An empirical study of communication competence of civil engineering graduates – implication of engineering curriculums

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Abstract

Drawing upon a major revision of undergraduate civil engineering curriculum in the University of Sydney, Australia, this paper presents a graduate survey with the specific objectives to: (i) assess the graduates' communication competence; (ii) identify the important communication skills required for entry level graduate position and job promotion; and (iii) ascertain the type of effective teaching and learning activities for developing communication skills of civil engineering students. The survey findings affirm the adequacy of communication training of the revised curriculum that integrates communication across different civil engineering core courses. Also, the results show that the graduates rank interpersonal communication skills, teamwork communication skills and technical knowledge and skills as the most important communication skills for a civil engineer at the entry level and for career development. They place greatest emphasis on teaching and learning activities that aim to prepare them for industry-related experience and to gain exposure in the real work settings. These findings could be used, for comparative purposes, by other institutions that may wish to evaluate their communication training within the context of civil engineering education.

Keywords: civil engineering, communication, graduate

1. Introduction

Communication skills are one of the top criteria sought by employers in recruiting engineering graduates. Markes' (2006) review on employability skill needs in engineering shows that communication skills have appeared in all 23 lists of employability skills (required of graduates) produced, in consultation with employers, by various recruitment organizations between 1998 and 2005. Despite the importance of communication skills, many research studies highlight that there is an increasing employers' concerns about the lack of engineering graduates' communication skills development. For example, Nair et al. (2009), in their survey of 109 engineering-related employers in Australia, found that the top three graduate attributes with greatest competency gaps (i.e., difference between the reality and employers' expectation) are: oral communication skills, interpersonal skills with colleagues and clients, and written communication skills. This finding is similar to those of previous industrial recruitment surveys, indicating that engineering graduates lacked communication skills required by employers (e.g., Lang et al. 1999; Meier et al. 2000; Scott and Yates 2002). In view of this deficiency, some researchers recognised the need to align engineering curriculum development with the industry need, by looking at how engineering graduates perceive their preparedness, in terms of their communication competence, for work in the industry. For example, Martin et al. (2005) and Vest et al. (1995; 1996) have correspondingly investigated the perceptions of chemical and electrical engineering graduates about the satisfactoriness of their communication skill training and development for their professional practice. Hitherto, in response to various areas of weaknesses identified, many engineering educational research have been conducted, especially in North America, to continually look for suggestions to enhancing communication skills training in generic engineering curriculums. Some suggestions include: (i) writing across the curriculum approaches where communication instructions are integrated into most undergraduate engineering majors; (ii) interdisciplinary courses with collaborative efforts between an engineering department and a department that places strong emphasis on communication, such as English language department; and (iii) a variety of support systems including writing and communication centres and online resources (Ford and Riley 2003). In the context of civil engineering education, Pauschke and Ingraffea (1996) provide a list of innovations in undergraduate civil engineering curriculum, highlighting an increasing emphasis on communication skills in classes. In promoting the concept of collaborative teaching and learning to enhance the communication content of civil engineering courses, Koehn (2001) found that students favour the opportunities for student input rather than formal lectures. Various learning and teaching methods for interactive communication in civil engineering classrooms have also been identified in Koehn (1995). These include: the use of thought-provoking questions and class discussion, the use of group-based assignment, and the involvement of practitioners as guest speakers.

It appears that there are many other factors shaping communication training in civil engineering curriculum. Of these, a major drive is the need to meet accreditation requirements, in particular to satisfy the generic (communication) skills expected by accreditation bodies, such as the Institute of Engineers in Australia (IEAust), and the Accreditation Board for Engineering and Technology (ABET) in the US. Other factors include: (i) the diverse educational settings across institutions (Ford and Riley 2003); (ii) increasing engagement of employers and industry bodies in curriculum reform (Pauschke and Ingraffea 1996; Shah and Nair 2011); and (iii) increasing use of communication technologies by the internet and the World Wide Web.

