Communication in Engineering Studies - Review and Case Study

Fidelis R. Mashiri
University of Western Sydney, Sydney, Australia
f.mashiri@uws.edu.au

Hui Jiao
University of Tasmania, Hobart, Australia
hjiao@utas.edu.au

***Abstract**: This paper reviews existing literature relating to communication in engineering education. A case study is then considered. The case study looks at the course structure of an existing civil engineering degree. Analysis of the different communication skills that can be obtained in this course is analysed. Deficiencies in the types of communication competencies that can be obtained are identified. Methods of improving these deficiencies are discussed.*

Introduction

The word "innovation" has its roots in the Latin word "novus" which means "new" and is derived from the verb "in+novare" meaning "to make something new" (Alexander 2006, p.22). Alexander (2006, p.22) points out that "the holy grail of teaching innovation has been to increase the quality of learning, the productivity of learning, while at the same time increasing access to learning". According to Hannan and Silver (2002, p.5) "For innovations to be seen as enhancing quality they must result in improvements in teaching and learning, in making the process and outcomes richer and more worthwhile". The point made by Hannan and Silver (2002) about quality and richness resonates with the proposed solution for the challenge in engineering schools on curriculum renewal.

The innovation explored in this study relates to recognition that the course structure for the Bachelor of Civil Engineering degree explored has limited units dedicated to the development of communication, especially oral communication. In addition the course structure also has limited units dedicated to rigorous research that leads to the attainment of lifelong learning skills. Communication and lifelong learning skills are among the graduate attributes that are required for accreditation of engineering programs in Australia (Engineers Australia Accreditation Board 1996), in the USA (ABET 2008) and in many other OECD countries. As pointed out by Bell (2000, p.63), "Good engineers possess more than technical competence – they are also skilled in teamwork, communications, ethics and the evaluation of engineering problems in societal and global contexts". In an article written by Galloway (2004) she observes that engineers are not trained in the skills required to work in today's workforce. She states that "Engineers, in general, have a negative image when it comes to social skills such as communication, public policy, leadership and management" (p. 128). Galloway (2004, p.128) suggests that "In [her] view, we must change the image of the engineer as seen by the public, we must educate our engineers in nontechnical skills that allow them to better communicate and manage and we must involve ourselves in public policy". "Businesses and industries nationwide are also recognising the centrality of communication skills in professional engineering practices", (Darling and Dannels 2003, p.2).

The authors have also observed through their experiences working at different universities that a significant amount of student presentations, including those for the final year project or honours thesis, still use "queue" cards or "written speeches". To the authors, this is a demonstration of a lack of

experience in oral presentations and therefore confidence in the student presenters to independently communicate or express their technical content or expertise. This lack of experience in oral presentations is brought about by the nature of assessments for the majority of engineering units that focus mostly on submission of calculation solutions.

To address some of these shortcomings, it is proposed that assessments in 3rd year design subjects such as, Concrete Structures, Steel Structures and Timber Structures be changed such that they contain assessments in the form of group project based learning major assignments. These project based learning projects will be assessed through two components with a focus on communication – an oral presentation and a project report. Lifelong learning skills and teamwork will also be addressed. In this proposal the content of the design units will not be changed, only the method of assessment or focus of the assessments.

These third year design units have been chosen for this curriculum renewal because their content is used in practice in the design and construction of a majority of civil engineering structures that are built from steel, concrete and timber. The design of these structures are therefore, based on Australian Standards. The use of these units, therefore, has the capacity to simulate real practice scenarios during the design of civil engineering structures. These scenarios may include the design engineer's liaison with clients and contractors on issues relating to requirements and or complexities of a design. The authors are directly involved in the teaching of these units thereby making it easier to undertake the innovation as this reduces the amount of buy-in required except that of relevant Committees and School Management.

Fernandez et al (2009, p 114) report that "Teamwork has been identified as one of the most important employability skills… and one of the skills used in industry". To encourage teamwork, a major design assignment "contract" will be signed by the participants pledging to work with other group members professionally and ethically. The groups will identify "champions" for different sections of the project based on academic strength or interest. These champions will be responsible for communicating progress in these sections of the projects through oral presentations at group meetings supported by written drafts. Each champion will have a reviewer. The reviewers for each champion and therefore section will be on a rotating basis to maximise participation and contribution of each group member in all the different sections of the project. This is designed to encourage interaction among all group members on a one-to-one basis as well as, as a group and to ensure that group members have a feeling of ownership, not only of the sections they are championing, but of the entire project.

