Engineering Graduate Program – how it affects the skills, attributes and career development of graduate engineers

Vivian Preston & Steven Goh
University of Southern Queensland
steven.goh@usq.edu.au

Structured Abstract

BACKGROUND
An Engineering Graduate Program (EGP) generally refers to a structured program within an engineering company that has been specifically designed to assist a University engineering graduate's transition into the workforce. It is important to ensure graduates are informed in applying for the various EGP as graduate employment can extend up to four years, requiring a large commitment from the graduate. With the overload of information about EGPs provided by hiring companies, this decision can become both confusing and overwhelming.

PURPOSE
There is a broad and varied spectrum of EGP dependent on the respective engineering employers. The aim of this research study was to provide an insight into a small sample of different EGPs. In doing so it aimed to assist engineering graduates in making more appropriate employment decisions. The following questions prompted this research study:

- Will it matter what company a graduate chooses to gain employment with?

- Are some graduate positions better than others? If so, in what way?

- What can be expected during the first few years of graduate employment?

- How will a graduates skills and attributes develop throughout this time?

- Will the choice of employment influence future career opportunities?

METHOD
This study used online non-validated surveys to gather information on graduate performance over a three month period from two perspectives; the graduate and their supervisor. Five engineering companies participated, each with a minimum of two Bachelor of Engineering graduates and their corresponding supervisors. Due to the nature and sensitivity of survey questions, all participants and their respective employers have been kept anonymous for the purpose of this research study.

RESULTS
Two types of EGP structures were identified in this study; Formal and Informal. Distinct differences in graduate performance and attitude were found between the two types of EGP structures. These differences could be linked to the nature of the EGP styles. This study also found that the difference in perceptions of graduate performance exist between graduates and their supervisors.

CONCLUSIONS
No matter what type of EGP an engineering graduate chooses, findings in this study show that improvement in skills, attributes and attitudes come with time and that career progression is, by nature, somewhat organic. It has however identified trends in skills and attributes that are better focussed on in each style due to the nature of the EGP. The author acknowledges that there is no right or wrong types of EGP, rather it is on an individual bases as to which EGP is better or rather appropriately suited for the individual graduate.

KEYWORDS
Graduate development, graduate training, career development, engineering graduate program

1   Introduction

Most engineering graduates, upon completion of a Bachelor of Engineering (BEng) degree, begin their career as a graduate engineer. To assist in the graduate's transition from University into the workforce, companies generally provide additional support to the graduate. In this study, this transition period is referred to as an Engineering Graduate Program (EGP) and normally covers the first few years of graduate employment.

It is perhaps due to the broad nature of engineering that there does not seem to be one standard EGP structure. As such, the following questions prompted this research study:
- Will it matter what company a graduate chooses to gain employment with?
- Are some graduate positions better than others? If so, in what way?
- What can be expected during the first few years of graduate employment?
- How will a graduates skills and attributes develop throughout this time?
- Will the choice of employment influence future career opportunities?

This project aims to study several EGPs by determining graduate initial skills and attributes levels, discover what changes occur over a three month period and relate this to their career development. It also aims to discover if the graduate's own perceptions of his or her skills differ from those of their supervisor.

It is hoped that the outcomes of this study will assist graduate engineers with their evaluation and selection of EGPs while providing an insight into their first few years of employment. In addition, the findings presented in this study may also assist engineering companies with implementing an EGP or re-structuring of an existing EGP by providing feedback as to the strengths and weaknesses of current EGPs.

2   Literature Review

A literature review identified many skills and attributes that are important for both graduate and experienced engineers. These were gathered from literature covering the following three categories;
- Professional requirements: Engineers Australia (EA) Stage 1 (Engineers Australia 2012) and Stage 2 competencies (Engineers Australia 2011);
- Academic requirements: The University of Southern Queensland (USQ) generic graduate attributes (USQ 2010) and engineering graduate attributes (USQ 2009), the University of Queensland (UQ) general graduate attributes (UQ 2011) and engineering graduate attributes (UQ 2012) and the University of Sydney (US) general graduate attributes (US 2004) and engineering graduate attributes (US 2009); and
- Previous graduate skills and attributes research studies on engineering graduates by Nguyen (1998), Male et al. (2009), Male et al. (2010), Tong (2003), Passow (2012) and general graduates by the Australian Association of Graduate Employers (AAGE) as rated by employers (AAGE 2011a) and as rated by graduates (AAGE 2011b).

