Student perceptions of generic skills and attributes development

Ellen Lynch[a] and Chris Browne[a]
[a]Research School of Engineering, The Australian National University

Abstract

Ten thousand new, accredited engineering graduates seek full-time employment every year in Australia. Similar to other professional qualifications, accredited engineering programs require students to demonstrate the graduate attributes described in the Engineers Australia Stage 1 Competencies. We conducted a pilot study that asked students to evaluate their own development of graduate skills and attributes over the course of their undergraduate degree. We found three key different typologies that describe how students perceive their development: Journey, Sequence and Focused trajectories. Considering these different trajectories during curriculum design provides an opportunity to support student learning at different stages of individual student's degrees and ensure they achieve accreditation requirements.

Introduction

Research has highlighted a disconnect between student, academic and industry expectations of the importance of generic skills and attributes in professional practice. These studies have identified the importance of 'soft skills', such as management and communication in the workplace, and current university approaches are not preparing graduates adequately with these skills (Crebert, Bates, Bell, Patrick, & Cragnolini, 2004; Lang, Cruse, McVey, & McMasters, 1999).

This research aims to understand engineering students' perception of their skill and attribute growth over their degree. This research builds on Nguyen's (1998) study examining the essential skills for an engineer from the perspective of students, academics and industry personnel, and Pitt and Mewburn's (2016) work examining academic job descriptions.

Students were provided with the description and selection criteria from 20 graduate engineering job advertisements. In small groups, students coded the selection criteria from a subset of jobs into 16 given generic skills and attributes, such as technical proficiency and life-long learning. The students were individually asked to self-assess at which stage in their degree they believe they had or would attain these skills and attributes. From these data, we observed that students differ in the order in which they perceive to acquire these skills.

Current understanding of graduate skills

The necessity for generic skills and attributes has been identified as integral to ensure 'employability security' in a rapidly developing workforce (Bridgstock, 2009). Because of this, it is important that graduates are adaptable to changing requirements, evolving work environment and developing technologies (Bridgstock, 2009).

These recognised shifts have pressured the tertiary education sector to produce 'work ready' graduates with increased employability (Barrie, 2006). Employers need graduates to be able to *'function in the workplace, be confident communicators, good team players, critical thinkers,*

problem solvers and to be adaptive, adaptable and transformative people capable of initiating as well as responding to change' (Harvey et al. 1997 cited in Crebert, Bates et al. 2004). Moreover, several reports commissioned over the past decade by stakeholders in higher education all acknowledged that a strong disciplinary knowledge base does not solely guarantee a graduate job, and the importance of generic skills and attributes, often referred to as 'soft skills' cannot be overlooked (Crebert et al., 2004).

Government and accrediting bodies are increasingly placing an emphasis on generic graduate outcomes, preparing graduates for professional practice (Barnett, 1990; Barrie, 2006; Bridgstock, 2009). Every year in Australia over 10,000 students graduate with a Bachelor's degree as accredited Engineers (Engineers Australia, 2015). With approximately 60% of all trained engineers employed in occupations closely connected to engineering, the education and training of these professionals is paramount.

Nevertheless, it has been argued that it is unrealistic to guarantee students will graduate from a university with prescribed generic skills and attributes, but that this can be facilitated through teaching of 'meta-skills' or transferrable skills (Blumhof, Hall, & Honeybone, 2001). How well students develop these skills and attributes depends both on the individual students in regards to motivation and attitude and how well staff understand and support the development of graduate attributes (Crebert et al., 2004; Scott & Yates, 2002).

Previous work has produced a mixed understanding of the importance of certain skills and attributes. 'Backwards mapping' of skills and attributes has been used to inform curriculum design, with graduates and their supervisors observing the importance of 'emotional intelligence' capabilities, whilst acknowledging that most of the teaching time at university was dedicated to profession-specific knowledge and expertise (Scott & Yates, 2002). This has also been observed by industry identifying non-technical skills and experience as most important (Lang et al., 1999). However, technical skills have also been shown to be just as important as knowing how to behave and operate within a corporation (Nguyen, 1998).

Regardless of their relative importance, this paper contributes to this debate by examining students' perceptions of when during their degree they believe they develop generic skills and attributes and could be applied to other professional fields.

Method and Data Collection

We created two tasks to investigate students' perceptions of advertised industry requirements, requirements of the EA competencies and their own development of skills and attributes. 182 students completed two activities, administered in a second-year compulsory course at a research-intensive university.

