

How engineers become CEOs: implications for education and training

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ABSTRACT

Purpose: This paper provides results of an investigation into the career progression of engineers in Australia, determining the skills and qualities they need to become large company CEOs and thus recommend strategies for long term career development.

Design/methodology/approach: This investigation used a questionnaire to gain a view on the perceptions of top-level executive who have an engineering degree on the training of engineers. It was aimed at discovering their perceptions as to the skills and attributes that they possessed that had assisted in their success. Questionnaire participants were selected on the basis that they held a Bachelors degree in Engineering and have been successful in the business world. These participants were sourced from the "Who's Who In Business" (WWIB) database. In order to maximize the level of responses, the questionnaire was distributed by both email and regular mail.

Findings: Findings indicate: CEOs often reach their position as natural career progression rather than actively seeking management; key attributes and skills are perceived as being more important than qualifications; Leadership, communication skills and financial training are the most important training requirements; most universities do not cover some highly desirable skill sets and attributes.

Practical implications: University courses can be adjusted to better reflect the needs of industry; students and engineers can plan careers more effectively by considering their personal attributes and the skill sets required of executives; professional development programs can be designed to maximise proficiencies at the most beneficial stage of their career.

Originality/value: There is some overlap between the skill sets of CEOs and engineers. Thus by effective education and training, engineers may be in a better position for the transition into the management.

Keywords: Engineering education; Engineering leadership; Professional development; Management education

1. Introduction

In the vast majority of cases it is a long and often torturous path to success for a CEO. Generally they start as young professionals learning the basics of their original trade before moving into middle management and then working their way up based on merit.

While there is no well defined 'character traits' required by a CEO, there are often skills and attributes that are perceived as

desirable and in some cases essential for CEO positions regardless of their "intelligence" or other skills.

Potentially the identification of these variables can lead to a model of successful executive career progression. In essence, to construct a framework that reflects how the majority of CEOs and other high level executives achieve their professional success. The development and validation of such a model can provide the basis for education and training programs that can maximize an engineer's chance of achieving executive success.

2. Literature review

Wood and Vilkinas [1] have looked at the topic of CEO characteristics from a number of different angles. They have built their study on the work of a number of others – using some basic characteristics as the basis for a questionnaire. The desirable characteristics of CEOs they identified through previous studies were achievement orientation, humanistic approach, positive outlook, inclusive, participative and empowering style, integrity, balanced approach, and learning and self awareness. These characteristics were chosen as they formed the core components across a number of earlier studies based on theoretical framework, CEO perception and staff perception approaches.

Wood and Vilkinas found that a humanistic approach and an achievement orientation were critical to CEO success. A positive outlook was also perceived to be very important. The remaining characteristics were confirmed as being important to CEO success but not as important as the others listed above.

Hunt [2] also provides some valuable information in his research into the ‘Key Components of Senior Executives in Australia’. His study has some direct correlation to the topic of this project although not focused on engineers and not going as far as looking into education and training implications.

According to Badawy [3], managerial competency is composed of three interrelated components: knowledge, attitudes, and professional skills. Badawy breaks down professional skills into three further criteria: technical, administrative and interpersonal. An engineer needs to be competent in all of these fields although the relative importance of each varies throughout a professional career. He identifies the major failure of management is normally related to interpersonal skills.

Peter Taylor [4], CEO of Engineers Australia [5], concludes that engineers probably make good managers but is less sure about engineers as leaders – although he does say engineers do have “a fair sprinkling of the traits that could see them become good leaders”.

Patricia Galloway (CEO, Nielsen-Wurster Group, Seattle, Washington, USA) in her book “21st Century Engineer: A Proposal for Engineering Education Reform” [6] argues for the need to broaden current and future engineers’ skills sets to become not only technically competent but also competent in communication and management practices. These soft “fundamental capacities”, she believes, are still not being taught at either undergraduate or postgraduate levels. Galloway paints the new global landscape where mega projects, sustainability, infrastructure security, and multicultural work teams pose challenges for which engineers may be unprepared. She lays out non-technical areas in which engineers must become proficient: globalization, communication, ethics and professionalism, diversity, and leadership.

