

Developing professional skills: you can't leave it all to final year!

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Structured Abstract

BACKGROUND

Reviews of Engineering Education have highlighted the importance of developing the professional skills required by practicing engineers, such as communication, teamwork, report writing and so on. The majority of engineering programs in Australia have at least one or two first year courses that initiate the development of these skills. However, not all of these introductory engineering practice courses explicitly teach students how to work in teams. After first year, the development of professional practice skills may be left to one or maybe two management type subjects. This paper examines an alternative model that uses a combination of practice courses and mainstream technical courses in a Civil Engineering bachelor degree program to provide explicit teaching and learning development of professional skills. It focuses particularly on the challenges of developing teamwork skills in the context of a highly culturally and linguistically diverse student body.

PURPOSE

Over the last 15+ years we have adopted a continuous review and improvement approach to curriculum development and built a project-based program that is highly regarded. However, the program team felt that there was room for improvement and this provided the motivation for the change in practice described in this paper. Our goal is to ensure that all of our students, regardless of their cultural, language and educational background can demonstrate that they have achieved the Engineers Australia Stage 1 competencies relevant to professional skills development, in addition of course to the necessary technical skill development.

DESIGN/METHOD

There were two main strategies used to strengthen professional skill development. The first was to embed skills development in at least one and preferably two mainstream courses in every year of the four year program. The second was to engage with experts from the non-engineering space (eg. student counsellor and curriculum designer) to work with the engineering academics, develop and co-teach specific components or projects within each course that explicitly included teaching and learning activities around professional skills. All of the changes and innovations made in these courses have been evaluated in detail using a range of methods including course experience surveys, one-minute evaluations and analysis of learning journals.

RESULTS

Formal and informal evaluations, in the courses where this approach has been applied, show that this has provided an effective and deep learning experience for students with increased teamwork competence and confidence in working inclusively. This initiative has been extended into later years of the Civil Engineering program and evaluation of its impact is being undertaken.

CONCLUSIONS

This approach will be further developed and applied across the program. It will be evaluated and continuously improved as we have students who have experienced it throughout their degree.

KEYWORDS

Professional skills, teamwork, diversity.

Introduction

Reviews of Engineering Education over the last 20+ years have constantly highlighted the importance of the development of the professional skills required by practicing engineers, (King, 2008; Markes, 2006; National Academy of Engineering, 2004, The Royal Academy of Engineering, 2007). Just as frequently, industry reports have lamented the lack of these professional skills in new graduates (Male, Bush & Chapman, 2010; Spinks, Silburn, & Birchall, 2006).

Professional skills, as opposed to technical skills, include communication (oral and written), teamwork, life-long learning, time management, ethics, sustainability thinking, project management, and many more. The majority of engineering programs in Australia have at least one or two first year courses that initiate the development of these skills, many through the use of the Engineers Without Borders project as an organising platform (Jolly, Crosthwaite & Kavanagh, 2010). However, not all of these introductory engineering practice courses necessarily provide explicit teaching and learning activities that teach students how to work in teams, for example, but rather assume that students will develop these skills through practice and osmosis. After first year, the development of professional practice skills may be left to one or maybe two management type subjects, or in some cases not even that, although there are some notable exceptions to this pattern.

This paper examines an alternative model that uses a combination of practice courses and mainstream technical courses in a Civil Engineering bachelor degree program to provide explicit teaching and learning development of professional skills. It focuses particularly on the challenges and opportunities provided in the context of a highly culturally and linguistically diverse student body.

Context of the study

Over the last 15 years the Civil Engineering program at The University of South Australia (UniSA) has adopted a continuous review and improvement approach to curriculum development and built a project-based program that is highly regarded. This is demonstrated in the Graduate Course Experience Questionnaire (GCEQ) Australian rankings where it consistently performs strongly on overall satisfaction, good teaching and generic skills development (University of South Australia 2014). Although the development of professional skills had been a particular focus for some time in the first and final year of the program, the approach had not been systematic and not sufficiently evaluated for effectiveness. It was also felt that the challenge of embedding explicit professional skill development within what would be described as traditionally technical courses had not yet been met.

The Civil Engineering program

The development of professional skills in a culturally appropriate manner is explicitly incorporated into the program statement for all engineering degrees at UniSA as follows:

The Bachelor of Engineering (Honours) at the University of South Australia uses an industry focussed, project-based teaching and learning approach to develop professional engineers who are well prepared to work in diverse, interdisciplinary teams to solve complex problems in a socially and culturally appropriate manner.