A list of 29 skills and attributes and nine attitudes was developed from the above research and used in this study. Of these, only those that contributed to research outcomes are discussed in this paper. As the sample size used in this study was small, skills and attributes were kept relevant to general engineering and not discipline specific.

It was found that many of the engineer skills and attributes studies recommended further research, in turn supporting a study like this one. The review also indicated that there have been very few time dependant studies done to date and no studies were found that used a dual perspective to analyse skill or attribute studies on engineers, thus relying on one opinion only which may or may not have skewed results. It is believed the combination of time dependency and dual perspective make this research study unique and of value to the engineering body of knowledge.

An engineering graduate survey conducted by The Association of Professional Engineers, Scientists and Managers, Australia (APESMA) found the following important issues as identified by survey respondents that are particularly relevant to this research study:

- "Engineering course structures are not geared towards the needs of industry;
- Degrees need greater emphasis on communication, management and marketing skills;
- Companies do not invest enough in ongoing training of their engineers;
- Employers lack structured training program for new graduates; and
- Some companies' graduate programs look great on paper but do not always achieve the goals they commit to." (APESMA 2011, p. 14)

These comments made by graduate engineers in 2011 were in line with those of previous annual studies, indicating ongoing issues with University education shortfalls, workplace training and EGP structures in Australia.

The final area covered in the literature was survey design as this was highlighted by its potential to have a direct effect on the accuracy and integrity of survey responses (SurveyMonkey 2011). In his study of the importance of Accreditation Board for Engineering and Technology (ABET) competencies, Passow (2012) made wording changes to some competencies midway through the study. This caused importance ratings to change significantly and highlights the significance of clear survey questions as not to skew the results. As such, recommendations by SurveyMonkey (2011) were taken on board during survey design to maximise the integrity of data captured as part of this research study.

3   Methodology

The scope of study is focussed on graduate engineers who have recently attained a BEng, within the past two years and are working in Australia. Information was gathered using online survey questionnaires that were developed in accordance with the recommendations in the literature review. It has been assumed that data supplied by participants during both surveys is honest, accurate and relevant and that each supervisor is in a position to enable them to answer the survey questions about the relevant graduate accurately and fairly.

To recruit participants, a list of potential engineering companies was prepared through internet searches, career websites and word of mouth. These companies were contacted via phone or email to determine if they met the participation requirements and were willing to participate. In order to allow for this comparison, a minimum of two graduates and their respective supervisors were required to participate for each company. It was thought that this would enable cross checking similarities and differences between graduates of the same company. As the surveys in this study ask for information and opinions relating to graduates, supervisors and their respective companies, findings presented in this study are done so anonymously.

Limitations of the study included the following:

- The observation timeframe between initial and follow-up surveys was restricted to three months due to University research dissertation strict deadlines;
- Many of the engineering companies approached to participate in this research study were concerned about providing graduate performance opinions and information in the surveys, making it difficult to recruit participants for this research study;
- Given the small sample size, it was not possible to select a single discipline and hence the study is not discipline specific.

Given these limitations, it was decided that five different engineering companies would give a good basis for EGP comparison. In total, twelve pairs of graduates and corresponding supervisors participated in this study, two – three from each different company.

4   Findings & Discussion

A five point rating scale was used for majority of survey questions in this study. Table 1 details four of the scales to assist in interpretation of results in the proceeding sections. These rating scales are referenced in this study as Rating Scale/Rating; example RS1/3.47 indicates scale RS1 was used with an average rating of 3.47. Generally, the lower end of the rating scale indicates a less favourable rating whereas the higher end indicates a more favourable rating.