The aim of this paper is to investigate the civil engineering graduates' perceptions of communication training in the University of Sydney, Australia. Under this aim, the specific objectives are to: (i) assess the graduates' communication competence; (ii) identify the important communication skills required for entry level graduate position and job promotion; and (iii) ascertain the type of effective teaching and learning activities for developing communication skills of civil engineering students. The results of this study will inform the main constituents of the importance of communication skills for civil engineering students, as entry level engineer graduates, and for their future career advancement. Additionally, the type of teaching and learning activities for developing the students' communication skills that are deemed the most effective will be highlighted in this investigation, which will help us promote best teaching practices in our curriculum. Likewise, these findings could be used, for comparative purposes, by other institutions that may wish to evaluate their communication training within the context of civil engineering education.

2. Context

In 2003, the civil engineering undergraduate program in the University of Sydney was revised (Airey et al. 2005). The identified drivers for the revision include: rationalisation of course offerings, changes in expectations from industry and institutions, simpler integration with civil engineering combined degrees, changing student expectations and abilities, and greater integration of generic skills development expected by the IEAust within the program. In terms of communication training, the major changes were to remove a course on "Communications" with low credit point, but instead integrated communication training with technical content across core courses. In particular, a third year course entitled "Engineering and Society" was added to the core program (El-Zein et al. 2007). It has a specific objective to improve students' communication skills and teamwork ability. The targeted survey respondents in this paper are alumni who have graduated since this major program revision.

3. Research method

A survey research design was preferred over other research designs (e.g., archival research, experimental research, and case study research) for its abilities to provide a relatively quick and efficient method to (i) obtain information from the targeted sample, and (ii) generalize the research findings based on the sample involved. However, it is recognized that the survey research design does have its major disadvantages of: (i) the low response rate, and (ii) the possible biases that arise from sampling and individual responses. Various measures were taken to deal with these shortcomings. The two major measures adopted here are: (i) the postal survey questionnaires were sent to all 230 graduates from 2007 to 2009 with local addresses, with reminder packages sent after two weeks from the initial mailing exercise in an attempt to improve response rate, and (ii) the use of official list of graduates in the sampling process (all research protocols were approved by the University's Human Research Ethics Committee prior to commencement of this study).

There are four sections in the survey questionnaire. In the first part, graduates were required to provide general information about their background (e.g., degree information, graduation year, current job). The second part is related to questions in assessing graduates' perceptions of their preparedness

to 21 specific communication skills using a seven-point Likert scale 1 (not at all prepared) to 7 (excellently prepared). These communication skills can be broadly grouped into eight major categories: (i) technical writing skills; (ii) general writing skills; (iii) interpersonal communication skills; (iv) teamwork communication skills; (v) oral presentation skills, (vi) electronic communication skills; (vii) public speaking skills; and (viii) technical knowledge and skills. In the third part, graduates were asked to indicate the importance of these eight categories of communication skills (1 = not important at all – 7 = extremely important) for entry-level graduate position and job promotion. The questionnaire ends with a section on teaching and learning activities. Graduated were asked to rate the effectiveness of eleven teaching and learning activities (1 = not effective at all – 7 = extremely effective) towards developing the communication skills of civil engineer students. An open-ended feedback box was also included to provide an opportunity for other recommendations.

Apart from descriptive statistics, one sample *t*-test was applied to the survey dataset to test the significance of graduates' self perceptions regarding preparedness to communication skills. This was done by comparing the mean scores of the sample to a known value. Here, a test-value of 4 (i.e., the neutral score) was used to evaluate graduates' perceptions if they were adequately prepared (mean score that is statistically greater than 4), or under-prepared (mean score that is statistically below or equal to 4) for each specific communication skill. Rather than simple averaging, this provides an objective measure in identifying specific communication skills that call for immediate attention to address weaknesses in communication training.