The first year of the Civil Engineering program shares 7 of 8 courses with either Mechanical or Electrical Engineering, or both, the second year has two shared courses and the third year has one. There are a total of four courses in the program that have an explicit professional skill development focus, although within a technical framework. These are the two first year professional practice courses *Sustainable Engineering Practice* and *Engineering Design and Innovation*, which are both taught by the Civil Engineering group and taken by all engineering students; *Civil Engineering Practice* in second year which incorporates an introduction to

Structural Engineering and is being taught for the first time on campus in the second half of 2014; and *Professional Engineering Practice* in third year that is taken by all engineering students but taught by the Electrical Engineering group. Project-based learning is embedded throughout all years of the Civil Engineering program and culminates with two capstone projects taken in the final year by all students that equal half of their course load.

Student diversity

A particular motivation for the change in practice described in this paper was the nature of the student cohort at UniSA. Diversity and opportunity would be two key words that describe the cohort. UniSA had access to education for disadvantaged community members enshrined in its founding act in 1991 and maintains this in its current mission and values statements. This is strongly supported by staff and in practical terms means that there are multiple entry pathways to the civil engineering program and that it has a very diverse student body. Entry pathways include:

- School leavers via traditional ATAR scores (typical cut-off score in mid 70's and made up 42% of applicants in 2014)
- Non-school leavers via STAT test or evaluation of previous tertiary study
- International students entering at first year level
- Associate Degree entry via the ATN aptitude test – these students take additional maths, physics etc courses but also undertake 1.5 years of the Bachelor program courses. Many are part-time and mature age entrants.
- SAIBT (South Australian Institute of Business and Technology) entrants – these students complete the first year of the program at SAIBT along with additional maths and English courses as required.
- TAFE Diploma or Advanced Diploma graduates who receive some credit
- Transfer students from other institutions, generally into second or third year
- Transfer students from 2 + 2 program with Flinders University
- International students who transfer into the second or third years of the program with credit for completed study overseas.

These multiple entry points at various stages of the program create particular challenges when trying to scaffold the learning of professional skills across the four-year program, since approximately 25% of the final year cohort enter the UniSA degree program in second year or later.

Student diversity and educational opportunity is reflected in the fact that 50% of students enrolled in the Civil Engineering program in 2013 were defined as being in at least one equity group, and many are in more than one of these groups (defined as Non-English speaking background, Rural and Isolated, Disability, ATSI and Low Socio-economic status). Female students make up 11.8% of the program cohort. Fee paying international students from a wide range of countries, comprise 33% of students, with the largest single group being from China, which made up nearly half of this number. However, in total, 54% of all students were born overseas and only 51% of students reported English as the primary language spoken at home (University of South Australia, 2014).

Despite the challenges presented by this diverse student body, the ultimate goal is to ensure that all students, regardless of their cultural, language and educational background, and regardless of their entry point to the program at UniSA, can demonstrate on graduation that they have achieved the Engineers Australia Stage 1 competencies relevant to professional skills development, in addition of course to the necessary technical skill development.

Developing professional skills across the program

There were two main strategies used to redevelop the curriculum to strengthen professional skill development. The first was to ensure that this was embedded in at least one and

preferably two mainstream courses in every year of the four year program. The second was to engage with experts from the non-engineering space – in this particular case a student counsellor and curriculum designer. They work closely with the engineering academics in each of these courses, and the program team as a whole, to review curricula, develop and co-teach specific components or projects within each course that explicitly included teaching and learning activities around professional skills. These developments commenced in 2012 with the first year courses and by the end of 2014 all of the redeveloped courses will have been delivered at least once. Those students who were first exposed to these improvements will be in final year in 2015.

Professional skills that are incorporated within this strategy include oral presentations, written communication, reflective practice, inclusive communication, and teamwork. However, the remainder of this paper will focus specifically on the teamwork skills development activities across the program.

Early year professional practice courses

First Year – SEP & EDI

In 2008, two common first year engineering courses were introduced to develop professional skills and introduce students to design and the Engineering Profession. They include the first semester course *Sustainable Engineering Practice (SEP)* and second semester course *Engineering Design and Innovation (EDI)*. These courses require students to develop complex skills of a 21st century engineer including communication, cultural awareness, reflective practice and collaborative skills such as inclusive teamwork. However due to a lack of a clear pedagogical approach in their development, students struggled to thoughtfully, effectively and efficiently develop these skills. In 2011, a curriculum designer (Dr. Patricia Kelly) and student counsellor (Diana Collett) were invited to work with the course coordinator to develop a scaffolded approach that revised lecture and tutorial activities to underpin and support skills development and completion of assessment tasks. This approach is discussed in Kelly, Smith & Ford (2012) and included, teamwork foundation activities held in tutorials, completing a team agreement for each project, submitting formative and summative peer assessments and students reflecting on their development in a journal.

