

Assessment of Hands-on Activities to Enhance Students' Learning in the First Year Engineering Skills Course

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***Abstract:** The engineering skills course at the CQUniversity has very comprehensive curriculum for the first year undergraduate engineering program to meet the pedagogical needs in accordance with both university's and Engineers Australia's objectives. The problem-based educational approach taken has recently incorporated a set of hands-on learning activities to help achieve students' learning goals. An anonymous survey was conducted after the first term in order to evaluate the effectiveness of these hands-on activities and to obtain students' feedback. This paper presents the findings and both quantitative as well as qualitative analysis of these results. The findings of the survey are very encouraging, and provide evidence of effectiveness of these hands-on activities on students' learning. Furthermore, the suggestions received through quantitative and qualitative feedback of this survey will be used for the course improvement in the future.*

Rationale

Engineering is based upon a variety of rules, theorems, and devices that must be understood by students and which involve primarily knowledge-based learning; but students must also learn to apply that knowledge practically through problem solving and design exercises (Chu & Leung, 2001; Ericksen & Kim, 1998). The traditional classroom teaching mode only gives student concepts of rules, theorems, and devices. Many employers are finding that graduates are too narrowly based and in practice need to accept wider training (Harris & Bramhall, 1999). In order to make engineering learning more interactive and effective, it is essential to change the way of traditional classroom teaching and need to incorporate various learning components in the curricula. These components can be real life design and build projects, industry engagement projects, modelling, hands-on activities, simulations, and so on. This approach of learning/teaching helps facilitating students to foresee and react effectively to the uncertainties of changing technological, social, political and economic world (Reed and Poppel, 2003). Anecdotal evidence and experimental studies strongly suggest that students enjoy hands-on activities and implicit and tacit knowledge acquired through hands-on activities in laboratory classes is valuable in engineering practice (Razali and Trevelyan, 2008; Sobek and Freeman, 2006).

Engineering skills at CQUniversity

The engineering skills courses in the first year undergraduate program provides maximum learning opportunities for students and enhances the pedagogical needs of students in order to obtain the desired learning outcomes at the introductory stage of their program. The courses are project based learning courses and offered in both terms (Engineering Skills 1 in term 1 and Engineering Skills 2 in term 2) and make up half the student's load each term. The course is offered internally (face-to-face) as well as in a flexible learning mode (distance education), with 32% of students learning in external mode in 2009. The course is available using a variety of learning approaches, including print-based, CD and video courseware, multimedia streaming technology, videoconferencing, teletutorials, residential schools and internet tuition through e-learning courses online (CQUniversity, 2009).

The engineering skills courses have been structured around Kolb's learning cycle with multiple learning activities and reflections such as reflective journals, individual activities, case studies, laboratory experiments, testing, and hands-on activities.

Kolb's theory of experiential learning has several important features incorporated within the learning style, such as:

- A self-directed approach;
- A reflective nature;
- The provision of feedback;
- The provision of learning with prior experience (Kolb, 1984; Jensen, Wood & Wood, 2004).

The engineering skills course introduces students to professional knowledge, skills and attitudes required for team work, self and team management. The course introduces students to modelling/simulation tools, common engineering materials, manufacturing processes, principles of workplace health and safety, and project risk assessment. The course does this through a series of projects. Four of these projects are known as the hands-on activities. There are two hands on activities per term. As part of the PBL program all the projects are conducted in teams. An evaluation of the hands on activities was conducted at the end of the first term.

Hands-on activities

The hands-on activities in the first term were from electrical and civil disciplines, and were designed to help students achieve the following learning outcomes:

- Demonstrate development of a professional attitude, problem solving skills, relevant technical knowledge and productive work practices using opportunities provided in assigned projects;
- Communicate, work and learn, individually and in peer learning teams in a professional manner;
- Perform research and communication tasks using information and communication technologies and use basic features of modeling/simulation tools;
- Use fundamental 'engineering language' in context;
- Discuss the socio-technical role of the professional engineer;
- Articulate an appreciation of the uncertain nature of engineering design;
- Describe and apply the basic principles of workplace health and safety, and project risk assessment
- Describe the uses (or applications) of a range of common engineering materials and manufacturing processes (CQUniversity, 2009)

Hands-on Electrical

Students were asked to develop a business plan for a prototype of a new market product – an audio amplifier for a personal music device (iPods etc). Students were provided a scenario in which they had to approach a venture capitalist for money to develop this prototype and grow their business. In order to do so, students created a business plan and a marketing plan detailing the business case for the new product, as well as a working prototype of the device. This working prototype involved the students soldering together an electrical circuit with custom made printed circuit boards (PCB's). In order to

promote their business (of audio amplifiers) students were also required to brand their company in a way designed to attract funding and promote the unique characteristics of their team. The whole exercise was designed to encourage students to learn and explore business aspects of engineering.