In assessing the importance which the respondents assigned to the eight major communication skills categories for entry-level graduate position and job promotion, importance index was calculated for each category using the following formula:

$$\text{Importance index} = \Sigma a X \times 100 / 7 \qquad (1)$$

where a is a constant expressing the weight given to each response, ranging from 1 (not important at all) to 7 (extremely important). $X = n/N$, with n the frequency of the response and N the total number of responses. This index helps in ranking the skills categories in accordance with their importance, and also determines any similarities or differences between entry-level graduate position and job promotion.

4. Results

A total of 32 graduates responded to the survey sent in the last quarter of 2010, representing a response rate of 14%. Despite reminder packages, it is noted that a low response rate is typical of studies involving engineering graduates (c.f. McGourty et al. 1999). (By comparison, the survey by Airey et al. (2005) on the respective curriculum revision in 2004 elicited a response rate of 13%). Table 1 shows the characteristics of the respondents that were made up of 23 males and 9 females. They were all local Australian full time students and the majority of them speak English at home (88%). In terms of degree program, most respondents were in civil engineering degree (69%), with the remaining respondents studied in civil engineering combined degrees (i.e., commerce, art, science, project engineering management). There were slightly more respondents graduated in year 2009 (59%)

than years 2007 and 2008. With an average of 2.24 years of working experience, the majority of the respondents were working on engineering related jobs (66%) at the time of the survey.

Table 1: Characteristics of graduates

Description	Frequency	% of graduates
Gender		
Male	23	71.9
Female	9	28.1
Language spoken at home		
English	28	87.5
Other	4	12.5
Degree		
Civil engineering	22	68.8
Civil engineering combined degree	10	31.2
Graduation year		
2007	4	12.5
2008	9	28.1
2009	19	59.4
First job upon graduation		
Yes	23	71.9
No	9	28.1
Job type		
Engineering-related	21	65.6
Other	11	34.4
Years of working experience		
Mean	2.24 years	

Table 2 shows the test results of the respondents' self perceptions regarding preparedness to 21 specific communication skills using one-sample *t*-test with a test-value of 4. It can be seen that the perceived preparedness mean scores for all specific communication skills grouped in: (i) general and technical writing skills, and (ii) technical knowledge and skills categories are statistically greater than 4 with p-value < 0.01, signifying adequate preparation in the respective communication skills. Indeed, the perceived preparedness mean scores for 'ability to apply analytic and problem-solving skills for research and inquiry' (6.13) and 'understand the technical terms used in the industry' (5.23) in the technical knowledge and skills category rank in the top three positions of the list (i.e., 1st and 3rd, respectively). The second highest scoring item is 'appreciate the importance of cooperation and tolerance in a team working environment' (5.41).

Table 2: One sample t-test of the graduates' self perceptions regarding preparedness to specific communication skills

	Test value = 4			
	Mean	Std. dev.	t	*p*-value
Oral presentation and public speaking				
Ability to collect and use accurate data to support oral presentations (e.g., using statistics published in journal articles and government reports)	4.63	1.289	2.743	0.010
Understand the use of visual aids (e.g., diagrams, photos) for effective oral presentations	4.50	1.191	2.374	0.024
Ability to incorporate appropriate oral presentation techniques (such as eye contacts and body gesture) in attracting and maintaining the attention of audience	3.88	1.289	-0.549	0.587

