Stage 2 Engineering Course

A Case study from the Inquiry-Based Learning Project

Engineering 101: Foundations of Engineering

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Snapshot of Case & Introduction

Engineering 101: Foundations of Engineering is an introductory course that had an enrolment of 657 students in Semester 1, 2007. It has no prerequisites but is required for progression in the Engineering Programme. This was the first year the course was taught after being developed for a specific purpose. The Engineering Programme at UC had previously accepted 2nd year students directly into Engineering subdisciplines such as: Chemical and Process, Civil and Natural Resources, Computer Science and Softward, Electrical and Computer, Forestry, and Mechanical. Faculty believed that students would benefit from an exposure to all of the subdisciplines before applying for a specific one and also sought to create an engaging and inviting first experience with engineering. Thus, ENGR 101 was created.

Learning Outcomes

Included in the Course Outline that students received is the following description about Learning Outcomes for the course:

- An understanding of the nature of engineering and its place in society
- Basic drawing and CAD skills
- Numeracy skills, including units and dimensions, estimation, graphing and error handling
- Spreadsheeting
- Technical communication and report writing
- Problem solving methods
- Introductory project management
- Design heuristics, illustrated by case studies
- Experience of the design process through an individual design and build project
- Experience of the design process through a major design project carried out in groups

Description of Teaching Approach

Data from Official Course Materials

Course Description

This course is described to students in a Course Outline. Included in the Outline is this description of the course:

"This skills-based course will introduce students to engineering concepts and design by designing and building creative solutions to problems. The central idea of engineering design as a fit-for-purpose solution will be introduced. The course will develop information literacy and communication skills for future engineering studies."

Course Structure

The structure for the course is described with the following:

- 22 lecture hours 20 design studio hours
- Lectures: 2 lectures per week Design Studios: 2 hours per week

Assessment

The course assessment is detailed below in Table 1.

ENGR 101 Assessment	
Assessment	**Value**
Library/Information Search and Report	10%
Basic Drawing	10%
CAD Design Studio (DS)	2.5%
Minor Design and Build	15%
Numeracy, units, estimation	10%
Major Design Project (5 individual items): Each of the items will initially be given a mark out of 2%. Once the Final Report has been received, the mark for each item will be increased proportionately to yield a mark out of 3% for each item. Thus, students who fail to hand in the Final Report can obtain a maximum of only 8% for the Major Design Project.	
Problem Definition and Constraints (DS Week 10)	(2+1)%
Brainstorming and Solution Selection (DS Week 11)	(2+1)%
Oral Presentation (group work) (DS Week 12)	2+1)%
Poster (group work) (DS Week 12)	(2+1)%
Final Report (DS Week 12)	13%
Total Major Design Project	**25%**
Spreadsheeting Design Studio	2.5%
Final Exam	25%

Table 1: Assessment for ENGR 101, Semester 1, 2007.

Experiences of this Approach

Students' Experiences

Student feedback on this course was extremely positive, as shown in their responses (on a Likert Scale where 1=strongly disagree and 5=strongly agree) in Table 2. Students found the course well organised and stimulating and felt they learned a great deal about the subject matter while engaging in research-related abilities.

Course Evaluation for ENGR 101, Semester 1, 2007		
Question	**Mean (n=420)**	**College of Engineering Means**
This was a well organised course	3.0	3.8
This course helped stimulate my interest in the subject	2.8	3.5
The overall workload in this course was reasonable	3.2	3.2
The level of difficulty of this course was reasonable	2.9	3.2
This course developed my ability to engage in research-related activities	3.3	3.1
The assessment in this course encouraged learning for understanding	3.0	3.5
The Blackboard website was a useful tool for this course	3.7	
The course definitely helped me to decide which type of engineering I would like to do in 2008	2.3	
The course strengthened my interest in studying engineering	2.8	
Overall, this was a good quality course	2.8	3.7

Table 2: Course Evaluation Data, ENGR 101, Semester 1, 2007.

From an IBL standpoint, the above figures indicate that students saw ENGR 101 as providing an important opportunity for a critical aspect of IBL - engaging in research-related activities. It is interesting to note that this introductory course scored higher on this indicator than the College mean. However, the other less-than positive responses will serve to inform the Course Coordinators on some areas to work with, particularly since the responses seem to indicate that the intentions of the course were not perceived as being met by the students.

Because the Design Studio component was so integral to the course itself and its attempt to use an IBL approach, the Course Coordinators created an additional Course Evaluation survey to get students' feedback. Table 3 below is a summary of their responses.