This paper therefore discusses a challenge – curriculum renewal in civil engineering with the aid of project based learning (PBL). The following aspects are considered:
(i) Identification and definition of the challenge - curriculum renewal in civil engineering,
(ii) Review of literature associated with curriculum renewal in civil engineering and
(iii) Recommended strategies to address the challenge relating to curriculum renewal in civil engineering.

Identification and Definition of the Innovation Challenge – Curriculum Renewal in Civil Engineering

The Engineers Australia Accreditation Board (1996) recommends that graduates from an accredited university program should have 10 generic attributes. Among these attributes, are attributes that relate to communication, teamwork and lifelong learning. These attributes are summarized as follows (Engineers Australia Accreditation Board 1996, p.3):

- ability to communicate effectively, not only with engineers but also with the community at large and
- expectation of the need to undertake lifelong learning, and capacity to do so.

The Engineering Accreditation Commission in the USA (ABET 2008) also has similar graduate attributes relating to communication and lifelong learning.

To achieve these competencies in communication and lifelong learning skills, the engineering programs need to have units dedicated to achieving this goal. Learning outcomes relating to

communication and lifelong learning skills can be aligned with assessments to enable students to gain these competencies (Biggs 2003).

A review of the course structure for Bachelor of Civil Engineering at the University of Tasmania (2009) and University of Western Sydney (2010) shows that the only units which are fully dedicated to communication, teamwork and the learning of lifelong learning skills are 2 Units, Engineering Design and Project Management and Civil and Environmental Engineering Project/Civil Engineering Honours at the University of Tasmania and Engineering Geology and Concrete Materials and Engineering Project/Honours Thesis at the University of Western Sydney. This represents an attempt to enable students to gain competence in communication and lifelong learning skills in only 6% of the units in the whole civil engineering course. The component dedicated to assessing students' communication skills, especially oral presentations in the whole course is therefore less than 6%. Civil and Environmental Engineering Project at the University of Tasmania and Engineering Project at the University of Western Sydney are 4th year research projects which includes in its assessment an oral presentation and progress and final reports. Engineering Design and Project Management and Engineering Geology and Concrete Materials are 2nd year units focusing on teamwork, design and oral presentation and written reports. This course structure shows that at the end of the 4 years at university, the student would have very little opportunity to acquire competence in communication particularly oral presentation and lifelong learning skills.

From this realization it is proposed to introduce a process innovation (Alexander 2006) in the form of a major project in some of the design subjects in 3rd year. On the radical-incremental spectrum, this process innovation will result in incremental change (Alexander 2006). According to Pennington (2003) incremental changes to the school's core units in this case will provide moderate disturbance and moderate risk. This may affect the school's perception as far as quality is concerned through bad SETLs (Student Evaluation of Teaching and Learning) if the students do not receive this change favourably. It is hoped that through effective communication of the purposes why these changes are being introduced negative perception of the changes will be reduced. The major project will be a project based learning assessment in design subjects as Steel Structures, Timber Structures and Concrete Structures. The assessments in the project based learning assignment will have a significant oral presentation component in addition to final project reports. The oral presentation part of the assessment will enable students to develop competence in communication skills to their peers and academic staff. The final project report will be structured in such a way as to enable students to develop competence in lifelong learning skills with dedicated sections on "literature review" and "future trends". An emphasis will also be made to ensure that these project based learning assessments are group based. This will add to students developing the following attribute (Engineers Australia Accreditation Board 1996, p.3):

- ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member.

The students will be supported in their development of oral communication through the provision of a best practice guide. Short presentations will be organised for each group every three weeks to enable group members to inform their peers and lecturers about their progress and challenges. The presentations will typically be of about 5 minutes in length for each student. Marks will be allocated in these short presentations for individual presenters to ensure that these presentations are viewed as genuine assessments by students. Feedback on presentations will also be given to individual students to highlight both shortcomings and improvements in oral communication.

The training of students in lifelong learning skills will be encouraged through ensuring that part of the project requirements go beyond what is covered in class. Investigative research in contemporary issues in design such as the link of designs to environmental issues such as "green concrete, steel or timber" or sustainability and their link to particular design projects will also be used as part of the training for students in lifelong learning skills.

Review of Literature Associated with Curriculum Renewal in Civil Engineering

In 1995, Jennings and Ferguson wrote that in previous years the training of professional engineers in the United Kingdom was perceived as a two stage process. The first stage focused on academic training at university and the second stage focused on industrial experience preferably under a structured scheme. The first stage was therefore concerned mostly with "fundamental technical aspects of their discipline" (Jennings and Ferguson 1995, p. 305). Other skills such as communication which are not of a technical nature were thought of as "more easily covered during the period of industrial training" (p. 305). Jennings and Ferguson (1995) however point out that even as early as 1950s there has been "Disquiet about the overemphasis on technical aspects of engineering education". This disquiet led to the Finniston Enquiry (Finniston 1980). The enquiry recommended that "The profession wanted less graduates who were trained only to be backroom experts and more who could interact with people outside of the profession, be proactive and take leading roles". This is the background that has led to accreditation bodies including communication as one of the attributes for engineering graduates (Engineers Australia Accreditation Board 1996; ABET 2008).