The release of the “2020 Vision: The Manager of the 21st Century” [7] (2020 Vision Report) in 2006 by Innovation & Business Skills Australia has seen some immediate effects on traditional managerial development and training, particularly at postgraduate levels such as the MBA program. Goh [8] highlighted the Vision 2020 Report’s findings supported with case studies, and discussed the report’s implications on engineering management education.

The report compiled by Boston Consulting Group attempts to identify the attributes and skills needed for future managers to be properly equipped to manage effectively. The 2020 Vision report essentially is a review of current development in managerial training and the change in trends of workplace’s demographics, and was hinged on the Karpin Report [9, 10] released in 1995. The reader is referred to the literature for more details on the work of the Commonwealth of Australia on Management Education [11-13]. The Engineers Australia’s Engineering Executive [14] recognition framework was also used to form the questionnaire.

3. Methodology

This investigation used a questionnaire to gain a view on the perceptions of top-level executive who have an engineering degree on the training of engineers. It was aimed at discovering their perceptions as to the skills and attributes that they possessed that had assisted in their success. Questionnaire participants were selected on the basis that they held a Bachelors degree in Engineering and have been successful in the business world. These participants were sourced from the “Who’s Who In Business” [15] (WWIB) database. In order to maximize the level of responses, the questionnaire was distributed by both email and regular mail.

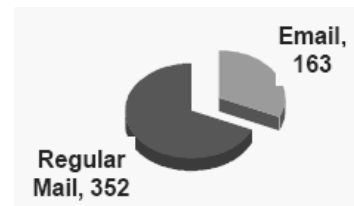


Fig. 1. Questionnaire distribution types

Figure 1 depicts a breakdown of the questionnaires sent out. There were 82 responses in total, 13 by email and 69 through regular mail. This represents a response rate of 8% electronically and 19.6 % in hardcopy, which is an excellent response rate considering the time-poor nature of these senior managers.

The WWIB database enabled the identification of the business, and hence business type of the listed engineers. In a general way, this shows how these successful engineers’ careers have progressed. That is, if they have achieved success simply by working in an industry that has a technical element applicable to their training, that is the skill sets of these engineers are applicable to management in general – not just technical based industries.

It would be expected that a larger percentage of the executives listed would work in technical industry while relatively few would work in non-technical industry. Table 1 identifies the industry sector of all listed engineers that work for companies listed on the Australian Stock Exchange (ASX). It lists the number of engineers in each industry group and compares it to the percentage of the number of companies listed in that industry group within the ASX. The industry sectors are listed as per the Global Industry Classification Standard. The distribution of companies in the ASX should approximate the number of management executives represented in the WWIB.

The Table shows a similar distribution between the number of engineers and the number of companies in the ASX. As expected there are proportionally more engineers in areas such as mining (materials), as there are more mining companies on the ASX, as opposed to Diversified Financials. This is a natural result of engineers basing their careers in industries that relate more closely to their chosen fields of study.

The industry sectors where engineers are over represented as CEOs are capital goods 15.9%, energy 12.3% and surprisingly, banks 6.7%. There is proportionally a large cohort of engineers in management within these groups than there are companies of these types within the ASX. The difference in the proportions for other industry groups is not as large.

Table 1.
Industry sector of engineers in management

	No. of Engineers	Distribution (%)	% of ASX
Automobile & Components	1	0.5%	0.5%
Banks	4	2.1%	0.8%
Capital Goods	31	15.9%	5.3%
Commercial Services & Supplies	7	3.6%	3.1%
Consumer Durables & Apparel	1	0.5%	1.2%
Consumer Services	1	0.5%	2.3%
Diversified Financials	13	6.7%	8.1%
Energy	24	12.3%	9.6%
Food Beverage & Tobacco	2	1.0%	2.4%
Health Care Equipment & Services	8	4.1%	3.5%
Materials	65	33.3%	28.0%
Media	3	1.5%	2.4%
Pharmaceuticals, Biotechnology & Life Sciences	2	1.0%	4.3%
Real Estate	9	4.6%	5.8%
Retailing	3	1.5%	2.4%
Semiconductors & Semiconductor Equipment	1	0.5%	0.1%
Software & Services	11	5.6%	4.2%
Technology Hardware & Equipment	4	2.1%	1.7%
Telecommunication Services	1	0.5%	1.7%
Transportation	2	1.0%	1.2%
Utilities	2	1.0%	1.5%
Total	195	Companies	2115

BOLD: Large representation of Engineers in senior management

Engineers are under represented in comparison to the distribution of company sectors mainly within the consumer type industries and surprisingly, within the telecommunications sector where you would expect a more technical orientation.