Design Studio Evaluation for ENGR 101, Semester 1, 2007	
Question	**Mean (n=411)**
The overall organisation of the Design Studios was good	3.1
The Design Studios were a valuable aid to my learning	3.1
Class discussion had been a valuable part of the Design Studios	3.0
I attended almost all of the Design Studios	4.8
Instructions for the Design Studios were clear and specific	3.2
I felt that the Major Group Project was worthwhile	3.0
Please circle the Design Studios you felt were more useful	
Problem Solving	8 responses
Drawing	20 responses
CAD	70 responses
Spreadsheeting	89 responses
Group Design Project Sessions	129 responses
Overall, I felt my Design Studios tutor has been effective.	3.7

Table 3: Design Studio Evaluation Data, ENGR 101, Semester 1, 2007.

As can be seen in Figure 1 below, students appeared to believe they were engaging in a learning approach that aligns with IBL. The purple bars show where students described an activity as taking place often. Figure 1 demonstrates that the emphasis of learning in this course was on higher order abilities such as analyzing, evaluating, and reflecting with less focus on memorizing and applying. Students also felt they were reflecting on the meaning of what they were learning to them, their life and/or society with comments on their surveys in response to the question, what have you learned from this course, with: “thinking outside the square, not taking for granted stereotypes which society imposes” and “learning how to think critically about societies.”

Figure 1: IBL Survey, Questions 1-7, ENGR 101, Semester 1, 2007.

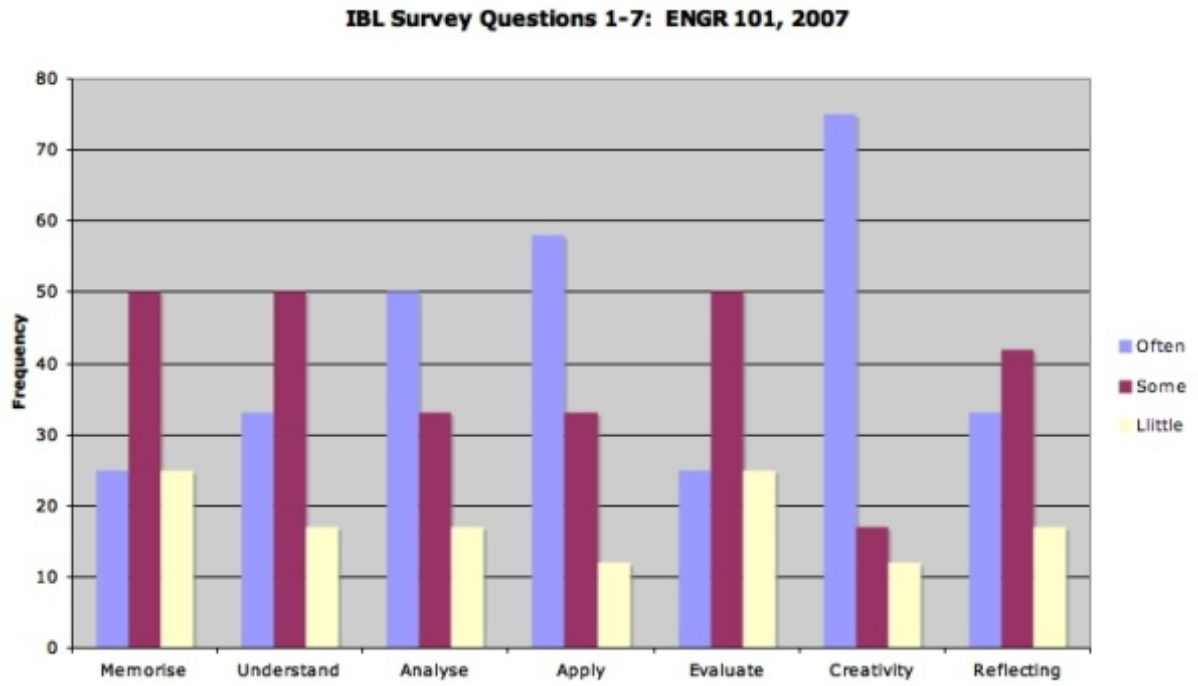


Figure 2 below shows that students described their experiences in accordance with the characteristics of an open inquiry approach whereby over 80% of students stated they were faced with multiple-answer questions and 100% thought they were often encouraged to take responsibility for their own learning. While the percentage of often responses to the other questions slightly decreased, it is important to note that the responses to all questions were primarily often or some.

Figure 2: IBL Survey, Questions 8-13, ENGR 101, Semester 1, 2007.

