Introducing a New Engineering Course: a Learning Experience for Students and Faculty

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Abstract

A Task Force was created by the Faculty of Engineering at the University of New Brunswick in September 2004 charged with creating a new course for all first year engineering students to be delivered for the first time in September 2005. The course, to be taken by approximately 270 students, was to integrate material from other first year courses, introduce the students to working in teams, contain a substantial design element through a design project, and introduce communication skills. Nine professors from throughout engineering “volunteered” to help develop and deliver the course. In this paper we own up to what we did wrong during the first two years of delivery of this course, and (naturally!) counter this by celebrating our successes.

Students are assessed based on a combination of individual and team submissions, with some submissions being oral and others written. This paper will outline the complex assessment scheme we initially used, and how we later simplified it.

Rubrics were used to evaluate many of the course assignments. For most of the instructors, this was the first time they had used rubrics and so it was a learning experience to both develop and apply them. We show how we adapted their use in the second year of delivery after the experiences of the first year. We were pleased with the way that the assessments were mostly built around the design project – this helped the students grasp why clear communication is vital and enabled them to obtain continual feedback on the project. We were also delighted that an element of social responsibility was introduced into the course by making the project an international “Engineers Without Borders” project based in Africa. We believe this added an additional dimension to the course and especially the project.

The professor-delivered skits were especially popular! Delivered by two wannabe actors, they introduced the students in a humorous manner to the different types of engineering that are taught at UNB. Engineering students at UNB have to commit to their specific engineering field from their first day at UNB, so these skits were included to ensure the students were exposed to all the UNB engineering disciplines.

We conclude the paper with our plans for delivery of the course in September 2007 and beyond.

1. Introduction

A Task Force was created by the Faculty of Engineering at the University of New Brunswick (UNB) in September 2004 charged with creating a new course for all first year engineering students to be delivered for the first time in September 2005. The course, to be taken by approximately 270 students, was to integrate material from other first year courses, introduce the students to working in teams, contain a substantial design element through a design project, and introduce communication skills. Nine professors from throughout engineering “volunteered” to help develop and deliver the course.

The course has now been delivered twice with the same core of instructors (supplemented with a small number of part-time instructors to replace faculty on leave), Graduate Teaching Assistants (GTA) and Undergraduate Teaching Assistants (UGTA) too. We have changed the course-integrating project each year, while maintaining its “Engineers Without Borders” (EWB) theme. The system of assessment was simplified in the second year, and we used rubrics both years in different ways. We often spent hours preparing two-minute skits in the first year, but managed to substantially reduce the planning time in

the second year with no noticeable deterioration in the (already poor) standard of acting.

In this paper we will describe what we as faculty learned, and what the students hopefully learned. We own up to our mistakes, and what we did right. We conclude the paper with our plans for the next delivery of the course.

2. Background

The teaching of Engineering at UNB has traditionally been organized and delivered by the individual departments. Thus the degree in Geomatics Engineering was delivered in 4-5 years by the Department of Geodesy & Geomatics Engineering. The degree in Civil Engineering was delivered in 4-5 years by the Department of Civil Engineering. There was minimal sharing of teaching resources, and so each degree was run essentially independently of all other degrees, with duplication of similar courses. Students would “sign up” to a degree from day one, while the transferring between degrees could extend significantly the time students had to spend at UNB. In addition, the Canadian Engineering Accreditation Board was requiring us to increase the amount of “design” students were exposed to, and we wished to increase the amount of “team” teaching to meet requirements of employers.

To reduce the number of duplicated courses, help facilitate degree transfer, and increase the exposure of students to design and working in teams, the Faculty of Engineering established a task force in Fall 2004 to produce a common first year among all engineering students. One of the courses in the new common first year would be a new course covering communication, teams and design. Over the following year, many planning sessions were held to develop the course. The result of all that planning was a new 6 credit hour course, “Design and Communication”, which is the subject of this paper.

3. Course principles

We established a number of principles under which we would offer the course.

- The major skills we wished the students to acquire were communication, working in teams, and design
- Communication was to include graphics, reading, writing, listening and oral

- The major skills were to be acquired and assessed around a project
- Students would work in teams when addressing the project, and for some of the assignments
- The project was to be an EWB type project
- The secondary knowledge we wished to pass onto students included the engineering profession, ethics, and techniques of how students can get the most out of their education
- We would interrupt lectures with humorous skits related to the course content
- Students were not expected to build a model of their design
- Students could not use university technicians to build their design
- We would have a number of guest lecturers

These principles have remained in place for both offerings of the course.