The teamwork foundations activities in SEP included; an icebreaker (eg. Speed meeting, People Bingo), negative brainstorming (Kelly, Smith & Ford 2012), introduction to Rank and Intercultural communication (Collett 2007) and importance of consensus decision making. The teamwork foundation activities in EDI built on these and included; an icebreaker, sharing and learning from past teamwork experiences, supportive & constructive communication strategies, team organisation and leadership styles. The teamwork foundation activities in these courses were only held in the first two tutorials, the remaining tutorials were focused on other professional skills development, technical content and working on group projects.

In SEP the core assessment task, worth 50% of the final mark, is the team-based *Engineers Without Borders (EWB)* project. The project requires students to devise appropriate and sustainable engineering solutions for remote communities from around the world. The project is assessed by a group report and presentation. In the first SEP tutorial, students discuss all the negative things that can go wrong in a group (negative brainstorming) and how these can be avoided. This group discussion helps inform a personal learning agreement that students then share with their group to help prepare their team agreement that they do in the following tutorial. In EDI, students complete two group design and build projects. The Minor Design Project (completed in weeks 2-6 and assessed via an individual report 20%) and The Major Design Project (completed in weeks 7-13 and assessed via a group report, design demonstration and team presentation 50%). Groups are allocated for the first project and students can choose their group for the second project. The Minor Project team agreement was discussed in the second tutorial, after groups were formed, and the Major Project team agreement was planned as an out of tutorial activity in week 7 but some students asked to

complete it within the tutorial as a first step to form their new teams. This indicates that students now expect to complete a team agreement and find it useful - evidence that this practice should be continued in later years.

Marks for group projects in SEP and EDI are peer moderated, to reflect individual student contribution and their teamwork attributes. This is done using an online peer assessment tool, SPARK (Freeman & McKenzie 2002). Each student must submit a peer assessment assessing their own contribution and the contribution of their group members. Students are also expected to provide supportive and constructive written feedback to their teammates.

In SEP students complete the peer assessment twice, firstly in week 8 (formative) and then again at the end of the project in week 13 (summative). They receive their preliminary peer assessment score and written feedback from their teammates in week 9 and this feedback is discussed in groups during the tutorial. Students can then use this feedback (if required) to improve their contribution and teamwork attributes before the second peer assessment. This feedback helps students to early identify their strengths and weaknesses and to support them do their best. In addition to the peer assessment, tutor observations and comments from students' reflective journals may also be used to moderate the individual project mark. In EDI students submit a peer assessment for both projects. They do not need to stay in the same group, however the feedback received for the Minor Project will help students improve their teamwork attributes for the Major Project, where the peer assessment will be used to moderate their individual mark.

All of the changes and innovations made in these courses have been evaluated in detail using a range of methods including course experience surveys, one-minute evaluations and analysis of reflective journals.

Prior course feedback illustrated how frustrated students were with their teamwork experience, however since the inclusion of these activities this opinion has shifted dramatically. Students now feel supported with their teamwork experience and see each teamwork experience as an opportunity to learn. Students are also experimenting with different team organisation and leadership styles and students are able to better reflect on their teamwork experience.

The course evaluation surveys (CEIs) for SEP and EDI showed a positive shift in student's attitudes between 2010 (the year before the commencement of the program) and 2013. Results indicated increased student agreement for both the provision of helpful feedback and overall course satisfaction as shown in Table 1. The increases are particularly noticeable in the second semester course (EDI) where the cumulative impact of the approach is seen. The number of responses also rose even though class numbers were approximately constant.

Table 1: Course Evaluation Feedback for SEP and EDI (2010 to 2013)

% Agreement	SEP				EDI			
	2010	2011	2012	2013	2010	2011	2012	2013
Received helpful feedback	67%	75%	81%	74%	45%	63%	82%	82%
Overall satisfaction	70%	77%	71%	78%	61%	75%	79%	86%
Number of responses	26	45	39	41	31	8	33	74

The reflective journals from EDI and SEP provided another source of valuable feedback on the teamwork foundation activities. A few students (representing the majority group) did not see the point to these activities and confidently assumed they speak for all.