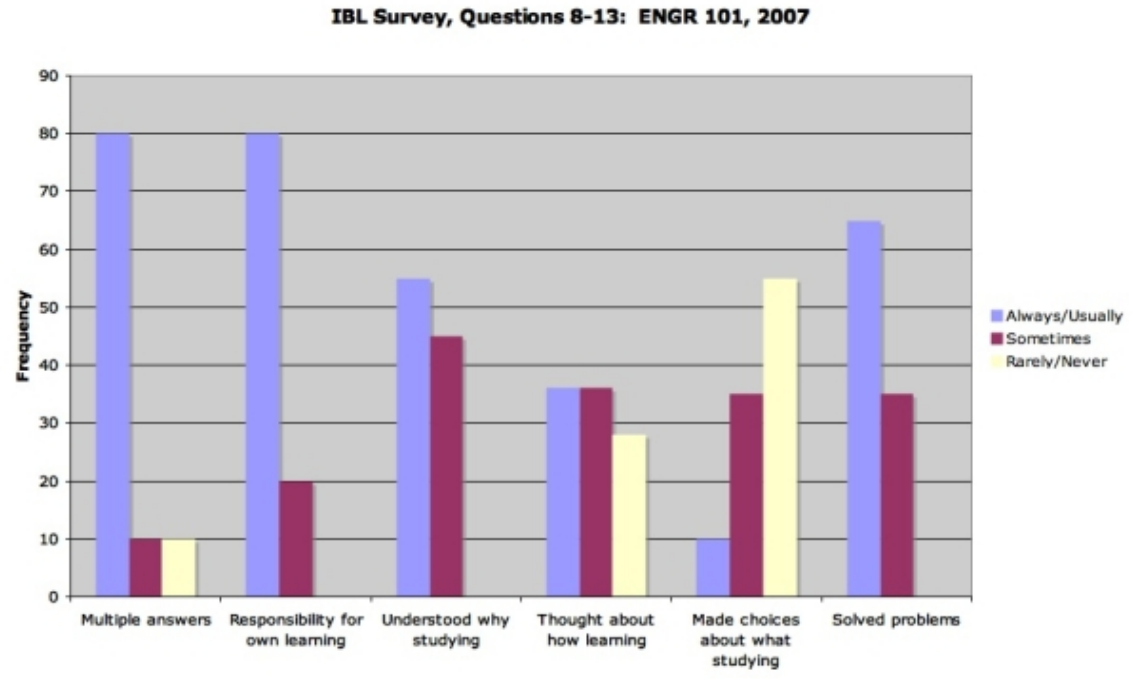
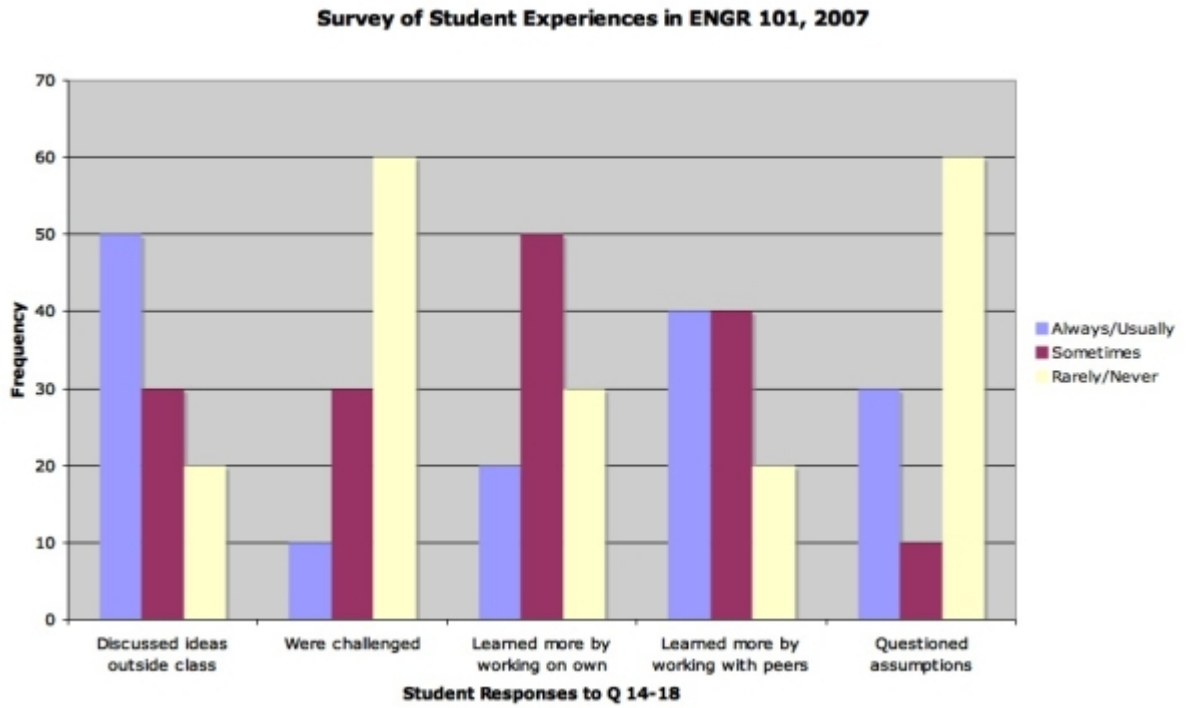