From the results, there is a correlation between the number of engineers that have achieved success in management within a particular sector and the proportion of companies within that

sector. This comparatively even distribution seems to suggest that engineers generally do have management skills that can be applied across all industries.

The respondent's details are tabled in Tables 2,3,4, and provides a good description of the surveyed sample. The majority of respondents are from the Civil, Mechanical, and Electrical disciplines. Most held positions at the CEO and Managing Director level, and most possessed postgraduate qualifications with 29.3% as MBAs, though 19.5% possessed no formal postgraduate qualifications.

Table 2.
Respondents by engineering bachelor degree

Degree	Number Surveyed	% of Total
BE (Chem)	11	13.4%
BE (Civ)	20	24.4%
BE (Elect)	22	26.8%
BE (Mech)	19	23.2%
BE (Mining)	7	8.5%
Other	3	3.7%
Total	82	100.0%

Table 3.
Current roles of respondents

Current Position	No. of responses	% of Total
CEO / Managing Director	34	41.5%
Chairman	14	17.1%
Other executive manager	18	22.0%
Non Executive Director	7	8.5%
Technical	1	1.2%
Retired	8	9.8%
Total	82	100.0%

Table 4.
Qualification of engineers in senior management

Qualification	No of Occurrences	% of Total
MBA	24	29.3%
Other Management Masters	16	19.5%
Higher technical qualification	16	19.5%
Management Diploma	18	22.0%
Technical Diploma	6	7.3%
PhD	7	8.5%
No other qualifications	16	19.5%

4. Findings and discussions

In order to develop a model of standard engineering degree and to better understand the progression of successful engineers the standard length of time spent in various roles should be understood. This issue was addressed in the questionnaire, by identifying if there is a general trend exists in that successful

engineers spent similar lengths of time in technical roles before proceeding into management.

The length of time spent in a technical role was expected to vary – some very successful people have elected to never use the technical aspects of their training. For example, some engineering graduates moved directly into the business world (eg. Investment Banking) or politics. Note that politicians were excluded from this study as it was not considered as a standard management type career progression.

Others have used their technical expertise built up over many years as a platform to switch into management. This may be considered to be the case for successful academics for example. In some cases, good research or other academic achievements have led people into management style careers. However, academics were also excluded from this study as the focus here is on management in business. Table 5 and Table 6 below shows the time spent in technical and management type roles.

Table 5.
Years spent in technical roles

Years in technical role	Number of responses	% of Total
Nil	4	4.9%
1-5 years	40	48.8%
6-10 years	24	29.3%
11-19 years	14	17.1%
20+ years	2	2.4%
Total	84	100%

Table 6.
Years spent in management roles

Years in management role	Number of responses	% of Total
1-10 years	9	11.3%
11-20 years	24	30.0%
21-30 years	30	37.5%
31-40 years	15	18.8%
41+ years	2	2.5%
Total	80	100%

Overall, the survey indicated the average time spent in a technical role before moving into management was found to be 6.6 year. This covered responses from individuals who spent no time in technical positions up to two respondents who spent 20 years in technical roles before management roles. Table 6 above shows the level of experience of those who replied to the questionnaire. After spending an average of six and half years in technical roles, the respondents have spent an average of 22.5 years in management. This was bounded by a range of 3 to 45 years in management roles.

While the motivation for the move into management was not a major focus of this project it gives some idea as to the personalities of these engineers that have succeeded in business. The majority believe that they reached their positions naturally through a normal career progression as shown in Table 7. That is, they did not actively pursue management, but their individual skills were recognized as being of the requisite standard to progress to higher levels of management, and that their organization facilitated the move into management.