.. I agree that the ability to work as part of a group is an important asset, but the time spent solely on understanding good teamwork was a bit too much. Most of the information presented will likely not have any impact on how the students in this course work in a group. (Male, ESB, 2012).

Some students did not initially see the purpose, but on reflection could see the benefit of these activities.

I initially did not see the purpose of the “ice breaker” activities but after completion of the activities I have now formed a small social study group with my peers and have even found other students who share the same area of interest regarding the topics for the major assignment. I believe that the first two weeks of engineering are crucial for forming peer relationships and networks (female, ESB, 2012)

Many other students, including some females, international students, rural students or those with a disability, valued the teamwork foundation activities and found them critical for their development.

.. when sitting in the tutorial for the first time it was silent and everyone kept to themselves however through the activities people quickly opened up and I was able to meet new people and make friends (Female, ESB, 2012)

Before my first tutorial I was unsure about communicating and working in teams with other students specially students that I never met before. The first tutorial came as a good influence as it encouraged me and gave me more confidence in meeting new students and working with them in teams, (Male, NESB, 2012)

Second Year – Civil Engineering Practice

In 2014, due to a move away from a completely common first year across all engineering, the opportunity was taken to add a new course in second year, called *Civil Engineering Practice*. The course introduces students to the range of specialisations in Civil Engineering and then focuses on an introduction to structural engineering including Limit States concepts, green building design and Building Information Modelling. Assessment involves an individual project and a small group project. The professional skills development focus within the course is primarily on communication skills and reflection. However, there are a number of team-based activities in tutorials and the concepts of rank and the strengths that individuals bring to teams are revisited specifically during one of these activities. Team agreements are also reviewed and used for the group project. It is intended in the future to develop on-line resources that review the concepts developed through the first year courses and make them available to students in *Civil Engineering Practice* to accommodate those students who enter the program in second year from SAIBT and international transfers.

Embedding professional skill development in technical courses

In the third year of the program all of the courses taught by the civil engineering group are heavily technical in focus, across the areas of structural, geotechnical and water engineering. At the same time there are a number of students who transfer to the UniSA program at the start of the third year through 2 + 2 and articulation arrangements who are unlikely to have been exposed to the professional skill development activities offered in the first two years at UniSA. Hence it was essential that the teamwork activities were reviewed and reinforced within a technical context. Two courses were selected for this purpose from 2014 – Soil Mechanics in the first semester and Water Resources Systems Design in second semester.

Soil Mechanics

Teamwork in Soil Mechanics is undertaken through a group project conducted in groups of four, which is worth 50% of the overall assessment. At the start of the project in Week 5, the student counsellor worked with the Course Coordinator to implement a written team agreement process. This is similar to that undertaken in the first year courses but focussed on the technical content necessary to complete the group project. Issues of rank and inclusive communication were re-visited. Although several of the students were familiar with team agreements from their first year courses, those who had entered UniSA after first year

or with credit for some courses were not. Approximately an hour of class time was devoted to organising teams, introducing team members, discussing the roles and responsibilities required to complete the project, allocating those to team members by discussion and consensus and documenting the agreement. The project was set up so that there are eight sub-tasks undertaken over the eight week duration. Each task required the activities of writing, calculations, drawings and recommendations to be undertaken and it was required that teams rotate these activities for each task so that each person would do each activity twice over the project duration. This allocation had to be documented in the written team agreement that was submitted with the project. In addition students were encouraged to rotate team leadership during the project, but this was not compulsory.

In week 9 of semester, half way through the group project, an anonymous evaluation was undertaken within the class. A total of 53 responses were received from the 82 students enrolled. When asked if they had participated in similar teamwork development activities before, 42 (75%) responded that they had done so in the first year courses (SEP/EDI). When asked to complete the statement “My teamwork experience so far has been ...” the responses were overwhelmingly positive, as summarised in Table 2.

Table 2: “My teamwork experience so far has been ... in Soil Mechanics, 2014

Response	Number	%
Good/very good/excellent	32	60
Average/fair/OK	7	13
Bad/horrible	3	5.7
Fun/enjoyable	5	10
Interesting	2	3.8
Other	4	7.5
Total	53	100

Peer evaluations were also undertaken in weeks 8 and 10, which could be used to moderate the marks up or down if necessary. A focus group discussion facilitated by a teaching and learning consultant in week 12 revealed that there were some concerns with the group work in terms of the percentage of the grade allocated to it, and some students not contributing sufficiently, but the standard course evaluation instrument completed online by students at the end of the semester had only four negative comments on the group work from 25 respondents.