Ability to arrange an oral presentation in a systematic manner	4.53	1.459	2.060	0.048
Public speaking ability	4.09	1.634	0.325	0.748
Teamwork and interpersonal				
Ability to work as part of a team	5.13	1.431	4.447	0.000
Appreciate the importance of cooperation and tolerance in a team working environment	5.41	1.292	6.159	0.000
Negotiation skills to achieving mutual benefits among different stakeholders	4.31	1.512	1.169	0.251
Ability to communicate with people of different background, experiences and culture	4.66	1.428	2.600	0.014
Active listening skills to understand others and take actions based on our mutual understanding	4.69	1.256	3.097	0.004
Ability to plan and organize my work in a systematic manner	5.22	1.184	5.822	0.000
Electronic communication				
Ability to adapt to communicating and working in an automated office environment	4.31	1.378	1.283	0.209
Ability to write email messages and share real time information among colleagues regardless of geographic dispersion and time constraint	3.94	1.390	-0.254	0.801
General and technical writing				
Ability to write general reports in a concise and clear manner	5.06	1.413	4.254	0.000
Ability to write technical reports in a systematic and clear manner	5.00	1.481	3.819	0.001
Technical knowledge and skills				
Understand the technical terms used in the industry	5.23	1.564	4.363	0.000
Ability to understand technical drawings	4.68	1.326	2.844	0.008
Ability to use and research information effectively in report writing	4.91	1.329	3.859	0.001
Ability to express and organize ideas and information into knowledge for use by myself and others	5.09	1.254	4.935	0.000
Ability to communicate and present complex and technical information to a group of audience	4.81	1.447	3.177	0.003
Ability to apply analytic and problem-solving skills for research and inquiry	6.13	0.707	17.000	0.000

There are five (23%) specific communication skills with perceived preparedness mean scores that are statistically below 4 at p-value < 0.05 level. These are: (i) 'ability to incorporate appropriate oral presentation techniques in attracting and maintaining the attention of audience'; (ii) 'public speaking ability'; (iii) 'negotiation skills to achieving mutual benefits among different stakeholders'; (iv) 'ability to adapt to communicating and working in an automated office environment'; and (v) 'ability to write email messages and share real time information among colleagues regardless of geographic dispersion and time constraint'. This indicates that the respondents feel under-prepared in these specific communication skills, suggesting remedial action is essential to examine and improve the identified weaknesses in communication training. In particular, training in electronic communication skills where the perceived preparedness mean scores of both specific skills (items (iv) and (v)) are statistically below 4.

Table 3 shows the importance indices of the eight major communication skills categories for entry-level graduate position and job promotion. It can be seen that the top three skills categories for both entry-level graduate position and job promotion are identical. These are: (i) interpersonal communication skills; (ii) teamwork communication skills; and (iii) technical knowledge and skills. However, the interpersonal and teamwork communication skills are deemed the most valuable in job promotion, with pronounced increase in the respective importance indices. Similarly, the importance

attached to both the oral presentation and public speaking skills has increased by about 6% from entry-level position to job promotion.

Table 3: Importance of communication skills for entry-level graduate position and job promotion

Communication skills	Entry level		Job promotion	
	Importance index (%)	Rank	Importance index (%)	Rank
Technical writing	25.6	5	19.7	7
General writing	22.8	7	20.1	6
Interpersonal	35.1	3	58.7	1
Teamwork	37.8	2	58.7	1
Oral presentation	25.5	6	31.7	4
Electronic	34.8	4	16.8	8
Public speaking	16.3	8	22.4	5
Technical knowledge and skills	49.4	1	52.5	3

When asked to rate the effectiveness of eleven teaching and learning (T&L) activities towards developing the communication skills of civil engineer students, all activities have recorded mean scores above 4 except role-playing activities (mean = 3.50) as shown in Table 4. It is noted that the respondents place greatest emphasis on two T&L activities that aim to prepare students for industry-related experience (i.e., industry internship, mean = 5.97) and to gain exposure in the real work settings (i.e., guest lectures from industry practitioners, mean = 5.72). This is followed by T&L activities related to oral communication skills: (i) organizing seminars; and (ii) placing greater emphasis on oral presentations, addressing the respective deficiencies noted in Table 2. The importance of these T&L activities was further highlighted in their recommendations in the open-ended feedback question.