There are three lecture hours and two three-hour lab sessions per week. The lectures are delivered to the entire class (about 230 students); the lecturing duties are shared (unevenly) among six of the nine instructors. The major topics covered in the lectures are graphics (13 lectures), design (8), technical writing (4), presentations (3), and the engineering profession (4). There is also one lecture on information sources (delivered by the librarian of the engineering library), two lectures on getting the most out of your education (GME), and a guest lecture by a high-profile practicing engineer.

The lab session topics include graphics (6 labs), design (7), presentations (4), technical writing (2), teams (2), and assessment (1). The thread common to many of the lab sessions was the design project which was assigned to the students early in the term. The lab sessions culminate in the presentation of each team’s design in the last week of the term. The full lecture/lab schedule is shown in Table 1.

The nine instructors are drawn from all the engineering programs, and the instructors were usually the instructors who had taught Technical Communication for each of the individual programs. One of the instructors has also been given the role of the course leader/administrator.

Lec.	Topic	Lab A	Lab B
1	Introduction		
2	Graphics 1		
3	Info Sources 1		
4	Graphics 2		
5	Design 1	Graphics 1	Teams 1
6	GME 1/TW/Teams		
7	Graphics 3		
8	The Engg Profession 1	Design 1	Presentations 1
9	Design 2		
10	Graphics 4		
11	Technical writing 1	Graphics 2	Assessment 1
12	Presentations 1		
13	Graphics 5		
14	Design 3	Design 2	Tech writing 1
15	Technical writing 2		
16	Graphics 6		
17	Design 4		
18	Presentations 2		
19	Graphics 7		
20	Design 5	Design 3	Teams 2
21	Info Sources 2/TW 3		
22	Graphics 8		
23	Design 6	Graphics 3	Presentations 2A
24	Guest Lecture		
25	Graphics 9		
26	Technical writing 4	Design 4	Presentations 2B
27	Presentations 3		
28	Graphics 10		
29	Design 7	Graphics 4	Tech Writing 2
30	Design 8		
31	Graphics 11		
32	Graphics 12	Design 5	Design 6
33	The Engg Profession 2		
34	Graphics 13		
35	The Engg Profession 3	Graphics 5	Open
36	The Engg Profession 4		
37	GME2		
38	Review/Feedback	Graphics 6	Presentations 3
-			

Table 1. Lecture/lab schedule

4. Fall 2005 offering

The course material was to be delivered by means of 3 hours of lectures each week, and two 3-hour lab sessions. The lectures were delivered to all 270 students, whereas the labs were delivered to groups of 30 students. Thus we had 9 separate lab sections; students self-selected their lab sections during

registration. We had a UGTA help with each lab session, and a GTA assigned to help with the marking for each section.

We randomly assigned students to teams, with six teams of five students per section. All teams were to work on a solution to exactly the same project. We chose an EWB project although this project was not being implemented at that time. The project was to investigate a more efficient way to remove water from a well in Zambia. The current system required the inhabitants of the village to form a human chain passing buckets up and down the well, throughout the daylight hours. This is the only source of water for the village. We knew there would be questions from students requiring further information, but felt we could handle these as they came in rather than try to predict the questions in advance.

We wanted to use rubrics for part of the assessment process. One of the course designers had had success in this in previous courses so we decided to adopt them for the course. This required us to develop the rubrics! Choosing criteria, and then articulating the assessment levels for each of the criteria in an unambiguous manner, was much harder than we expected.

We were concerned that students only knew about the engineering discipline they were studying and so we wanted to broaden their knowledge of engineering. We initially thought we would do this in the easiest way by having one lecture explaining the different fields of engineering. However, instead we decided to use two minute skits during lectures to illustrate these fields of study in a humorous way.

In order to assess teamwork, we had all students complete worksheets based upon their teamwork. We also forced students to take on roles in their teams (e.g., team leader, minute taker, devil's advocate) through a role rotation system, with team leaders submitting a report at the end of their rotation. Logbooks were to be kept by each student to record in a permanent way design ideas, minutes from meetings, initial calculations. The UGTAs were to check these for completeness at the lab sessions.

