Engineering Communication Interface: An Engineering Multidisciplinary Project.

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It is no longer sufficient to graduate engineering students from tertiary institutions with a sound knowledge of engineering theory and practice alone. Well developed professional communication skills, collaborative work practices, effective self management and a clear understanding of social responsibility and ethical practices are also essential for the new engineer who hopes to contribute to the profession and build a career. The Engineering College at the American University of Sharjah has recognised this reality with the development of a course in language enhancement and professional communication through engineering multidisciplinary projects (EMDPs). The paper outlines the context of the EMDPs emphasising the interface between engineering and communication. The paper relates academic research skills to higher order cognitive domain skills, and evidence is presented from other studies concerning to the shift to professional communication and how this relates to the learning outcomes.

Summary

"It is no longer sufficient to graduate engineering students from tertiary institutions with a sound knowledge of engineering theory and practice alone". There is considerable documented evidence to support such a claim. In a recently published Australian study undertaken with 300 engineers with between 5 and 20 years experience Male, Bush & Chapman (2010) have shown that competency deficiencies in engineering business, communication skills, self management and attitude, problem solving and teamwork are areas for improvement in engineering curricula. These findings reflect other studies which have also highlighted such competencies as in need of improvement. Bodmer et al (2002), in a European and US survey of 1372 engineers, identified leadership, social skills and communication to be lacking in graduates; an international survey (WCEC, 2004) of 1091 chemical engineers during their first five years of employment found deficits in management, effective communication and leadership. Male, Bush & Chapman assert "communication is the competency that features most frequently as a deficiency in Australian surveys" (2010, 56) and work conducted by Ashman et al (2008) and Nair et al (2009) reinforces this contention.

These studies have in common a focus on competencies that are deemed essential but often deficient in engineering workplace situations either by engineers identifying their self-perceived shortcomings or by more experienced engineers observing the limitations of junior colleagues. Either way, the necessity for effective communication and management skills is clear. The impact of information communications technology (ICT) has necessitated attainment of these skills by virtue of the abundant opportunities available for collaboration and communication between professional colleagues. This communication increasingly engages an educated, informed and concerned public. Recognition of this reality is embodied in the Carnegie Mellon University Department of Engineering and Public Policy (EPP) which seeks to develop in students an understanding of the interface between society and technology and the skills that will enable effective work at that interface. Students in the EPP department study their engineering degrees in the context of the social and ethical expectations that are increasingly important for the engineering professional and learn how to "seek advanced assistance … in areas beyond the traditional expertise of engineers" (Carnegie Mellon University, Department of EPP, 2008). Furthermore, the Carnegie Mellon degrees recognise the need to develop collaborative work practices as students are expected to "demonstrate an ability to integrate conventional technical analysis with behavioural and other social issues, where the engineer is a participant in teams composed of many disciplines" (Carnegie Mellon University, Department of EPP, 2008). This recognition of inter-disciplinary study resonates with the work at our institution which we shall now briefly describe.

Other research emphasises the need for engineers to be able to integrate technical expertise with behavioural and societal issues, to work on solving complex problems in teams composed of professionals from many disciplines and exhibit high level communication skills. The OECD's 'Definition and selection of competencies: theoretical and conceptual foundations' (DeSoCo) project is foundational to many of these studies. The project work, published under the editorship of Rychen and Salganik (2003), developed a conceptual frame of reference for key competencies. It was based on theoretical and conceptual approaches to competence informed by political and practical considerations. The rationale for the work

took into account the fact that rapid and continuous change in technology required adaptability rather than mastery; social diversity necessitated different kinds of personal relationships (more contact with those different from oneself); globalisation created interdependencies with actions subject to influences and consequences beyond regional and national boundaries (economics and pollution for instance).

Investigations based on the DeSoCo conceptual frame of reference, such as that conducted in Malaysia by Zaharim et. al. (2008), recognize changes in economic growth patterns are creating higher demands for engineering employability skills. The study identified deficiencies between the perceptions and the expectations of employers and showed that significant gaps exist between the skills actually possessed by employees and those thought to be important by employers. Significant deficiencies were found in teamwork, communication, and problem-solving with associated weaknesses in understanding professional, social and ethical responsibilities. A qualitative study conducted by Martin et. al. (2005) with chemical engineering graduates in South Africa revealed similar findings. The study showed that the foundations of success for the respondents, technical knowledge and technical skills, were not sufficient for success in the profession. Attributes necessary for success in industry (interpersonal skills, communication, teamwork and management) needed to build on this foundation. In particular, this study emphasized that communication is dependent on interpersonal skills, and teamwork and management are dependent on communication. In a mid-decade study of the Indian engineering education sector, Goel (2006) found that traditional resource-based approaches were still very much in evidence rather than the outcome-based approaches which would address the perceived lack of requisite competencies such as "ability to apply knowledge, design skills, problem solving skills, … ability to work in multidisciplinary teams, communication skills, sensitivity towards global, societal, and environmental issues, and sensitivity towards ethical and professional issues" (p. 48). Goel's proposal to alleviate this lack was the adoption of a three-dimensional framework of competencies to categorize the skills that address existing deficiencies and emerging needs. The framework included firstly, attitudes and perceptions then productive habits of mind and finally acquisition and meaningful use of knowledge.