Table 4: Recommendations on teaching and learning activities for developing communication skills of civil engineering students

	Mean	Std. dev.
Placing greater emphasis on industry internship	5.97	1.60
Inviting industry practitioners as guest lecturers to share their knowledge about the industry	5.72	1.53
Organizing seminars to improve students' oral communication skills	5.63	1.36
Placing greater emphasis on oral presentations	5.50	1.08
Placing greater emphasis on technical workshops for students to gain hands-on experience on the application of technical equipment	5.44	1.41
Organizing small discussion groups	5.19	1.28
Placing greater emphasis on technical report writing	5.09	1.53
Organizing regular laboratory sessions for students to learn basic computer applications	4.75	1.68
Placing greater emphasis on group assignments	4.53	1.50
Placing greater emphasis on essay writing	4.19	1.60
Introducing role playing activities	3.50	1.65

5. Discussion

Encouragingly, the survey findings show that the graduates are generally satisfied with the communication training in their undergraduate civil engineering program, which adequately prepared them for workplace requirements after graduation. Although there are a few specific communication skills that were perceived inadequately prepared, these skills can be taught without adding new courses to the existing curriculum, provided new teaching activities and assessment tasks aiming at developing and testing these specific skills are implemented in some courses. For example, oral presentation techniques (such as eye contacts and body gesture) should be one of the assessment criteria in evaluating student oral presentation. Similarly, e-learning platform can be used for group-based assignments where students learn to communicate electronically including: (i) setting goals; (ii) documenting progress; (iii) group editing of document; and (iv) sharing of information. These communication activities could be accounted for in grading group assignments.

Although it is recognised that graduates assign varying importance to different communication skills in their career advancement, the findings suggest that interpersonal, teamwork, and technical knowledge are skills strongly affecting new civil engineering graduates' employability and their advancement and success in industry. Indeed, the importance of these employability skills has been reported in previous studies across different engineering specialties (e.g., Vest et al. 1996; Heitmann 2003; Markes et al. 2004). The curricular implication here is that group-based projects, which simulate 'real-world' experiences, would be ideal for practising such key communication skills, and fostering a cooperative (rather than competitive) learning atmosphere to reflect the interdependency of engineers in the workplace.

In terms of T&L activities, it is not surprising that the respondents have placed greatest emphasis on industry internship. The internship could provide students with opportunities and meaningful experiences applying theories and practices discussed and applied in the classroom environment, thus enhancing their employability skills. This is consistent with Koehn (2004), who found that, via practical industry experiences, civil engineering undergraduates could better appreciate the health and safety issues and ethical considerations in the industry, and more importantly, this could bring about better student performance in their: structural engineering course, project management/scheduling and estimating course; and teamwork exercise. Likewise, Tovey (2001) suggests that the environmental, social, and cultural conditions of the workplace can help students identify their own strengths, interests, and abilities, aiding them in making decisions about their education as well as their career path following graduation. The common decisions that students in the surveyed institution have made following their industry internship are i) changes in their specialties in civil engineering, and ii) selection of elective courses related to civil engineering applications.

6. Conclusions

A graduate survey can be a useful tool in evaluating a curriculum revision. It is believed that graduates with a certain amount of post-graduate working experience can supply an informed assessment of preparedness and importance of communication training of a program. This allows

engineering educators to reflect on the strengths and weaknesses of a program, and therefore to enhance the curriculum in problem areas demanding improvement.

Overall, the survey findings affirm the adequacy of communication training of the revised curriculum that integrates communication across different civil engineering core courses. The identified deficiencies in oral and electronic communication skills training could be addressed through better design assessment of communication skills and the use of group based projects in teaching. Also, the findings show that graduates agree on the importance of the same set of three communication skills for new civil engineering graduates' employability and advancement and success in industry. These skills, which relate to interpersonal communication skills, teamwork ability, and technical knowledge and skills, could be taught by: i) placing greater emphasis on teaching and learning activities that aim to prepare students for industry-related experience, and ii) promoting the role of the industry internship to gain exposure in the real work settings as recommended by the graduates. The latter requires a greater involvement of our industry partners regarding the placement and mentoring of our students during their internships.

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