is likely that students fail to see the value of technical communication when it is taught

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in isolation of stereotypical engineering work (i.e. analysis and design). The rationale for continuing with a separate course has fallen under scrutiny at this university and elsewhere, as departments move increasingly to incorporate communication skills. Clearly, the time is ripe for innovations in the teaching of essential communication skills to engineering students.

A recent in-depth, qualitative study by Friesen [2] of students' learning of engineering design indicated that an innovative capstone design class, referred to as the 'Design Trilogy', may be an ideal site to experiment with pedagogical innovations in the teaching of technical communication. The Design Trilogy is distributed over three distinct courses and taken by undergraduate students over three academic years. Mastery learning is encouraged as undergraduate students are given three opportunities to experience the design process while completing design projects obtained from industry.

Friesen's purpose [2] was to explore teaching and learning experiences in the Design Trilogy to determine how the three courses, individually and in synergy, contributed to learning engineering design. In six focus groups, undergraduate engineering students identified communication as one component of the design curriculum. They expressed an interest in seeing more integration in the curriculum of the Design Trilogy so that curriculum components appear more cohesive and directly related to one another. This relationship should be evident in each individual course as well as across the trilogy of courses. Students recognized that course content and assignments were more meaningful and learning was enhanced when they were embedded in a realistic context, in this case being the design projects in the Design Trilogy courses. The study also identified that students' observations and interest in enhanced integration in the curriculum supported constructivist principles of learning, as well as experiential principles to teach processes in the situations in which they are used.

A brief review of the literature reveals that various attempts to integrate communication skills into engineering curricula have met with success, resulting in a positive acceptance by faculty and students [3,4,5]. Ramachandran *et al.* [3] report on the integration of teaching communication and design in students' sophomore year using a team-taught approach. Through the course, students came to appreciate that communication is an integral part of the design process; the same appreciation would not be achieved if they were learning design or communication separately. Similarly, in a study conducted by Hirsch *et al.* [6], it was found that students in an integrated design/communication course became better communicators because of a higher level of motivation. Due to their involvement in real-world design, students wanted to explain their designs precisely and clearly to users, clients and instructors.

## THE PROCESS OF INTEGRATION

The overall objective of the Design Trilogy is to teach undergraduate engineering students the entire design process from formulation of a design problem to fabrication of a prototype. Within this overall objective, the following specific objectives have been set:

(i) to strengthen team building skills;
(ii) to strengthen communication skills (all aspects);
(iii) to instil a sense of professionalism;
(iv) to develop project and business management skills;
(v) to instil safety and human factors engineering principles.

Based on the philosophy that students should have the opportunity to develop their skills under conditions similar to those they can expect after graduation, the Design Trilogy relies on open-ended design projects provided by industry clients. Mastery learning is emphasized as students are expected to progress to different stages of the design process as they complete each of the three courses [7].

The Design Trilogy has incorporated a communication component into its curriculum since its inception. One major targeted area includes student collaboration in a team-based environment, culminating in a peer review at end of term. Additional requirements are the conduct of professional meetings and the delivery of written and oral reports to classmates, professors and industry representatives. Formalizing the integration of technical communication into the Trilogy curriculum became largely a question of making explicit from instructional and evaluative standpoints what had previously been implicit for years. Perhaps the biggest change was that the technical communication content would now be taught by a trained technical communication expert rather than by an engineer.

Of the thirty-five hours of lecture time allocated to technical communication, 15 h is allocated to Design Trilogy I, 9 h to Design Trilogy II, and 11 h to Design Trilogy III. Correspondingly, grade allocations in each of the courses are as follows: 40% of the grade in Design Trilogy I, 30% of the grade in Design Trilogy II, and 30% of the grade in Design Trilogy III are allocated to the technical communications portions of each course. To pass each of the courses, a minimum grade of 'C' must be obtained for the technical communication component. A grade of 'F' is assigned if this condition is not met.

***Design Trilogy I***. Technical communication topics covered are public speaking techniques, impromptu presentations, minute taking, conducting effective meetings, conflict resolution, writing effective e-mails and letters, writing strategies, abstract and executive summary writing, document

design and effective visual aids. A variety of teaching techniques are used, often with the course instructor working together with the technical communications instructor.