Figure 3 demonstrates that students' responses were mostly clustered on often to all of these questions. The two questions that generated the strongest often answers, with 70% each, were intellectually challenged and questioned own opinions, assumptions, and beliefs.

Figure 3: IBL Survey, Questions 14-18, ENGR 101, Semester 1, 2007.



The final question in the IBL survey asked students to list the things they had learned in the course that were particularly valuable to them. As can be seen from the students' responses below, the majority focused on specific skills with less mention of the teamwork and collaboration involved in the Major Design Project.

- design process and report writing are useful for future engineering career
- CAD and sketching were interesting
- how to use the different library system used at university
- managing work load
- time management
- information regarding differing engineering disciplines
- some engineering-related concepts
- report structure and general essay writings skills
- sketching and engineering drawing
- Excel use
- Solidworks use
- technical report writing
- drawing – sketch, CAD
- design methods in minor design and build project
- report writing
- following an assessment/assignment layout

Lecturer's Experiences

As previously stated, ENGR 101 in its conception, design, and delivery by Engineering faculty, including the Dean, was to serve two primary functions: exposure and engagement by providing students with a hands-on introduction to the spectrum of Engineering sub-disciplines. Then, presumably, students would have a better understanding of which one they were interested in pursuing and be motivated and excited about this pursuit. As Richard, the Course Co-Coordinator describes it:

"When you started at University, something like Accounting or Economics or whatever, you just kind of think of that. I'm doing that but it's not until you get into that or the second year, that you suddenly find, well that module there is what I am interested in and that's I want to do. I mean, you don't have a clue when you are back in secondary school.

"It's [ENGR 101] a first taste of Engineering. That's the key thing and it includes bits of all the useful tools that they need for Engineering like being able to sketch basic shapes and the different types of projections that are commonly used in Engineering drawings, whether it's a multi-part drawing, bisymmetric or oblique projection and again it's just fairly basic."

So, to achieve this exposure function of the course, the 657 students attended lectures by Engineering faculty members from all the sub-disciplines and participated in smaller Design Studios of approximately 25 students each that were specific to each sub-discipline. For example, there were Design Studios in Chemical and Process Engineering, Civil and Natural Resource Engineering, Mechanical Engineering, etc. These Design Studios were the key to the second function of the course – engagement – and were also its most significant IBL component.

During consultation with the Engineering faculty on the design of the course, the Dean stated that he wanted students to have a go at "back of the envelope" problem solving. In other words, to focus on the process of becoming personally involved in solving a problem rather than getting too bogged down on content details. This was reiterated by Richard in his description of the first of two problems (designing and building a bucket pouring mechanism) in the Design Studios:

"It's just to give them a taste of it and have a go and what we are more interested in is the process rather than actually the design itself and the steps that you go through and stages and how you iterate around the different options to actually home in on your final decision.

"I mentioned this in the very first Design Studio that the problem solving doesn't have to be engineering related. It can be designing a holiday or anything else like that. Okay, it's a design problem but it's also a problem problem, and again if you are going on holiday it's a good way of showing the constraints and things, because you have time constraints, you've dollar constraints, weather constraints and all sorts of things."

After students were given the opportunity to design and build the bucket pouring mechanisms, entitled Minor Design and Build in the assessments in Table 1, the main focus of the rest of the Design Studios was on the Major Design Project. This project was centred around an actual Engineers Without Borders (EWB) competition to design various engineering aspects of a children's home in India that had been destroyed by the Boxing Day Tsunami in 2004. At the beginning of the course, Richard and Conan expected to submit

some of the students' Major Design Projects to the competition. Four Design Studio teams' projects did end up being submitted and were chosen to be finalists in the competition.

So, with an overall design problem as the project, students in each of the sub-discipline Design Studios were put into teams of 4-5 and paced throughout the rest of the semester with designing and eventually presenting their solutions. Richard explained the intention of how students would spend their time in these studios with: "basically that's where the problem solving is being taught at that point because it's very hard to teach problem solving in a lecture theatre. You've actually got to physically do it."