We wanted to use the rubrics for assessment, and also assign percentage grades for other work. In addition, once students had achieved a certain level on a rubric, work submitted later in the term could not lower their rubric grade since the student had shown evidence of a certain level of ability. Some grades were team based, others were individual work. Students also had to

achieve certain “check marks” against items to be submitted (e.g., logbook completion), but were not graded on the work.

We assessed written assignments for content and style. Feedback would be given within the written document, and a level on the relevant rubric would be decided upon.

For us, an element of communication we wanted to emphasize was graphical communication. We wanted the students to be able to show graphically their design. To accomplish this we had a number of lab sessions devoted to the use of AutoCad.

4.1 What went wrong

We had enormous difficulties with the project. As the project did not actually exist, we constantly had to make up answers to questions from students. “How much water does a person need per day?” “Is the water for the animals too?” “How much water does a cow need in a day?” “How many animals does the village have?” It was constructing consistent answers to these questions that ate up the time at the weekly “one hour” instructors’ meetings. We had to change the size and shape of the well after a few weeks which was extremely unpopular with the students.

We should have used the rubrics for feedback only rather than trying to use them to provide a grade too for submitted work. Overall, our assessment method was far too complex. We heard from students that they had no idea what grade they were likely to achieve for the course even once all the coursework had been assessed.

There was inconsistent and generally inadequate marking of the writing component of assignments. Some instructors marked the assignments themselves, others relied completely on their GTA. It was clear that not all the GTAs were competent enough to assess the written English. Technical expertise did not translate into an expertise in the written language.

We were hindered in the AutoCad labs by a lack of computers with the software due to the software licensing agreement. This meant lab sessions with AutoCad were cut to 90 minutes instead of three hours as we had expected. With some computers in the AutoCad room not working, this often led to overcrowding. With the lab cut in time, students felt they spent too much time completing predefined tutorials rather than using the software. “I can’t do

anything else with the software than do the tutorials” was a statement made by the students.

The teamwork component of the course was not particularly well presented or administered. Students completed role reports, worksheets and logbooks, but we didn’t really teach “teams”. In the first offering of the course we did not have an instructor who had taught teams before, or assessed students working in teams.

4.2 What went right

The skits were great! Providing two wannabe actors with an outlet for their terrible acting skills, they did introduce the students to the different types of engineering taught at UNB, although far too long was spent preparing for each two minute skit.

Although there were substantial challenges with the project, and the students did not like us changing the size and shape of the well, they did like the concept of an EWB project. They embraced the concept of considering social aspects of their design and – by the end of the course – the student teams produced designs and did address the social impact of what they were designing. An example of a final design is in Figure 1.

We had an excellent guest lecture (given by Caroline Baillie from Queen’s University) which provoked many questions and much discussion afterwards.

The instructors team-taught the course, which for some was the first time they had had to work with other instructors on the delivery of a course. The different skills each had, and their different engineering backgrounds, enabled us all to learn from each other.

5. Fall 2006 offering

For 2006, we made a number of significant changes to the labs. The lectures were similar to 2005, with the biggest change being in the graphics lectures as we had a new instructor. We also added a theme to the skits, with each skit showing what role an engineering discipline might play in reconstructing the island of Palau if it was hit by a typhoon. We formed the teams ourselves, trying to ensure teams had students from a number of engineering degrees, were of varying ability, and if they had any females at all, they had more than one. Each section had five teams of six students per team.

Figure 1. Example of water hoisting design [1]

We simplified the assessment process, with rubrics being used for feedback only, not assessment. We also changed the written final project report from an individual submission to a team submission. This made more sense as the team had been working together over the term and so to produce individual reports seemed inconsistent with the concept of working as a team.

The course mark was based on performance on 15 deliverable components, attendance at the 22 scheduled lab sessions, and completion of a teamwork workbook. Eight of the deliverables are related to the team design project, and the other seven are related to other aspects of the course. The weighting of the major components was:

- Attendance at labs – 10%
- Design project – 40%
- Assignments – 30%
- Report on an Engineer – 20%

Deliverables with a substantial written component are assessed for content and writing separately. So, for example, the guest speaker review mark will be 60% writing and 40% content, while the initial design document will be 40% writing and 60% content. Overall, the technical writing mark made up about 35% of the course mark.