How does this relate to initiatives at our institution? All undergraduate degree programs in College of Engineering are accredited by the Engineering Accreditation Commission of ABET of the United States. English fluency is a necessary condition for success in a global economy and therefore, to help develop fluency, all instruction is conducted in English with a strong emphasis on developing excellence in communication skills, both written and oral. The United Arab Emirates is located on the crossroads between East and West, most of our graduates will work in an international environment so we value global awareness and cultural sensitivity.

The request of the Dean of the College of Engineering for the incorporation of an EMDP into the language and communication course, ENG207, was to provide the engineering undergraduates training in a range of collaborative, communication and academic skills. Accordingly, a pilot program was developed and implemented during the Spring Semester, 2010 with three of the ten sections in the course. The program also aims to instil leadership qualities anchored in moral and ethical principles. One of the key elements of ABET accreditation is the requirement that programs continuously improve the quality of education provided. The move to include the engineering multidisciplinary project (EMDP) as the core element in a required language and communication course in the third year (prior to the senior design project) is an example of ABET driven program improvement.

In the previous ENG207 course the focus had been on document organisation, technical writing and an oral presentation. The revised course reflects the need engineers have for competencies beyond a sound technical knowledge and engineering skills. In addition to document organisation the revised syllabus requires students to work in multidisciplinary groups (e.g. civil, chemical, mechanical, electrical, computer engineering) make a succinct collaborative oral presentation and produce a written report on their multidisciplinary projects. In this work students need to demonstrate socially responsible, ethical procedures and principles. Other important aspects of the revised course facilitate the project work. Students are trained to conduct effective meetings, to plan and document decisions, to set goals and meet deadlines, to manage themselves and their peers, to show leadership to review their peers. There is emphasis on responsibility at personal, inter-personal and community levels developing the sense of a community of professional practice.

Bloom's Taxonomy provides an underpinning for this revised ENG207 course. The course objectives, program outcomes and assessment activities address educational objectives in Bloom's three domains, affective psychomotor and cognitive.   The ENG207 course objectives embody particularly affective and cognitive skills and especially the higher order skills in each domain [affective: valuing, organizing, characterizing; cognitive: analysis, synthesis, evaluation]. Furthermore, the course objectives address the competencies that the studies referred to throughout this paper have identified as essential to a successful engineering career. Our students, through the work they undertake in the EMDP, are expected to attain the following objectives:
- Demonstrating use of appropriate and effective standards and strategies in professional (engineering) communication
- Demonstrating writing and presentation style sensitive to audience and message function
- Exhibiting individual, collaborative and multidisciplinary technical communication skills
- Demonstrating understanding of appropriate content, format and graphics for professional (engineering) documentation and presentations
- Displaying awareness of ethical and social responsibility issues that arise in technical research and documentation

At an affective level these objectives embody skills of valuing information, accommodating different ideas and ideals. Attainment of the skills enables students to compare and to elaborate on what is known and what has been learned in order to establish beliefs and standards. Preparing and presenting the EMDP as oral and written discourse with supporting organizational documentation exemplifies cognitive skills.   The project work requires students to use analysis, inference and synthesis in the compilation and patterning of the discourse and the information. The skill of evaluation, in the presentation and defense of project work requires making judgments about information, and attesting the validity of ideas and quality of work based on given criteria. Overall our new ENG207 course shows a coherent relationship to degree program outcomes specified by the university in the following terms:
- Evaluate written and oral communication, identify key ideas and establish hierarchies of information, work collaboratively in teams: and
- Structure clear and persuasive arguments based on an analysis and presentation of evidence.

Other aspects of the course that probe more particularly the operational aspects of the EMDP, the student engagement and their perceptions of the contextualized nature of the teaching will be discussed by our colleagues in their examination of cross-discipline teaching.

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