Table 1: Rating Scales used in study

Rating Scale	(1)	(2)	(3)	(4)	(5)
RS1	Poor	Below average	Average	Above average	Excellent
RS2	Not at all prepared	Somewhat prepared	Prepared	Well prepared	Very well prepared
RS3	Not as expected	-	As expected	-	Better than expected
RS4	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied

4.1   Engineering Graduates

The analysis has demonstrated graduate strengths and weaknesses that appear to be similar across all graduates participating in this study. These are presented in Table 2 and use the RS1 rating scale.

Table 2: Graduate strengths and weaknesses

Strengths		Weaknesses	
Skill Attribute	**Average Rating (RS1)**	**Skill Attribute**	**Average Rating (RS1)**
Ethical conduct	4.17	Experiments	2.96
Teamwork	4.08	Networking – diverse groups	3.08
Problem solving	3.96	Financial / cost control	3.13
Self-management	3.92	Networking – outside organisation	3.25
Lifelong learning	3.92	Negotiation	3.29
		Drawing / sketching	3.29

Ethical conduct, Teamwork, Problem solving, Self-management and Lifelong learning appear to be focussed on heavily at University and are in line with those graduate skill and attribute strengths identified in the literature review. On the other hand, Experiments, Networking (outside organisation and diverse groups), Financial / cost control and Negotiation featured as graduate weaknesses in the literature review. As this study has found similar trends in graduate strengths and weaknesses to those found in previous studies during the literature review, it has given a good indication that results of this study are valid. This indicates that the findings presented in the following sections may be a sufficient representation of engineering graduates, even though the sample size used in this study was small.

In addition, survey respondents indicated that Negotiation, Software exposure and Technical skills directly relevant to current career paths were lacking in their University qualification. As engineering disciplines and specialist areas can be broad in industry, the author believes that this is, and will continue to be, an issue for Software exposure and relevant Technical skills that can only be helped by the student having a clear idea of what specialist area they want to pursue and selecting a more specific type of degree that some Universities offer. However when a student is unsure of the exact speciality they will, or would like to, pursue in the workforce, a general degree in their field of interest is most likely the best option. A specialist degree for this type of student may limit their career options after University. This does however indicate that improvements to University degrees may be required, perhaps by extending the program an additional year to address the shortfalls.

On the other hand, the most beneficial skills and attributes that graduates gained during their University degrees were Research, Problem solving, Teamwork and general Technical skills. This is reflected in the following sections of this chapter when graduates ranked their current

level of these, and other, skills and attributes highly. This is a positive reflection on University courses in Australia.

4.2   Engineering Graduate Programs

Information collected from engineering graduates and their supervisors in this study could be classified in to one of two distinctly different structures of EGPs. For the purpose of this study, these have been named Formal and Informal.

Formally structured EGPs generally include rotations (either between projects and / or departments), training and variety of work leading to graduates being exposed to many aspects of the engineering industry. Graduates on these programs felt they were better prepared by their University degree (RS2/3.43) than Formal graduates. This may be linked to the fact that this Formal style of EGP appears to better utilise non-technical skills that were developed well during University. Supervisors of these graduates indicated their graduate had good Time management skills (RS1/4.29) compared with the Informal group (RS1/3.60), although it is unclear if this is a perception based on graduates following a structured program making this easier. Supervisors also felt that it took these graduates less time on average to develop into qualified engineers (2.71 years) than those in the Informal group, highlighting the importance of non-technical skills in engineering. It is interesting to note that these graduates rated their expectations and satisfaction with the EGP lower (RS3/2.14 and RS4/3.57 respectively) compared with Informal graduates. This could be due to the variety and rotations being unexpected or force the graduate out of their comfort zone.

Informal EGPs tend to be flexible and tailor better to the individual graduates while providing more responsibility and leadership opportunities than Formal EGPs (according to survey respondents). These graduates reported gaining more technical skills as the EGP was very hands on however they felt that their University degree did not prepare them as well (RS2/2.40) as it did for Formal graduates. Graduates were unclear as to the duration of their graduate role and supervisors felt that it takes a graduate on this style of program longer to be classified as an qualified engineer (3.40 years) than those on Formal programs. Overall, these graduates indicated a higher satisfaction (RS3/3.00) and expectation (R/4.20) rating in regards to their EGP and also showed much higher loyalty (RS1/4.60) than Formal graduates (RS1/3.71). The author believes that this is due to the fact that this style EGP is better suited to the individual and that these graduates indicated they received more support from senior staff members than Formal graduates did.