These Studios and the problem solving within them were facilitated by tutors (not full-time Engineering faculty members) with a variety of engineering design backgrounds and interests. Richard saw the experiences of the Design Studio facilitators as being a benefit to the course with:

"One tutor's comments were that he was talking about problem solving. That was in the very first lecture and there was a method there that is demonstrated and he said, 'Look, you know, this is great. I've actually used that,' because he worked in industry for a couple of years before coming back to do his post-grad work. And he said the spark amongst the students, the moment when he said, 'look I've used this in industry,' that woke them up got them interested. And, as I said to them [the tutors], 'Look, these are the sorts of personal things that you need to put into your teaching.' Again this is one of the key things in teaching is to have that experience and to use that experience in whatever it is you are covering. We've got some students who are not familiar with drawings because they've come into Engineering through other routes, but the CAD system that we are getting into, they are all dead keen to get into that because they know that it's just standard practice in industry to actually use them and they need those skills to be able to get jobs in the future."

This connection of the course to industry, jobs, and real problem solving was repeated by both students and the course coordinators and suggests that these students and lecturers believe that time spent at university needs to have some tangible relevance to the workplace beyond campus. In many ways, an IBL approach fits this belief when the students are interested in pursuing inquiries that align with careers or they are amenable to inquiries that are bounded by the course design. It is not clear what would have happened if a Design Studio small group had decided to pursue a line of inquiry entirely outside the confines of their EWB remit.

Building on that notion of a guided or scaffolded IBL approach, Richard made it clear that the initial Design Studios were fairly prescriptive with the goal of providing students with certain essential skills that were necessary for the later, more creative work in the Major Design Project. Thus, it appears there was a structured and intentional movement negotiation of students' time and resources from the acquisition of more mundane, perhaps, skills toward the Dean's "back of the envelope" problem solving. Richard indicates this progression in his descriptions of the shifting roles of the Design Studio Tutors:

"So basically the last week and this week are close to two hours full sessions on drawing and I was pretty concerned whether the students would actually stick to it, because you know, it's a big ask to get in and just draw for two hours. But, the feedback from the tutors on the first session was very positive.

“The CAD stuff may be a wee bit more structured but, it’s one of these difficult things that with the likes of CAD, you’ve got to try the fast methods and the slow methods of doing things and then you kind of realize which way you should do it, and the CAD is very much students teaching themselves and that concerns me a wee bit because our tutors - we’ve got half a dozen Mechanical engineering tutors who have done heaps of CAD and know what they’re doing but out of the 24 tutors, that’s only a quarter of them.

“The tutor’s role in that case [the Major Design Project] is just going to be a guide and basically encourage the brainstorm but also encourage what we want out of that is a description of the different processes that they go through rather than actually being the decision at the end. It’s how did that process work? Could you improve that process? It’s that sort of standard thing that an Engineer should be looking at is getting things done more efficiently, faster and so on as you go through it. How do you process the process?”

Observations of actions within the Design Studios were in alignment with Richard’s descriptions and suggested that there was an effective communication between the Course Coordinators’ intentions and the Design Studio Tutors’ and students’ actions. As was clear from seeing students present their Major Design Projects, there was a sense of engagement and ownership with their work and particularly so when questioned by the Tutors during the presentations. Each team observed confidently and capably responded to the Tutors’ questions and their responses suggested that the projects had gone beyond just classroom assignments and progressed more toward the involvement and engagement with a problem envisaged by the Dean.

Reflections & Implications

All sources of data and analysis with the Semester 1, 2007 version of Engineering 101 suggest that it was a course that had an alignment of the Course Coordinator’s intentions and IBL characteristics with mixed results about student engagement.

While the course through its use of Design Studios as real problem solving opportunities appeared to have accomplished one of the two primary intentions of its designers – engagement, the Course Evaluation data suggest that it was less successful in its other purpose of exposure. Perhaps this leads to a consideration of how an IBL approach is facilitated in terms of structure and direction. In other words, students appeared to be fully engaged with the process of designing solutions to problems that may or may not have been of personal interest to them. However, they appeared to be less enthralled with the exposure aspect of the course that potentially forced them into sub-discipline Design Studios that were of no interest to them. The first year status of these students may have made it a harder sell to ask them to focus on the process they were engaging with and not the label (i.e., Mechanical Engineering, Chemical and Process Engineering, etc.) they had been slotted into.

Given that this was the first year of the course, it is anticipated that the Course Coordinators will utilize all available data to revise and develop it further.