We improved the handling and teaching of teams. Joining the instructors was a professor familiar with teaching of teams from her own degree. We used a workbook to explain the process of team formation and working in teams. We used a related website for students to give feedback on their team development, feedback on their team members, their own weaknesses and strength, and also award marks to themselves and each other member of their team near the end of the course. We used the marks awarded to other team members in the final course grade evaluation.

We maintained the project as an EWB type project. In fact this time we developed it with an EWB volunteer in place in Mali. The project was based around reducing poverty in Mali by processing surplus mangoes in some way so they could be exported. The students were required to design an attachment to a motor to process the mangoes. From the instructors' view, having someone in Mali made a significant improvement to the handling of the project. No longer did we have to devise answers to the questions, we simply emailed them to the EWB volunteer in Mali who would supply correct answers within a few days. Some student teams made good use of the graphics software and prepared good quality engineering drawings – an example is in Figure 2.

In the labs we reduced the number of UGTAs, and maintained the use of GTAs to help with the marking.

We changed the software used for the graphics component of the course. UNB decided to replace AutoCad with Pro/Engineer, and so we used Pro/Engineer for the later part of the course while using Google SketchUp for the first few weeks of the course.

5.1 What went wrong

The number of weeks spent on the project was far too many. Students were in total agreement at the end of the course that they hoped they would never see or hear of mangoes again!

Figure 2. Example of mango processor [2]

We had significant technical difficulties with the website to support the teams work. This created frustration for the students and the instructors. After a few false starts the website worked okay, and did provide a means for students to provide feedback and assess themselves and other team members in a secure manner; this feedback was non anonymous. Students were also unhappy with the peer review process. Peer evaluation is used on a number of higher level courses where students are happy to give feedback on each other. We believe the first year unhappiness with the process is due to their younger age, the feeling that they are “snitching” on their fellow students, and the fact that these students are straight from high school. The final peer evaluation where students assigned marks to their team members was anonymous.

We continued to have difficulties assessing the written assignments for both style and content. Once again we tried to use engineering graduate students to help assess and provide feedback on the grammar. With one notable exception, the GTAs were not sufficiently skilled to provide the feedback required and assess in a consistent manner.

The students were of the opinion that the 3-hour lab sessions were not used effectively. We were initially surprised by this comment as we had scheduled team meetings to take place during the lab sessions when the students would also be working on the topic for that lab. We believe this comment is linked to their dislike, by the end of the course, of the project.

5.2 What went right

The skits were great! And we managed to prepare them faster than before. Figures 3 and 4 illustrate

some of the props used to illustrate different types of engineering during skit rehearsals.

Figure 3. Material of the boat used to explain Chemical Engineering

Figure 4. Star Wars computer game simulation used to explain Software Engineering

We had another excellent guest lecturer (Laura Logan from Air Canada).

Once again the students liked the project being based in Africa, but were of the opinion that equally socially important projects could be devised for more local situations.

6. Comparison of offerings

The assessment process in 2006 was far more transparent to the students compared to the 2005 offering. It was fairer to the students, and enabled them to be able to estimate how well they were performing on the course. It was also much easier for the instructors to apply. We have compared the grade profile of the two years the course has been offered and the comparison is shown in Figure 5. We can see in Figure 5 that the 2006 offering obtained a grade profile much closer to a “normal” distribution (although it is biased to the higher grades). Noticeably absent in 2006 was the high percentage of A and B+ grades awarded, and the steep drop from B+ to B.

Figure 5. Grade distribution for 2005 and 2006.

We are able to see in Figure 6 that in 2005 a higher percentage of students were awarded the higher grades (A+ to B) than in 2006. This could be due to better students, but we feel it was due to the complex marking system used. The system was so complex we were even having trouble implementing it. To ensure no student was penalized by our possible misinterpretation of the rules, we always gave students the benefit of the doubt and so increased their grade when in fact this may not have been justified. In 2006 our simpler marking system, and our increased confidence in the course, meant we no longer had to err on the side of caution by giving students the benefit of the doubt – the grades to be awarded were quite clear.