Table 3 outlines skills and attributes where there was a distinct difference in performance level between the two groups, as ranked by graduates. The trend for Formal graduates being better developed in non-technical skills and attributes and Informal graduates being better developed in technical skills and attributes is evident in this table.

Table 3: Skill and attribute levels as ranked by graduates

Skill attribute	Formal (RS1)	Informal (RS1)
Research skills	**4.00**	3.00
Supporting / mentoring others	3.00	**4.00**
Drawing / sketching	2.71	**3.60**
Lifelong learning	**4.14**	3.40
Engineering practical knowledge	3.29	**3.80**
Networking – diverse groups	**3.00**	2.60
Knowledge of tools/materials relevant to discipline	3.43	**3.80**
Decision making	3.43	**3.80**
Leadership	3.43	**3.80**
Self-management	3.43	**3.80**
Problem solving	**4.14**	3.80
Communication – written	**3.71**	3.40
Negotiation	3.29	**3.60**

4.3   Time Dependencies

A simple (1) Yes (0) No scale was used to assess graduate improvement over the three month observation period. Distinct general differences in the improvement rating between Formal and Informal groups were evident and these are listed in Table 4.

Table 4: Highest improvement level of skills and attributes over observation period.

Formal EGP	Informal EGP
Teamwork	Engineering theoretical knowledge
Lifelong learning	Critical thinking
Time management	Modelling
Self-management	Experiments
Negotiation	Drawing / sketching
Acceptability to change	Supporting / mentoring others
Networking (all three types)	

Again, it can be seen that the Formal graduates improved more in the non-technical skills. In particular Teamwork, Lifelong learning, Time management and all three forms of Networking have all been discussed as being a reflection of the Formal EGP structure. This further confirms that the improvements are due to the EGP structure as they are consistent over the three month observation period. Informal graduates improved more in technical and leadership type skills. Again, these skills listed in the above table can be related to the structure of the Informal EGP.

Although the above skills and attributes showed a distinct improvement tendency to one particular group of EGP structures, this study identified issues of perceptions when ranking graduate performance. This is summarised in Table 5. Graduates have a tendency to over-rate themselves on majority of the skills compared to supervisors. The four skills in the combination category are those which one group over-rated and the other under-rated. This further illustrates the wide perception difference amongst the graduates and supervisors.

Table 5: Tendencies for rating improvement of skill attributes.

Graduates rated higher	Supervisors rated higher	Combination
Critical thinking	Acceptability to change	Research skills
Creativity	Networking – within the organisation	Ethical conduct
Decision making		Supporting / mentoring others
Communication – oral and written		
Teamwork		
Leadership		
Lifelong learning		

Attitude improvements were ranked using the scale (-1) Worse, (0) Same and (1) Better. It was encouraging seeing that graduates and supervisors averaged the same rating within each group for confidence; 0.83 for Formal and 0.80 for Informal. This indicates that regardless of perspective or type of EGP structure, improved confidence is a natural progression. Loyalty average ratings over the three month observation period for Formal graduates showed a decline (-0.17) compared to Informal graduates (0.40). Loyalty was already ranked substantially lower by Formal graduates (RS1/3.71) than Informal graduates (RS1/4.60) in the initial surveys and this further supports the pattern that loyalty continues to decline while the Formal graduate is employed on their EGP.

4.4   Engineering Graduate Program Summary

No matter what type of EGP an engineering graduate chooses, results in this study show that improvement in skills and attributes come with time and that career progression is a natural pathway. It has however identified trends in skills and attributes that are better focussed on in each style due to the nature of the EGP. A summary identifying the traits unique to each group is presented in Table 6. The author acknowledges that there is no right or wrong EGP, rather it is on an individual bases as to which is better EGP for the individual graduate. However the author believes that there is a need for a hybrid program that may or may not

already exist, for those graduates who would like an all in one EGP that combines the best of the Formal and Informal EGPs.