Twenty online job advertisements for graduate engineering roles were selected as representative of the current job market. Students were provided a genericised version of the job advertisements, with identifying information such as location, salary and job title removed. Employers were denoted by pseudonyms; for example, Company A. The jobs were pre-coded to identify 16 similar skills and attributes required across all 20 job advertisements, listed in Table 1. For the purpose of analysis, these skills were grouped into five main dimensions, aligned similarly to Nguyen's (1998) areas of focus. 'Qualification' was not considered further in the results, as this dimension could only occur upon graduation.

Dimension	Skills/Attributes
Knowledge (Technical knowledge and skills)	Knowledge of standards Technical proficiency Software proficiency Engineering knowledge base
Attitude	Personal attitude Self-motivation Life-long learning
Professional (Social and professional skills)	Communication skills Team-work skills Time management Critical thinking skills
Experience	Professional conduct Stakeholder engagement Customer service Previous experience

Table 1: Dimension analysis of skills and attributes

A group workshop activity was designed which included a worksheet tasking students to identify which of the 16 skills were required for each of eight selected jobs. This was followed by an individual survey which asked students to identify when they believed they had or would have the 16 skills. The activity had human ethics approval, and students were informed of ethical concerns prior to commencing the activity. Surveys collected no personally identifiable information and students were not incentivised in any way to complete the study. Participation was optional, and students were informed that their contribution would not affect their marks in the course in any way.

Data collection and data entry

The activity was completed in 2016 in tutorial sessions over one week of a compulsory course. Students were given an introduction, and then 15 minutes to complete the group workshop activity in unallocated groups of 2-5 students. The activity was followed by a brief discussion, then students were asked to complete an individual survey that collected data about the population demographics, work experience, how many skills they thought graduates required to obtain a graduate role and the development of the generic skills and attributes over time.

Each worksheet and survey was given an identification code based on the collection group and small group. Once collected, the surveys were kept in sealed envelopes in a secure location. The interpretation of survey and worksheet data was straight-forward, requiring minimal coding or categorisation. Demographic information was collected, including age, gender, international/domestic and year of study. There was one text-based response on the survey, asking students to report their degree. Students who reported engineering, or variants of the degree including combined degrees were classified as engineering students. 'Other' was any other field, including computing, software engineering, science or other subject. 'NA' was used to report students who did not respond to the question or did not specify a degree field.

Students were asked to identify when they believed they developed or will develop the 16 skills in time periods of 'Start of degree', 'Now', 'By Graduation' and 'Not important to develop'.

Results

Basic demographic data from the survey responses are summarised in Table 2. For each category, the average perceived time taken to acquire each skill is reported. The majority of participants were male, and there were more international students than domestic. Approximately 90% of students were undergraduates completing a bachelor of engineering, 78% were 21 or under and 30% had completed a form of work experience. To compute the given data, numerical values were assigned to the responses: 'Not important to develop', 0; 'Start', 1; 'Now', 2; 'Graduation', 3.

			AVERAGE TIME OF SKILL/ATTRIBUTE ACQUISITION			
CATEGORY	Type	Total	Knowledge	Attitudes	Professional	Experience
Age	21 & under	142	2.59	1.56	1.83	2.25
	22 & over	39	2.36	1.64	1.95	2.23
	NA	1	-	-	-	-
Gender	Female	41	2.58	1.64	1.92	2.34
	Male	141	2.53	1.56	1.83	2.22
Status	International	99	2.53	1.63	1.91	2.30
	Domestic	83	2.56	1.51	1.78	2.20
Year level	1-2	89	2.54	1.58	1.85	2.25
	3+	93	2.54	1.58	1.85	2.25
Degree	Engineering	146	2.53	1.59	1.87	2.25
	Other	12	2.53	1.59	1.87	2.25
Work experience	None	130	2.60	1.62	1.90	2.30
	Any	52	2.40	1.47	1.72	2.13
	Sum	182				

Table 2: Demographic information of survey population

Table 2 shows that *Attitudes* and *Professional* skills are considered to be attributes that students generally perceive they come to university with or are acquired early in their degree, whereas Knowledge and Experience is developed later in their degree.

To understand whether or not work experience had an influence on student perceptions (Scott & Yates, 2002), the demographic categories were compared, shown in 3. Using Fisher's exact test, no statistically significant differences were found at a 95% confidence interval between gender, status and year level categories with respect to having worked in a professional engineering environment, and potential bias between categories was not considered further.

