# THE ROLE OF EXPERIENTIAL LEARNING IN DEVELOPING STUDENTS' GROUP-WORK AND PROBLEM-SOLVING SKILLS IN DESIGN ENGINEERING

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## What's in this case study for you?

This case study investigates the role of an impromptu design task in the development of group-work and problem-solving skills in design for a large class of first-year Mechanical Engineering students. The task required the students to work within a newly formed group to design, build, and test a design concept from a simple written specification and an assortment of construction materials.

*"I think it was good because everyone just got thrown in and you had such a short time to do it, and you had to really try and coordinate everything to get it completed in time. I think it prepared us for the later stages of the course – seeing what each group member was capable of, how they work together as a group".*

## Issues in student learning

- Students need support in forming relationships with other students from their chosen discipline.
- Students need to understand the relevance of gaining analytical skills in preparation for subsequent years.
- Students need to understand why group-work skills are relevant to the discipline.
- Students are often unaware of problem-solving as a process/method.
- Students need to be aware of the importance of time management.
- Students are not always sure of how and when to ask questions.

## Strategy

### Background

The development of this case study occurred within the framework of the first-year engineering course MECH1120: Design and the Engineering Profession. Over 250 first-year engineering students undertook the course and, of these, 25 per cent were from non-English speaking backgrounds.

*"It really impacted our understanding of properly defining our problem".*

The curriculum is structured around several fundamental learning objectives. These include:

- to introduce students to the engineering profession
- to instil an appreciation of the importance of communication in engineering life

- to introduce students to engineering hardware and components
- to introduce students to a methodology for design problem-solving and decision-making within groups.

The impromptu design activity described in this case study focused on the second and fourth items in particular.

## How was the course redesigned to address issues in student learning?

**(a) What specific attributes were developed and assessed?**

*IEAust and UNSW Graduate Attributes*

There is an increasing awareness of the importance of developing and assessing students' problem-solving skills throughout their degree, including both the creative and rational aspects of these skills. Several reports have suggested that employers perceive engineering graduates to have insufficient problem-solving, creative-thinking and communication skills (DETYA 1999; Selinger 2003). New competitive strategies for industry such as Concurrent Engineering, which place critical importance on collaboration between participants from many disparate areas of expertise, lend support to this perception (Prasad 1996).

*"…specific constraints made the project very, very hard. But looking at it in hindsight I'm glad that it was a difficult project to solve…problem-solving as a practical thing I found really good".*

The desired learning outcomes for MECH1120: Design and the Engineering Profession, the first-year course described in this paper, were developed in accordance with the attributes outlined by the professional engineering body Engineering Australia (formerly IEAust).

*"We really weren't sure how to start – everyone was making suggestions… I suppose there was a lot of creativity, like we were just trying several things…".*

The outcomes relevant to this course are that, upon entering the workforce as professional engineers, students should have the ability to:

- communicate effectively
- undertake problem identification, formulation, and solution
- utilise a systems approach to design
- function effectively as an individual and in teams.

These skills are also strongly reflected in the recently introduced graduate attributes policy at UNSW, which states that students should develop the capacity for analytical and critical thinking and for creative problem-solving, the skills required for collaborative and multidisciplinary work, and the skills of effective communication (UNSW 2003). The following statement from Brendan Parker, Dean of Engineering at UNSW, also suggests the need to focus on the role of creativity in problem-solving early in the education of engineering students:

> To produce well-rounded graduates capable of taking on the diversity of careers that engineering offers, we need more emphasis on the creative side of engineering, with a broad approach to design beginning early in the programs.

In addition to introducing students to problem-solving, group-work, and communication skills in design Engineering, the impromptu design task described in this paper was developed to encourage students to enjoy the intellectual excitement and challenge of studying in their field and to support students in developing a sense of belonging to their discipline community.

First year presents an opportunity to positively influence the direction and attitudes that students adopt in their university and subsequent professional careers. In addition to achieving the above learning outcomes, the course was designed to enhance the learning experience in ways that the students perceived as exciting, challenging, interesting, fun, and relevant.

*"It definitely did help me make some of that mental shift… shift towards more of an Engineering mentality".*

**(b) How were the attributes developed and assessed?**

*The impromptu design task*

In the first week of session 1, 2003, over 250 first-year engineering students assembled in the Keith Burrows Theatre for their very first engineering lecture in the MECH1120 course. The group of students who undertook the course were first-year, first-session mechanical, manufacturing, aerospace, mechatronics engineering students. Of these, 25 per cent were from non-English speaking backgrounds.