Table 6: Summary of traits unique to each style of EGP.

Formal EGP	Informal EGP
Rotations	Responsibility
Variety	Independence
Networking	Leadership
Training	Performance based progression
Guided	Strong technical focus
Structured	Sink or swim approach
Clear timeframes	Unclear timeframes
Lifelong learning	Flexible and tailored to Graduate

4.5   Recommendations for graduate engineers

As a result of findings presented throughout this study, a guide has been prepared to inform engineering graduates of what to expect from graduate employment and to assist them with making employment selection (Table 6).

Table 6: A guide for graduate engineers.

Formal EGP	Informal EGP
Choose this type of EGP for graduates who: • Are unsure of specialty area to pursue • Would like variety in their role • Want to continue self-development through training • Want to improve their confidence	*Choose this type of EGP for graduates who:* • Know which specialty area to pursue • Would like to develop or utilise leadership / management skills • Want a more technical role • Enjoy responsibility and independence • Work well under pressure • Have high confidence

The author recommends that the soon to be graduate engineer decide which set of skill attributes they want to develop together with the type of program inclusions that best suit their needs to determine which style EGP is best suited to them.

5   Implications & Recommendations

5.1   Recommendations

Many important lessons have been learnt throughout the course of this research study and as such the author has made the following recommendations for future studies on EGPs:
- Increase the sample size to increase validity of such a study.
- Differentiate between engineering disciplines to ascertain if this has an effect on graduate performance and development.
- Identify other types of EGP Structures. It is recommended that more investigation be done into the EGP structure as there may very well be more than two types as identified in this study, there may also be hybrids structures.
- Consider the type of engineering role, for example site or design, as this may have a significant impact on results and should be considered when defining EGP structure categories in future studies.
- Ensure supervisors are equipped to assess graduate performance. The author is not sure of the best way to do so, however it will again add integrity to the results of future studies.
- Establish which perception is a 'more correct' representation of actual performance ability for each of the skills and attributes.

- Increase length of observation period to give a better indication of time dependent development and ideally conduct the initial survey within the first few months of the graduate's employment to give better initial performance indications.
- Use a percentage rating scale for rating skills and attributes. The rating scale used to rank graduate skills and attributes made analysing results difficult, as they rated themselves to their 'ideal' current performance instead of mastering of the skill or attribute. It is recommended that a percentage type scale be used where zero reflects a non-existent skill and 100% reflects a perfected skill. It is hoped that this will enable graduates and supervisors to indicate more accurate ratings that allow for future improvement and that this scale can be used in the follow up survey as well, rather than the Yes/No scale that was used in this study.
- Another important area that should be covered is graduate salary to identify how this relates to performance and attitude.

5.2   Implications

This study has suggested some shortfalls in tertiary education and the authors believe that considerations should be given to extending the BEng an extra one year to address this issue. It is hoped that the results presented in this study will give graduate engineers an insight into the differences between Formal and Informal types of EGPs. As such, they will be better prepared as to what to expect in their graduate role. Loyalty of graduates, particularly those on Formal EGPs, will most likely improve as a result of higher expectation and satisfaction ratings. Employers may find it beneficial to take the findings presented in this research study on board when developing or restructuring their EGP to improve graduate development.

6   Summary

This study has found that the structure of EGP may affect the skills, attributes and career development of graduate engineers. It has shown that there are unique differences in graduate development between the two types of EGP structures; Formal and Informal. Formal EGPs appear to encourage continued graduate development through training and lifelong learning while guiding the graduate using a pre-defined structure. It exposes the graduate to a broader scope of engineering due to project or department rotations. Informal EGPs tend not to have an official structure and are normally dependant on graduate performance, development and competency as to how they progress. This style tends to give the graduate greater responsibility, independence and leadership opportunities while heavily focussing on the technical nature of engineering. The scope of the graduate role is narrower as it appears to specialise in one particular area or field of engineering.