		Total	Any work experience	None	P value
Gender	Male	141	38	103	0.4326
	Female	41	14	27	
Status	International	99	31	68	0.4126
	Domestic	83	21	62	
Year level	1/2	89	22	67	0.3249
	3+	93	30	63	
	Sum	182			

Table 3: Comparison of work experience by demographics

We considered if demographics affected student beliefs on how many of the advertised skills are necessary for a graduate role, shown in Table 4. A small number of responses reported that no skills were required, so were omitted from reporting, alongside 'some' and 'most' being combined. Using Fisher's exact test, no statistically significant differences were found at a 95% confidence interval between gender, status and year level categories with respect to beliefs of number of skills required, and potential bias between categories was not considered further.

		Total	Some/Most	All	P value
Gender	Male	138	115	23	0.4524
	Female	40	36	4	
Status	International	97	84	13	0.5321
	Domestic	81	67	14	
Year Level	1/2	86	74	12	0.6821
	3+	92	77	15	
Work Experience	Any	46	42	4	0.1594
	None	127	104	23	
	Sum	178			

Table 4: Comparison of number of skills required for a graduate engineering role by demographics

Description of Student Typologies

An analysis of survey data showed that in almost all situations graduates believed that they would acquire the relevant skills for a graduate position on or before graduation. However, the sequence and timing of developing these attributes varied over time, with *Attitudes* and *Professional* tending to be acquired early, and *Knowledge* and *Experience* tending to be acquired later in a degree program. It is important to also note that skill attainment in this study was binary, and that further work in this area could investigate the acquisition of skills on a continuous scale.

The combinations of individual's perceptions were analysed to determine whether there was any common trends between responses. Three main typologies emerged from these data, described as *Journey*, *Sequence* and *Focused* learning trajectories. These categories are shown in Table 5 for the skill dimensions.

	Start	Now	Graduation	% of all responses
Journey		Attitudes		28.0
			Knowledge	
		Professional		
		Experience		
Sequence	Attitudes			21.1
			Knowledge	
	Professional			
		Experience		
Focused	Attitudes			18.9
		Knowledge		
	Professional			
		Experience		

Table 5: Classification of typologies

The typologies were mapped to demographic traits to investigate if different groups of students perceive attribute acquisition differently. These data are shown in Table 6. Gender, status and work experience show significantly different results at the 95% confidence interval using Fisher's Exact Test, suggesting that these demographic factors are an indicator for how students perceive they acquire skills.

Category	Type	Journey		Sequence		Focused		P-value
		Count	%	Count	%	Count	%	
Gender	Female	14	34.1	7	17.1	11	26.8	0.000361
	Male	35	25.0	30	21.4	22	15.7	
Status	International	29	29.6	18	18.4	10	10.2	0.0462
	Domestic	20	24.1	19	22.9	23	27.7	
Year level	1-2	10	11.2	21	23.6	14	15.7	0.562
	3+	21	22.8	16	17.4	19	20.7	
Work experience	None	35	27.3	7	13.5	12	23.1	0.00517
	Any	13	25.0	30	23.4	21	16.4	

Table 6: Summary statistics of learning typologies by demographic

The cumulative trajectory of skill development have been plotted in Figure 1 for each dimension of the attributes. It shows in general that Attitude and Professional skills are those that students believe they have acquired by 'now', but that Experience and Knowledge are attributes they will acquire by graduation. Journey learners tend to be more conservative in their timelines, whereas Focused learners tend to be more forthright in their perceptions.