The introduction of technical communications begins with evaluations of the brainstorming sessions and public speaking techniques. The new system allows for individual evaluation as each student enters the programme. Ongoing evaluations throughout the term allow for feedback and opportunities for students to improve their techniques. Topics covered in the second week include effective meetings and e-mails. The students are then required to use these skills in their group meetings and in communication with their industry clients. The next skill taught is that of conflict resolution. This is a subject that is best understood through experience. The lecture series is followed up with a lab exercise to better explain the process. In the lab, students are required to produce, in groups, an e-mail explaining a potentially disruptive work situation. This e-mail must be written using proper techniques as learned in class. Unknown to the group is the fact that one individual has been set up to disagree with their interpretation of the rules. This allows the group to test the conflict resolution techniques.

By mid-term the lectures are covering writing strategies. By this point the groups need to have ideas formulated and designs underway for their projects. This is the time that students start to compile the written portion of their project. To assist in this procedure the lab periods are focused on writing strategies, for style and content, for the group projects. The last subject covered is that of abstracts and executive summaries. At this point, the students are finalizing their reports and are able to incorporate this knowledge into practice.

***Design Trilogy II.*** Topics covered include writing literature reviews and evaluation of both oral and written communication.

Assignments include the preparation of an annotated bibliography, peer editing of a draft report and peer evaluation of an oral presentation. The annotated bibliography is intended to teach students how to critically evaluate written sources of information. For a given topic (which is either directly related to their design project or to the lecture material), students must locate eight sources (with a maximum of two being internet sources). For each source, the following information is required: the complete bibliographic citation, a summary of the content and conclusions and an evaluation of the source (i.e. author qualifications, problems with the information, usefulness of the information). A short oral presentation is made to share findings with the class.

In two further assignments, students are expected to provide constructive criticism to their peers. First, draft reports must be edited according to a specified format. The edited reports are returned to the design teams before the due date for the final draft, and the students discuss their feedback with them. Individual students are graded on the thoroughness and tone of their editing by the technical communications instructor. Second, students must evaluate the oral presentations made by their peers at the end of the semester. Feedback is given to the design teams and individual students are graded on their evaluation of the oral presentation.

***Design Trilogy III.*** Topics covered include conducting informative interviews, memo diplomacy, job preparation strategies, specification writing, preparation of bids and tenders and general techniques for report writing. Technical communication items are presented jointly by the engineer and technical communications instructors. It could be argued that the engineer provides insight into the 'language of engineering' while the communication specialist brings insight into the formal mechanisms of 'technical expression'.

While there are no independent technical communication assignments in Design Trilogy III, the instructors investigate the possibility of more links to existing topic areas and expansion to others where appropriate. A key aspect of Design Trilogy III is providing students with enough time to work on their projects, so the challenge for the instructors is to weave technical communication into the course at times when it makes most sense during the term. Ideally, the learning should happen within the context of the industry-based project in such a manner as to reinforce the importance of communication.

***Design Trilogy I, Design Trilogy II & Design Trilogy III.*** In addition to the assignments that are specific to each course, the final written reports produced by design teams in each of the three courses are graded by both the technical communication instructor (communication aspects) and the course instructor (technical aspects). The grade assigned to the design project is influenced by the quality and effectiveness of the writing. A meeting, with all instructors in all three courses, is subsequently held to review the reports. From the instructor perspective this was found to be very useful, not only from what it brings to the evaluation process, but insight into how communication aspects can be reinforced through other activities during the term.

## CONCLUDING COMMENTS

Since the formal integration of technical communication into the Design Trilogy, the course has been taught twice. Reaction from instructors and students has been positive. The engineering instructors can evaluate design reports on technical merits knowing that the communication aspects will be covered. The technical communication instructor can evaluate the design reports on

communication merits knowing that the technical aspects will be covered. Students learn both the engineering design process and the importance of technical communication to convey their design ideas. With the presence of an industry client, students realize that their communication effort is not simply an academic exercise.

A tremendous advantage of this approach is in the cooperation and synergy that can be developed by the presence of two instructors in the classroom. Spontaneous discussion with instructor input from both a 'technical' and a 'communication' perspective exposes students to a broader array of thoughts and ideas. The cooperation between instructors is perhaps most useful in the evaluation of the course assignments, particularly the written report where it can be difficult to separate the 'technical' from the 'communication' issues. Now, the engineering instructor can focus on the technical details of the design and the technical communication instructor can focus on the details of the writing itself.

To date, there has been no formal evaluation of the integration of technical communication instruction into the capstone design courses. Research is planned in the near future in which the technical communication instructor will compare course results from the biosystems technical communication coursework and the standard technical communication course which is taught to other engineering departments. Despite the lack of numerical evidence available at this time, all of the instructors involved have deemed this experiment to be a success. On the recommendation of the instructors involved, a curriculum change in the Department of Biosystems Engineering has occurred; undergraduate students are no longer required to complete the faculty-wide, stand-alone technical communication course.

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