The introduction of project based learning in the civil engineering curriculum at the University of Tasmania and the University of Western Sydney will give students the opportunity to apply theories learnt in class to a real life setting. Almgren (2008, p. 242) points out that "It is critical that students experience the opportunity to work on exciting projects in order to fully ground the theories they are taught in class". Almgren (2008, p. 242) also points to the importance of experiential learning by pointing out that "if experiential learning involves collaborative, socially-relevant projects, students will also develop the professional skills of teamwork, communication, and leadership while they hone their technical skills".

"The increased mobility of engineers…" Lucena et al (2008, p.433) also means that communication becomes a very important competence in graduating engineers especially considering that engineers may be required to communicate in multinational companies operating in various countries and regions and deal with colleagues in multiracial work groups.

It has been found that "Situated learning is particularly critical in language development" Paretti (2008, p. 492). Project based learning in the 3rd year design subjects will provide a context of learning that is authentic. According to Paretti (2008, p. 493), "Design courses, because they typically engage students in authentic engineering tasks, provide ideal sites to engage students in authentic engineering communication to foster situated learning". Paretti (2008, p.493) also points out that "In the course of developing a design, student teams must frequently communicate with one another, their advisors and outside experts to succeed". Communication at these various levels allows the students to develop communication skills to suit the different situations as they arise. This typifies real workplace practice.

Another important skill that graduate engineers need to learn is lifelong learning skills. Redish and Smith (2008, p. 296) refer to this as learning "to develop adaptive expertise". Adaptability is important in that it gives students the confidence to cope with change and the ability for self improvement.

Recommended Strategies to Address Curriculum Renewal in Civil Engineering

The civil engineering discipline lecturers will draft a proposal for curriculum renewal. The structure of the design units will be based on scaffolding learning (Jackson et al 1998, Stewart et al 2007), where the first part of the unit will be designed to form the building blocks that can be later used in the final major assignment. The major assignment will be a project based learning assessment consisting of an oral presentation and a project report. The proposal for curriculum renewal will contain a list of proposed projects for each design unit. The proposal will also contain rubrics for criterion-based reference assessment for the oral presentations and the project report. The focus in these assessments is therefore on both oral and written communication in this curriculum renewal.

For curriculum renewal in the civil engineering degree at the University of Tasmania and the University of Western Sydney to be implemented, approval must be obtained from the relevant school

and faculty committees. In the School of Engineering, which is part of the Faculty of Science, Engineering and Technology at the University of Tasmania and part of the College of Health and Science at the University of Western Sydney, approval will consist of the following stages:

(i) A proposal of the curriculum renewal to include project based learning assessments focused at communication, teamwork and lifelong learning skills will be drafted by the civil engineering discipline lecturers.
(ii) The draft proposal will be presented to the Head of School for his comments and preliminary approval.
(iii) The input of the Degree Coordinator or Head of Program will be sought and his suggestions incorporated into the draft proposal.
(iv) The draft proposal will be submitted to the School Teaching and Learning Committee or School Academic Committee for amendments and approval.
(v) The final draft will be submitted to the Head of School for his approval.
(vi) The final draft will be submitted to the Faculty Teaching and Learning Committee or Education Progression and Assessment Committee for final approval.

Since this curriculum renewal is only changing the assessments that are required in the design units, university committee approval is not required.

Conclusions

Literature in engineering education shows that communication is a valuable skill that should be acquired by students prior to their graduation and entry into the workforce. This skill is essential because of:

(i) Mobility that is associated with engineering graduates. This mobility is related to the fact that numerous engineering companies which are either national or multinational expect or has opportunities for their engineers to work in various locations within countries or around the world. When working in various locations, engineers are expected to cope well working in multicultural and multidisciplinary teams and
(ii) The expectation from companies or engineering organisations especially council, state and national, is for engineers to have the skills and ability to liaise with the community to promote and highlight the benefit of new engineering infrastructure.

This means that it is important for the engineering curriculum to include a provision, within its course structures, that allows students to acquire essential communication skills.

A review of the curriculum at two universities, have shown that there is a minimal provision for assessments that encourage the acquisition of communication skills, especially oral skills.

Design units within the course structures have been identified and earmarked for a curriculum renewal that will promote both oral and written communication skills in a setting that simulates possible scenarios in the workplace through problem based learning group projects.

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