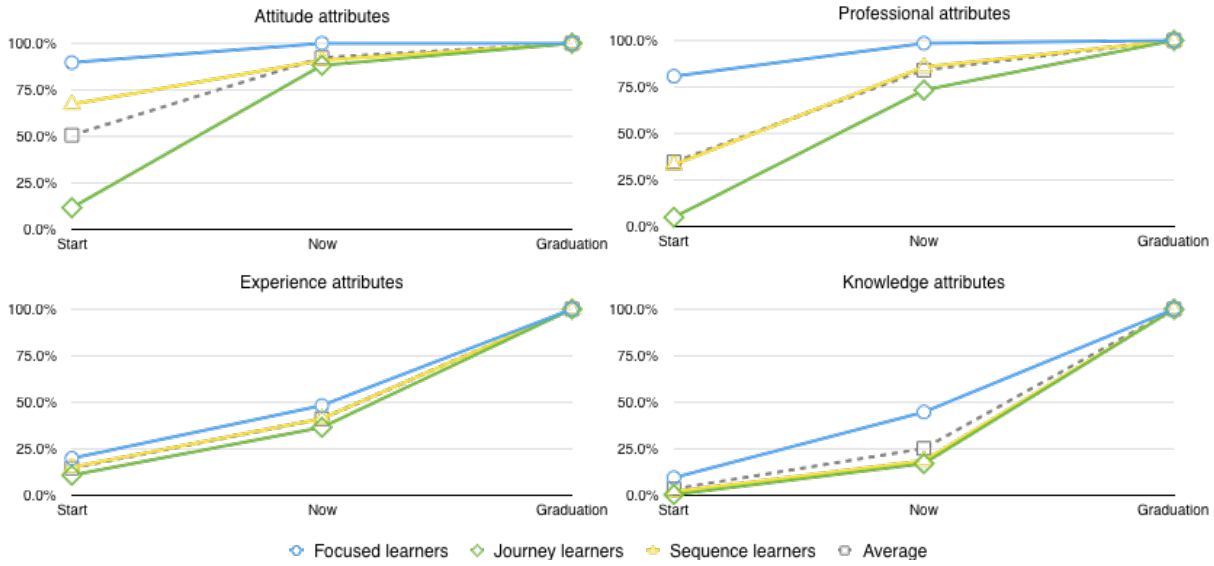

Figure 1: Attribute acquisition for learning typologies

A brief summary of the three learning typologies follows.

Journey

We describe this category as 'on a journey', as development of professional skills and attitudes may indicate more of a balanced development of all skill dimensions over their degree. 28% of students surveyed were identified to be in the journey category. Females, international students and later-year students were more likely to be journey learners. Journey learners were

also more likely to have completed work experience and may therefore understand how much more they need to develop to meet industry standards (Crebert et al., 2004).

Sequence

Sequence learners demonstrate a middle-ground between Journey and Focused typologies, making progression on different skills over their degree. *Attitudes* and *Professional* skills are acquired generally before *Experience* and *Knowledge.* Overall, 20% of students surveyed were identified to be 'Sequence' learners. Sequence learners were more likely to be males, domestic students and those with work experience.

Focused

Focused learners appear to focus on content and knowledge, and reported coming to university with pre-developed professional skills and attitudes. Overall, these students believed they possessed the skills and attitudes sooner than any other group. 18% of those surveyed were identified to have a 'Focused' learning trajectory. Focused learners tended to be females, domestic students and with no work experience.

Discussion

Curriculum design often treats students as a homogenous cohort. However, the suggested typologies indicate a need to support different stages of student learning and development at different times to ensure growth is continuous and studies remain personally relevant (Felder & Silverman, 1988).

One observation about the data collected is that it is only based on student perceptions. Students were not, for example, tested or validated as having achieved these skills across a common benchmark. A good example here is time management, where a student might perceive having good time management skills because they submit their assignments on time, despite having left starting the assignment to the last possible minute (John & Robins, 1994).

In addition to differences across individual's perceptions of skill acquisition, an individual is likely to develop and refine these skills over time. For example, the students who had good time management but left starting their assignments to the last possible minute may learn from experience to refine their manage their time better, and reflect on their earlier self as not having time management skills. A limitation of the current data could not be used to investigate absolute differences between individuals, or differences over time (Anderson, 1981).

Another important consideration is that almost unanimously students believed that they would acquire all the skills listed by graduation. This could be explained through the faith that students may have in their educational institution, but could also be explained as a misconception that graduation is the end of their learning, rather than a stepping stone for life-long learning (Stein & Irvine, 2015). For example, the time management required of a professional is different from that of a student, and if the graduate does not continue to refine and develop their skills they may not progress in their career (Crebert et al., 2004).

To this end, the data can be used as a starting point to help enable all students to continually grow into well-rounded 'work-ready' graduates. It may be assumed that students are more likely to focus on skills they do not have, meaning the skills students believe they possess may not be growing at the necessary rate (Anderson, 1981). Moreover, all typologies may benefit

from creating realistic and identifiable benchmarks for technical knowledge throughout the degree. This may be achieved by communicating clear milestones in the early years, but also increasing the focus on growing technical knowledge alongside professional skills through industry integration (Crebert et al., 2004).

Suggestions to support Journey learners

To support 'Journey' learners the benchmarks of attributes and skills' horizon may need to be initially limited and incrementally increased. The learning development of these students is gradual growth over time, to possess skills later. By lowering the initial benchmark and increasing it over their degree, these students' development could increase with expectations, ensuring they are definitely prepared for industry (Anderson, 1981). Additionally, these students would benefit from work experience placements to help nurture all of their development dimensions earlier (Crebert et al., 2004; Scott & Yates, 2002).