Within two weeks, students participated in a learning activity referred to as "impromptu design". Impromptu design competitions are a well known and very effective experiential method of engaging students in problem identification, formulation and solution and also in group work. They also provide an opportunity for students to develop a sense of identity with the discipline and meet other students in the course. Quite often, they are used as "ice-breakers" for breaking down barriers to effective management; they also highlight the importance of teamwork within industry.

*"I think it was good that we got to see it work instantly… not something that's going to happen a few months down the track. You know, we design it, we test it, see if it works…".*

Prior to the activity, students were randomly divided into groups of eight. This meant that each student had the opportunity to meet at least seven students in the course. Each group was given a bag of materials, some tools, an egg, and a sheet containing the problem description including all the rules and constraints that limited the solution space. The sheet also made some suggestions related to group processes – for example, it was suggested that students begin by allocating roles and responsibilities to the members of their group. The materials that each group received included cardboard, paper, pasta, super glue, twine, pegs, scissors, Exacto knives, a sponge, sticky tape, an egg carton holder, blu-tac, cotton balls, cigarette filters, and rubber bands.

*"I feel that in terms of design we really learnt a lot just from our own experimentation".*

The task simulated the designing, building, and testing of a bus shelter to protect the life of an occupant (the egg). The shelter needed to withstand the impact of a model truck along a ramp (2m long at an angle of 45 degrees with a hard stop at the end). A diagram of the testing ramp was provided, and students had access to the model truck that was used in the testing phase.

Students were given one hour to design, build, and test their solution. Tutors were provided for students during the session to answer questions, simulating the process of interaction with a client in industry.

A week after the task, students were asked to submit a 500-word report on the impromptu design activity (the assessable component of the task), which required them to reflect on their task

performance, including both their experience of the design process and their performance as a team.

*Relationship between the impromptu design task and other components of the course*

Although the impromptu design task provided students with hands-on (concrete) experience and introduced them to group work and problem-solving processes in design, other key elements in the course gave students an opportunity to reflect and build on this experience.

Drawing on theories of experiential learning (Kolb 1984) and research into the development of students' transferable skills (Gibbs et al. 1995), the course also included online discussions and a written report (observation and reflection), a series of lectures (the formation of abstract concepts), and a second, larger design task that enabled students to practice their skills based on what they had learned (testing in new situations).

# Discussion

## Benefits

The impromptu design had several advantages in terms of student learning:

- The task alerted students to the importance of asking questions – "a fundamental cognitive mechanism in design thinking" (Eris 2003).
- The task provided a basis from which the lecturer could emphasise key ideas and concepts in subsequent lectures.
- Students were fully engaged with the activities because of their exciting, fun, and competitive nature.
- The activities exemplified realistic collaborative design problems.
- The task allowed students to base their development of new concepts on real, emotionally charged activities through supported reflection.
- Students were required to interact with others in their course and begin establishing academic support networks.
- Final-year and postgraduate students provided an immediate point of relevance to the first-year students through their involvement with the project.
- The students gained valuable experience in collaborative writing, conducting meetings, planning and implementation of projects, and group skills.
- The project provided opportunities for further research into how students learn the design process.

> *"I thought that the biggest component of the entire MECH1120 was group work. I think there are some things that lecturers cannot teach that you have to sort of be in the position and experience and see it for yourself and then judge and act accordingly…".*

### Problems encountered

Most of the problems encountered throughout this project resulted from inadequate time available for planning. This lack of time resulted in some difficulty in building the test rig.

Similarly, this lack of time resulted in a weakness in the structuring of lecture material to support reflection and concept development. It was felt that, by getting the project underway, opportunities for improvement for subsequent years would present themselves.

## Student feedback, evaluation and improvements

To evaluate the role and effectiveness of the impromptu design task and other elements of the course, two student focus groups were conducted in the middle of session 2, 2003. Students were asked to describe their experience of the impromptu design task. These focus groups provided information about how students approached the problem, the most difficult and interesting aspects of the task, and the students' experience of working in groups to achieve the objectives. Further questions were designed to collect information about whether students were able to make connections between various aspects of the course and to identify the particular skills students felt they developed.

Feedback from the focus groups suggested that the impromptu design task was an effective way to introduce students to the process of problem-solving and group work in design. In particular, students learned about the importance of planning and the role of asking questions in order to define a problem space. Their comments suggested that they viewed problem-solving as both a structured and creative process.

Feedback also suggested that additional opportunities for structured reflection would be useful to further consolidate students' learning. Overall, this study suggests that working in teams and the problem-solving technique for design is an ongoing learning task that requires continuing support and reinforcement at subsequent stages in students' degree program.

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## Acknowledgements

I would like to sincerely thank Adrian Lee and Michele Scoufis for their enthusiastic support for this project. I would also like to thank Stephanie Wilson for her efforts in making this project sustainable.

## More information

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