At the time of writing this paper the team agreement process is being implemented in a second semester course *Water Resources Systems Design*, which also incorporates a major group project and the same evaluation tools will be undertaken in the second half of 2014.

The capstone design experience

In the final year of the Civil Engineering program all students undertake two major project courses that make up 18 of the 36 units in that year One is a research project and the other a design project. In the *Civil Engineering Design Project* course, students work as companies of 25-30 students on a real project that is in the developmental stage. Engineers from industry, involved in the project, act as clients and students undertake the tender, feasibility study and detailed design stages for the work (refer Mills, 2007 for additional description). In 2014 this meant that three companies were formed for the 79 students with each company working with a different client on a different project. The entire project is built around team work and student management of the process. After the initial tender stage which is undertaken in teams of 6 to 8 students in the first two weeks, the student company then determines the appropriate team structure needed to undertake the feasibility study for

weeks 3 to 7, and then reorganises again for the detailed design stage in the last six weeks. The company management team is elected by fellow students and team leader roles are rotated each stage. It should be noted that in 2014, 46% of the students in the course were international students, which was much higher than usual.

Whilst there has always been an extensive process of peer assessment, with ongoing feedback on team performance, until this year it has been assumed that the significant exposure to teamwork in courses in the earlier years was sufficient for students to undertake the teamwork activities in the design project successfully. However, in 2014 with assistance from the student counsellor and curriculum developer, a series of additional activities were incorporated into the project sessions such as a Global Mindset quiz, forming effective teams, learning about mentoring, collective team agreements, reflecting on teamwork effectiveness, the DOPE test, personal rank profile, conflict management, diversity and engineering a better workplace. In addition the SPARK peer assessment instrument was used for the first time in the course.

Clearly this was a lot to introduce in one semester. As the teamwork development activities are implemented consistently across the program so that all students entering fourth year will at least have had one year of specific exposure to these activities, there should be less need to incorporate so much in this final year course. An in class evaluation instrument was administered in week 13 that asked students to rate their current competence in teamwork on a scale from 1(not competent) to 5 (very competent). Of 55 respondents, 47 (85%) felt that they were either competent or very competent. Similarly in response to the statement "In this course I was able to develop my ability to collaborate with others" that was included in the standard course evaluation instrument, 93% of students either agreed or strongly agreed with this statement.

The most encouraging evidence for the effectiveness of the teamwork learning activities, particularly given the culturally diverse student group, comes from student reflective journals. These indicated that the activities were considered valuable by a wide range of students including Australian students who had or had not done similar activities in earlier courses:

In week 4 we had two guest lecturers who came in and discussed how to effectively work in teams and be a positive part of a team environment. Although I found some parts of the lecture particularly repetitive of information of past courses and discussion it was a good refresher and reminder to work hard when in a team environment. This helped in our particular groups to find each other's strengths and weaknesses and what we think we can improve on. Male student, Australian, would have done SEP and EDI

I really really liked this lecture – I feel that as a group it brought us together and it was good to have a bit of a laugh and do some activities together to break the ice a bit ☺. It was also very interesting for me when we had to write down the roles we would like to work on in this project that we don't normally do. I am normally designated the leader in pretty much all previous group projects I have ever worked on, I love public speaking and organising, so it seems to fit me well. However when I stopped and thought about what I need to develop – it is letting someone else (and trusting someone else) to be the leader, take the group where it needs to go and collect the work on time. Female student, Australian first language English, would not have done SEP and EDI teamwork activities.

international students who had transferred into the program in later years:

This class is really meaningful, it makes me more clear about how can I play my role well in a team and also what should I keep improving on. Male international student, transferred to UniSA for third year

and NESB local students:

During this week we had two guest lecturers. They present us with lot of ideas on how to work as team. It was one of the best lessons I have ever had, it was more not only working in team but also a lot of challenging ideas to contribute to the group members. Male student, African refugee now Permanent Resident.

Conclusion and the way ahead

Professional skills development should not be left to final year and the first year pedagogical approach is laying a strong foundation for the development of these necessary skills. This approach is now being further developed and applied throughout the program. Formal and informal evaluations show it provides an effective and deep learning experience for students with increased teamwork competence and confidence in working inclusively. This approach will be evaluated and continuously improved as we have students who have experienced it throughout their degree.

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