Table 7.
Reasons for move into management

Reason for move into management	No. of responses	% of Total
Always wanted management	20	24.4%
Only promotion available	4	4.9%
Avoiding technical career	3	3.7%
Natural career progression	46	56.1%
Good offer to move to management	2	2.4%
Other reasons	7	8.5%
Total	82	100.0%

Table 8.
Importance of skills/attributes and training requirements

Skill / Attribute	Importance - Average Response (out of 10)	% Respondents Suggesting Training Required
Integrity	9.52	7.5%
Leadership	9.07	58.5%
Communication Ability	8.88	66.0%
Handle complexity	8.79	11.9%
Interpersonal Skills	8.72	41.3%
Drive / Ambition	8.70	2.5%
Initiative	8.62	6.3%
Business Acumen	8.70	56.6%
Decisiveness	8.51	13.8%
Energy / Passion	8.49	3.8%
Analytical / reasoning skills	8.39	45.0%
Achievement orientation	8.33	7.6%
Self Awareness	8.14	23.1%
Strategic Planning	8.15	73.6%
Emotional Intelligence	8.00	20.5%
Team player	7.99	18.8%
Conceptual skills	7.90	12.5%
Financial management	7.82	88.7%
Planning ability	7.23	41.3%
Entrepreneurial ability	7.12	13.8%
HR Management	7.07	50.6%
Project Management	7.02	65.8%
Technical competence	6.70	64.6%
Sales / Marketing ability	6.28	47.8%
Mentor	6.28	6.5%
Administrative Ability	6.24	31.7%
International Experience	5.99	7.6%
Multi-company experience	5.78	2.6%
Disciplinary knowledge	5.73	38.2%

BOLD: 50% and over suggesting training required are highlighted

The survey then looked at the perceptions of CEOs as related to their own success. Although it may be argued that the respondents have a subjective view of themselves and the reasons for their success, these executives are best placed to answer the question of management success. Not only have they achieved success themselves but are in positions that often require the

assessment of managers, and grooming of future managers. In particular, the respondents are familiar with the pressures of an engineering career, and more importantly to this study the degree to which their university studies and training prepared them for success. Although individuals do have different views as to the importance of various characteristics, the responses gathered were sufficient to identify a general trend.

Table 8 contains the responses from the questionnaire and provides a score from 0 to 10 to each of the skills and attributes, with 10 being the most relevant. Naturally the most important skills or attributes are those that are likely to have the most important implications for education and training.

The most important attribute required by CEOs, as identified in the questionnaire is "Integrity". Integrity had an average importance score of 9.52 compared to the next highest score being 9.07 for leadership. However, unsurprisingly, integrity was not seen as requiring training as it is to a large extent considered to be an inherent character trait rather than something that can be 'taught'.

Table 9 below shows the highest importance scores as per the questionnaire with the added criteria of scoring over 7.5 and over 50% of respondents suggesting that some sort of training is required. This also provides an indication of the deficiency or skill/knowledge gaps from the formal education undertaken by the respondents.

Table 9.
Skills/Attributes with highest importance with training required

	Importance - Average Response	% Respondents Suggesting Training Required
Leadership	9.07	58.5%
Communication ability	8.88	66.0%
Business Acumen	8.70	56.6%
Strategic Planning	8.15	73.6%
Financial management	7.82	88.7%

However, education and training can occur throughout an individual's career. When the importance factors are compared to the suggested stages that training should occur, a pattern or training continuum is suggested.

Table 10 shows those attributes that the questionnaire respondents thought required formal training. The percentage figure shown indicates the numbers of people who thought training was required – only those greater than 30% are shown. This is developed further in Table 11 which shows the questionnaire results in terms of skills that require training at each stage of an engineer's career.