7. Future delivery of the course

We plan to make a number of improvements to the next delivery of the course (to take place in the Fall term of 2007).

Figure 6. Grade tally for 2005 and 2006.

- We will be developing our own webpage for student peer feedback and assessment. In this way we will be able to ask exactly what we want, and be able to determine the data we need. We will also be in control of the removal of confidential information given by the students.
- We plan to use a short and long project in future years. In the short project, students will work in teams for about four weeks on a simple project such as “design a new device, or improve an existing device, to make students’ lives easier”. This type of project at other universities usually results in a food-related device, such as an automatic pancake flipper. The longer second project (with new teams) will be an EWB type project. We plan to develop a set of “principles” for the project (e.g., an item or system developed must be sustainable). The teams can then choose a project anywhere in the world and it will be their responsibility to show their project meets the project principles. We resisted the idea of letting students choose their own project in the first two years to ensure we maintained better control of the course in its early years. There was enough development to do for the course without having to deal with idea of possibly having 54 different projects! Now the course has been delivered twice we feel the time is right to let the students choose.
- We plan to hire markers from outside the Faculty of Engineering to assess the writing aspect of student submissions. Ideally they would be experts in technical writing rather than prose. Possible candidates might include retired engineers or professional technical writers, or GTAs from the social sciences.

- Assign five of the nine instructors to the course in any one year. They would be responsible for most, but not necessarily all, of the lecture material. Thus instructors could have a year off from teaching the course. We would use UGTAs to run the lab sessions, with one UGTA assigned to each section. Have two instructors “on duty” each afternoon, with each one looking after two lab sections. Each instructor would thus be on duty two afternoons per week which is the current requirement where the instructors have to run the labs. Overall, the workload for an instructor would be about the same (more lectures but less work in the labs) but this would not be carried out each year, only in a year when an instructor is assigned to the course.
- Have an administrative assistant to assist the course coordinator. The coordinator would be responsible for the course content and scheduling, while the administrative assistant would be responsible for paper flow – recording marks, maintaining website, etc. At the moment the coordinator carries out all these functions.
- Regarding the graphics software, we plan to maintain the use of Google SketchUp at the start of the course, and use Solid Edge 2D for the later weeks of the course. Solid Edge 2D provides layout styles, diagramming, annotation and dimensioning that comply with a number of drafting standards including ISO and ANSI. Like Google SketchUp it is free to download and use, enabling students to install it and use it on their laptops thus immediately overcoming the license and room booking difficulties we have experienced.
- We are also considering the adoption of the marking scheme of “exceeds expectations”, “meets expectations”, or “needs more work”.
- We hope to continue with the skits, maintaining a theme to them if possible. For the 2007 offering we are considering going into space and basing the skits around the International Space Station. The initial thoughts are to relate the skits to a particular lecture rather than describe a type of engineer, as the types of engineering may now be delivered in a small number of lectures.

8. Conclusions

We move into the third delivery of the course with increased confidence. We believe our plans for the marking and feedback of the written assignments will significantly improve the quality of the technical writing component of the course.

Allowing the students to choose their own projects will provide an increased variety of projects (what we wanted to avoid in the first two years) helping maintain the interest of the instructors in the project. By choosing their own projects students will have more ownership of the project which we hope will translate into higher quality projects and prevent students becoming bored with them.

We will continue to include the social responsibility element to the course, partly through maintaining the project as an EWB type project. We believe asking the question “should we?” rather than just “can we?” is an important aspect to being an Engineer.

Having an introduction to working in teams is an important aspect of the course. In many other courses at UNB students have to work in teams, but before this course they had received no formal instruction on how to make teams work effectively. We hope this course will improve the ability of students to work in teams in later courses and so the teaching of teams on the course will continue to be improved over the coming years.

In Engineering, we are increasing the amount of design in many higher level courses and so the inclusion of instruction in the design process should help student performance in those courses. We will continue therefore emphasizing the design element of the course.

Our two wannabe actors are still waiting for their big break, and so they plan to continue their skits in future years. Wanting to avoid being typecast so early in their “acting” careers, they are moving into producing skits based upon individual lectures. We look forward to their production of a skit based upon the use of the semicolon!

9. References

- [1] Allison, C, A. Campbell, J. Diamond and G. Morris. Presentation to ENGG1013, UNB, December 2005.
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