Hands-on Civil

Students were assigned the task of recommending concrete mixes for use in building houses in Haiti in the Caribbean. One of the essential parts of being an engineer is being able to respond to challenging new situations with innovative solutions. This is particularly the case in a global context where solutions appropriate to one country are not necessarily suited to another. In many parts of the world, the shortage of permanent housing is a major problem. In countries such as Haiti, the challenge is building houses as safe and as cheap as possible. Currently concrete bricks from which the houses are made are often produced in situ. The most expensive part of these bricks and therefore the houses is the cement; everything else is in plentiful supply.

Additionally the project scope challenged the students to learn technical information relating to the concepts of:

1. Moulds Compression
2. Bending

For the project scenario, students were given access to ‘an old testing rig made by the last group of engineers that came through, though no one can remember how they used it’. The students were asked to determine the experimental procedure for each challenge, the materials they would need and the data they would collect as well as determine how they would analyse the data and their criteria. The students then made the concrete samples, allowed them to cure then tested them in the testing rig according to their plan.

For all hands-on projects in the course, it is essential that students do a risk assessment before actually starting the project or hands-on activities. The format (template) of the risk assessment has been provided to them in the beginning of the academic year.

Students’ experience: learning journey

It was observed throughout the term that students enjoyed engaging in the hands-on activities as they promoted active learning, effective participation, team interactions and also developed problem-solving skills. In general students were enthusiastic participants in the hands-on activities and performed the learning tasks to a very high standard.

Students’ feedback

An anonymous online survey was conducted after students obtained their grades for the first term. A questionnaire using 13 questions or items, as listed in Table 1, was designed for this survey. Students were requested to respond to each item in the questionnaire using a five point scale; strongly agree, agree, neutral, disagree and strongly disagree. An opportunity was also provided for students to comment on their experience at the end of the questionnaire in order to collect qualitative feedback on hands-on activities.

Findings and Discussion

Generally student feedback surveys, whether paper or online, have very low response rates (Ogier, 2008; Gamliel and Davidovitz, 2005, Nulty, 2008). Nulty (2008), in a summary of eight examples, outlines a much lower response rate for the online surveys than the paper-based ones (on average, 33% compared with 56% = 23% lower). However, the response rate for this survey was very high (53.55%; N=51). Overall results obtained from the survey were very positive as discussed in the following sections.

Figure 1 gives a graphical presentation of the survey results on the effectiveness of hands-on activities.

Table 1: A list of questions/items used in the survey for students' feedback.

No	Question/Item
1	The Hands-on activities were effective in helping my learning in engineering skills.
2	The Hands-on activities helped my understanding of basic and advance concepts in this course.
3	I think the use of Hands-on activities in this course helped to improve my grade for this course.
4	I enjoyed learning while doing Hands-on activities during the term.
5	The Hands-on activities incorporated in this course were easy to do.
6	The Hands-on activities were well designed.
7	The Hands-on activities were too open ended.
8	The Hands-on activities helped me understand more about different engineering disciplines.
9	The Hands-on activities helped me to improve my team skills.
10	Hands-on activities helped me to improve my communication skills.
11	I think Hands-on activities should remain part of this course in future.
12	I think my other courses should include Hands-on activities to facilitate my learning.
13	Overall, Hands-on activities helped me develop as a professional engineer.

The survey results suggest that students studying the engineering skills course are extremely happy with the hands-on activities. Furthermore, results showed direct evidence of the hands-on activities on students learning and academic achievements. Moreover, most of the responses are extremely positive and in the range of 'strongly agree' and 'agree'. The following sections briefly describe key findings of the survey results.