Table 10.
Skills/Attributes requiring formal qualifications

Skills/Attributes	% Respondents
Strategic planning	30.0%
Financial management	70.8%
Project management	31.1%
Economics	41.9%
Accounting skills	40.0%

Table 11.
Importance of skills/attribute s developments across career stages

Undergraduate Studies	35.7%
Accounting skills	32.5%
Economics	32.5%
Analytical / reasoning skills	30.4%
Financial management	26.1%
Project management	
Technical role	59.1%
Communication skills	56.1%
Further technical skills	56.1%
Administration	47.5%
Analytical / reasoning skills	41.3%
Project management	
Junior management	59.2%
Legal awareness	46.7%
Leadership	33.3%
Strategic planning	32.6%
Financial management	30.4%
Project management	
Mid-management	27.1%
Strategic planning	20.0%
Leadership	18.4%
Legal awareness	16.3%
Business acumen	15.9%
Change management	
Senior Management	4.5%
Change management	4.4%
Leadership	4.2%
Strategic planning	4.1%
Legal awareness	2.3%
Business acumen	

In general, there appears to be four main skill areas that respondents believe engineers would benefit from specific training after graduation. These skills are Leadership, Communication, Financial, Problem solving (including analytical reasoning and strategic planning).

4.1. Summary of findings

Findings of this investigation indicate:

- CEOs often reach their position as natural career progression rather than actively seeking management.
- Personal attributes are perceived as being more important than postgraduate qualifications.
- Leadership, communication skills and financial training are the most important training requirements.
- Most undergraduate and postgraduate education providers do not cover some highly desirable skill sets, and often skills gained are not immediately applicable to the workplace.

5. Implications and recommendations

Suggested Implications:

- Undergraduate and Postgraduate courses offered by engineering schools can be adjusted to better reflect the needs of changing operating environment.
- Engineers can plan careers more effectively by considering attributes and the skill sets required of senior engineering manager of the 21st century.
- Professional development programs can be designed to maximise proficiencies at the most beneficial stage of an engineer's career.

The following recommendations relates to undergraduates and junior engineers:

- Have a career plan. Only by recognizing and taking opportunities can career progression be maximized.
- Do not rush promotion, be recognized on your merits. The majority of high level executives believe that they arrived in their positions without actively seeking management.
- Sound technical acumen is required for recognition of potential for advancement into management.
- Improve communication skills and interactions with others. The importance of communication skills is highlighted repeatedly, not only by CEOs, but in the literature and by empirical evidence.
- The majority of current CEOs recommend an MBA. However they are likely to be viewing the situation retrospectively – organizations and recruitment companies currently appear to be looking for individuals with higher degrees in management focused in a particular field or area of business.
- Develop leadership potential through life experience, whether through the work environment or outside interests. An understanding of leadership theory can help but must used in context.
- Gain a wide range of experience. Experience not only provides a basis of knowledge but can reveal interests in particular fields that can provide motivation towards a career path.
- Learn to think and plan strategically. Combined with problem solving, the ability to appreciate the 'bigger picture' is an essential skill for those in high level management.

The following recommendations relates to teaching institutions:

- Technical skills are vital for undergraduates but also for senior managers; they should not be compromised for management skills.
- Financial skills should be incorporated into undergraduate programs as an elective. It is a vital skill and one which most engineers will face in their careers. As a field of study, it is not well understood by engineers, and does not always make intuitive sense to an engineer.
- Undergraduates team-related and communication skills should be practiced throughout technical courses.
- Management and leadership skills should be taught at a post-graduate level.

- Management skills are best focused at a particular industry through customization.

6. Summary

This study has investigated the skills and attributes of CEOs within an Australian context and related them to the skills and attributes of engineers in order to determine how engineers can succeed in management careers, and how education and training can best support this career path with a 21st century outlook.

CEOs surveyed were found to have strong communication and strategic thinking skills enhanced by leadership. They attained their positions via many different career paths but there are similarities on the types of skills and attributes required to reach senior executive level positions.

In comparison, engineers were discovered to be good at problem solving but, in general, lack leadership and communication skills. This was evidenced in the literature as well as a general trend in the comments of respondents. This, of course, does not mean that some individuals are not highly competent in these areas – only on average that engineers are less skilled than their peers in other professions.

The focus for both individual engineers and learning institutions should therefore be to develop the skill set that is common across the two groups. Leadership, Communication and Financial skills stand out as being important for engineers intending to pursue a career in management, but yet have the ability to maintain a deep knowledge of their industry.

There is some overlap between the skill sets of CEOs and engineers. Thus by effective education and training, engineers may be in a better position for the transition into the management.

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