Recommendations for graduates to assist choosing an EGP have been presented in this research study; however it is important to reiterate that the sample size used was small and only five EGPs were examined. Therefore caution is urged when making graduate employment decisions based solely on this research dissertation. In addition, there may well be intermediate style EGPs that exist yet were not included in the sample size or identified in this study. The author believes that these programs may incorporate a 'best of both worlds' scenario; however it is left to future studies to explore this further.

In addition, results have indicated that perceptions do influence the ratings of graduate performance. As such it is possible that some previous studies on graduate performance may be misleading or biased due to the perceptions of the group of survey respondents selected. For example, some studies that identified skill attributes lacking by graduate engineers, from an employer's perspective, concluded that the graduates themselves were lacking in these areas. However, the results of these studies may rather be the EGP is lacking development of these performance areas rather than the graduates themselves. In addition, the choice of employer perceptions may also introduce misleading results in that

their opinion of some performance areas may not be the most correct. Therefore, it has been recommended to assess the areas of graduate performance to identify which perception is a more accurate representation of actual performance.

Finally, this study has also found that an opportunity may exist to improve the BEng program by extending one additional year to include the identified shortfalls. There is opportunity to explore with future studies under larger sample sizes to expand upon this point.

7   References

AAGE 2011a, *The AAGE Employer Survey 2011: Survey Report*, Australian Association of Gradaute Employers Ltd, Mitcham North.

---- 2011b, *The AAGE Candidate Survey 2011: Survey Report*, Australian Association of Graduate Employers Ltd, Mitcham North.

APESMA 2011, *2011 Graduate Engineer Employment Survey Report*, Melbourne, viewed 04 August 2012.

Engineers Australia 2011, ENGINEERS AUSTRALIA Chartered Status - a Handbook for Applicants, Barton ACT.

---- 2012, 'STAGE 1 COMPETENCY STANDARD FOR PROFESSIONAL ENGINEER', viewed 16 Marh 2012, <http://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/110318%20Stage%201%20Professional%20Engineer.pdf>

Male, SA, Bush, MB & Chapman, ES 2009, 'Identification of competencies required by engineers graduating in Australia', pp. 882-7,

Male, SA, Bush, MB & Chapman, ES 2010, 'Perceptions of competency deficiencies in engineering graduates', *Australasian Journal of Engineering Education*, vol. 16, no. 1, pp. 55-68,

Nguyen, DQ 1998, 'The Essential Skills and Attributes of an Engineer: A Comparative Study of Academics, Industry Personnel and Engineering Students', *Global Journal of Engineering Education*, vol. 2, no. 1, pp. 65-76,

Passow, HJ 2012, 'Which ABET Competencies Do Engineering Graduates Find Most Important in their Work?', *Journal of Engineering Education*, vol. 101, no. 1, pp. 95-118, EBSCOhost, a9h, item: 71608309.

SurveyMonkey 2011, 'Smart Survey Design', <http://s3.amazonaws.com/SurveyMonkeyFiles/SmartSurvey.pdf>

US 2004, *Policy Framework*, viewed 28 March 2012, <http://www.itl.usyd.edu.au/graduateAttributes/policy_framework.pdf>.

---- 2009, *Graduate Attributes in Engineering*, viewed 28 March 2012, <http://sydney.edu.au/engineering/civil/current/undergraduate/attributes.shtml>.

Tong, LF 2003, 'Identifying essential learning skills in students' Engineering education', Monash University Malaysia.

UQ 2011, *3.10.05 Graduate Attributes*, viewed 01 April 2012, <https://ppl.app.uq.edu.au/content/3.10.05-graduate-attributes>.

---- 2012, *Graduate Attributes*, viewed 01 April 2012, <http://www.eait.uq.edu.au/graduate-attributes>.

USQ 2009, *USQ Engineering Graduate Skills Table*, USQ, viewed 01 April 2012, <http://usqstudydesk.usq.edu.au/mod/resource/view.php?id=120527>.

---- 2010, *The Qualities of a USQ Graduate*, viewed 01 April 2012, <http://policy.usq.edu.au/portal/custom/detail/the-qualities-of-a-usq-graduate/>.