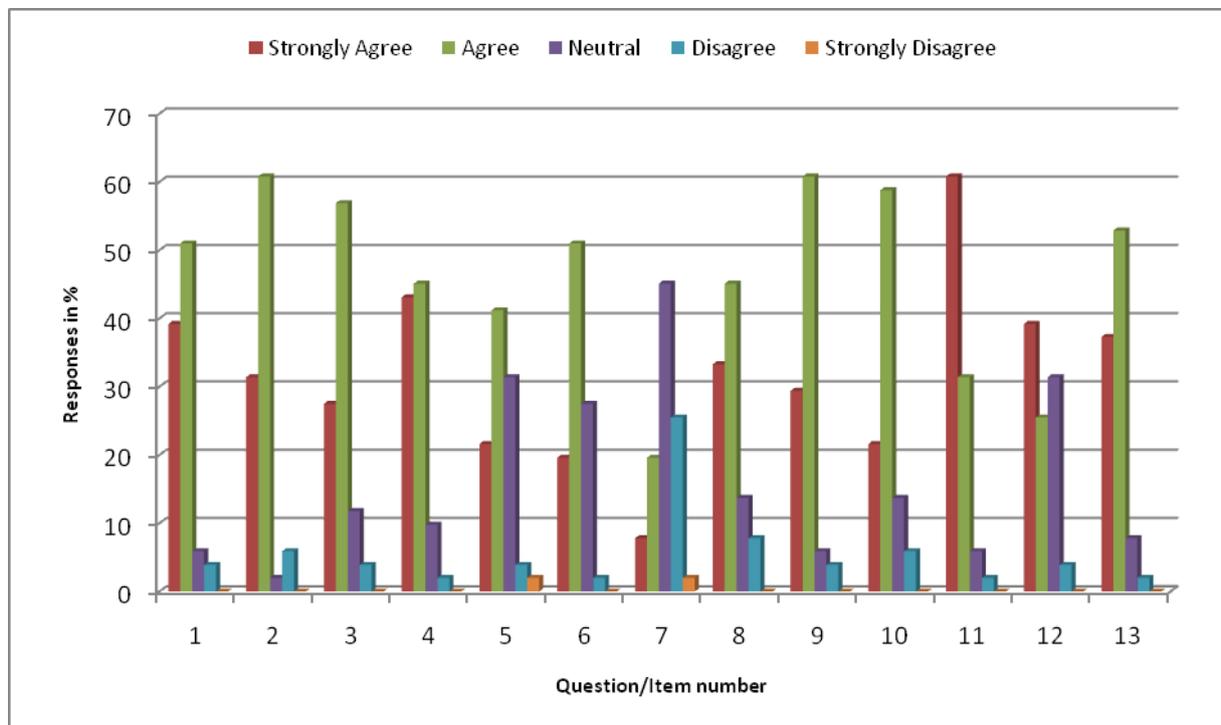


Figure 1: Chart showing survey results on the effectiveness of hands-on activities in the course. (N=51)

Academic improvement

Most of the respondents agreed that the hands-on activities were effective in helping their learning of engineering skills (Strongly Agree 39.2%, Agree 51%). Students have further agreed that the hands-on activities helped their understanding of engineering concepts (Strongly Agree 31.4%, Agree 60.8%).

When asked about the impact of hands-on activities on student grades, students believe the use of hands-on activities in engineering skills course helped to improve their grades (Strongly Agree 27.5%, Agree 56.9%).

Learning was enjoyable

Most of the students enjoyed learning while doing hands-on activities (Strongly Agree 43.1%, Agree 45.1%) and they thought that the hands-on activities were well designed (Strongly Agree 19.6%, Agree 51.0%).

When asked about if the hands-on activities were too open-ended, most of the respondents were neutral (Strongly Agree 7.8%, Agree 19.6%, Neutral 45.1%).

Interpersonal and professional skills development

The survey results further reported that hands on activities helped improve team skills (Strongly Agree 29.4%, Agree 60.8%) and communication skills (Strongly Agree 21.6%, Agree 58.8%) of students. Overall, students accepted that hands-on activities facilitated their development as a professional engineer (Strongly Agree 37.3%, Agree 52.9%, Neutral 7.8%).

Future engagement and expansion

Most students were of the opinion that hands-on activities should remain part of this course in future (Strongly Agree 60.8%, Agree 31.4%). Interestingly, students also felt that their other courses should include hands-on activities to facilitate their learning (Strongly Agree 39.2%, Agree 25.5%, Neutral 31.4%).

Qualitative Feedback

The feedback questionnaire also provided students with an opportunity to comment. This has helped in collecting useful qualitative feedback from the students on the effectiveness of hands-on activities. This section describes qualitative feedback of the survey with key examples of student feedback on hands-on activities. Overall the qualitative data collected during the survey is very positive. For example:

The hands-on activities were very interesting and fun, they helped the group come together and we got to know and trust each other.

Another comment was:

The Hands-on Projects allowed for the uncertain nature of engineering design to be shown in a way that is hard to appreciate until it happens to a design of your own. Great Work

One student respondent raised concerns about the overlapping with other projects. As commented by the student:

Hands-on activities were great, they just became very stressful when they overlapped other projects.

Concluding remarks

This paper has presented the survey results on the evaluation of hands-on activities incorporated in the engineering skills course in the first term of the undergraduate engineering program at CQUniversity. The survey results and findings provide valuable insight on students' views on the hands-on activities. Feedback revealed that students enjoyed the hands-on activities in the engineering skills course. Most importantly hands-on learning activities helped students to achieve the desired educational objectives of the engineering skills course and helped them in their understanding of engineering as a profession.

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