Suggestions to support Sequence learners

To support 'Sequence' learners, a greater focus on continuously growing all skills, rather than focusing on one is suggested (Biggs & Tang, 2011). As these students believe they possess skills early, there is no defined way of monitoring continued growth. Assuming their focus is on a singular dimension, the other dimensions may not be grown at the same rate and as their expectations are not increasing, they may not meet industry requirements by graduation. A possible solution to help the sequence learners is integration of attitudes and skills assessment with increasing difficulty, in addition to encompassing all dimensions and promoting progression of all simultaneously (Anderson, 1981). This allows students to be continuously growing in all dimensions to ensure they meet industry standards by graduation.

Suggestions to support Focused learners

To support 'Focused' learners, a greater focus on assessing and promoting personal skills and attributes is suggested. By evaluating and incrementally growing skills it ensures students realise the importance of all dimensions (Bennett, Dunne, & Carré, 2000). Because these students appear to develop personal skills and attitudes early, their focus may not be on developing them (Anderson, 1981). Consequently, they may fall short of industry standards as the skills and attributes are not actively grown over time. Focused learners may also benefit from integrating 'soft skills' awareness into the curriculum and continuously promoting growth (Crebert et al., 2004).

Conclusion

The importance of developing generic skills and attributes as an engineer cannot be overlooked. By understanding the typologies of student development in key generic skills and attributes, curriculum can be tailored to ensure all students grow into diverse, flexible and capable graduates. Students' development over time revealed three key typologies: Journey, Sequence and Focused skill development trajectories. These typologies have been used to make individual suggestions to support these students in their journey and decrease the discrepancy between students' abilities and industry requirements. This pilot study points to many areas of further research, such as a longitudinal study to track students' development over a number of years and comparison across cohorts and institutions. As it stands, these findings will be used as one source of information to facilitate changes in curricula to equip graduates with the skills to meet industry expectations and navigate a rapidly changing world.

References

Anderson, J. R. (1981). *Cognitive skills and their acquisition*: Psychology Press.

Barnett, R. (1990). *The idea of higher education*: McGraw-Hill Education (UK).

Barrie, S. C. (2006). Understanding What We Mean by the Generic Attributes of Graduates. *Higher Education, 51*(2), 215-241. doi:10.1007/s10734-004-6384-7

Bennett, N., Dunne, E., & Carré, C. (2000). *Skills Development in Higher Education and Employment* (Society for Research into Higher Education Ed.). Buckingham [England] ; Philadelphia: Society for Research into Higher Education & Open University Press.

Biggs, J. B., & Tang, C. (2011). *Teaching for quality learning at university: What the student does*. Milton Keynes, United Kingdom: McGraw-Hill Education.

Blumhof, J., Hall, M., & Honeybone, A. (2001). Using problem-based learning to develop graduate skills. *Planet, 4*(1), 6-9.

Bridgstock, R. (2009). The graduate attributes we've overlooked: Enhancing graduate employability through career management skills. *Higher Education Research & Development, 28*(1), 31-44.

Crebert, G., Bates, M., Bell, B., Patrick, C. J., & Cragnolini, V. (2004). Developing generic skills at university, during work placement and in employment: graduates' perceptions. *Higher Education Research & Development, 23*(2), 147-165.

Engineers Australia. (2015). The engineering profession: a statistical overview. *Canberra: Engineers Australia*.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering education, 78*(7), 674-681.

John, O. P., & Robins, R. W. (1994). Accuracy and bias in self-perception: Individual differences in self-enhancement and the role of narcissism. *Journal of Personality and Social Psychology, 66*(1), 206-219. doi:10.1037/0022-3514.66.1.206

Lang, J. D., Cruse, S., McVey, F. D., & McMasters, J. (1999). Industry expectations of new engineers: A survey to assist curriculum designers. *Journal of Engineering Education, 88*(1), 43-51.

Nguyen, D. Q. (1998). The essential skills and attributes of an engineer: A comparative study of academics, industry personnel and engineering students. *Global Journal of Engineering Education, 2*(1), 65-75.

Pitt, R., & Mewburn, I. (2016). Academic superheroes? A critical analysis of academic job descriptions. *Journal of Higher Education Policy and Management, 38*(1), 88-101.

Scott, G., & Yates, K. W. (2002). Using successful graduates to improve the quality of undergraduate engineering programmes. *European journal of engineering education, 27*(4), 363-378.

Stein, J., & Irvine, A. (2015). *Career preparedness and lifelong learning*: Salt Lake City, USA.