CHAPTER 1

THE STUDY IN PERSPECTIVE
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1.1 Introduction

This research is an exploratory field-based study into how engineers make the transition into management roles in the Australian context. It specifically investigates the factors influencing the transition and the attitude of practising engineers towards those factors. In particular, it analyses the differences in attitude between the various subgroups of engineers.

The expected outcomes of this research study are strategies to manage the transition, from both an individual and an organizational perspective. The findings of this study are expected to have implications for the development and design of curriculum in engineering education at both undergraduate and postgraduate level, training and development strategies, and organizational policies and systems geared towards the transition. Given the centrality of engineers and management in some business organizations, it is important to understand the process of this transition and to develop strategies to make it effective.

1.2. Significance of the research

This research is significant for several reasons. These include the important role of engineers and management in industrial society, the critical role that engineers play in the integration of various functions and their multiple roles in industrial organizations, and the extent of and problems encountered in such transitions.

Most engineers move into management roles at some stage in their careers, and their numbers increase with the length of service (Badawy 1983; Williams 1988; Lloyd 1991a). In fact, even routine engineering work involves certain managerial or administrative activities. In spite of such large numbers of engineers being in management, it is generally believed that they lack soft skills such as communication, business management and interpersonal skills to be successful in
management positions. The transition is, therefore, difficult and ineffective in many instances (Badawy 1983; Roberts & Biddle 1994).

Engineers make up a significant proportion of the managerial pool in Australian manufacturing and infrastructure sectors. A better understanding of the role of such engineers and engineer-managers, their utilisation and changes in their roles, is thus important (CTSC 1991). This is especially so in Anglo-Saxon countries such as the UK and to some extent in Australia, where management is somehow disconnected from the production and delivery of goods, even in the manufacturing and infrastructure industry sectors (Glover & Kelly 1987; Lee & Smith 1992a).

Engineers are considered to be important in improving the international competitiveness of Australian industry through the design and production of innovative goods and services and through improving the utilisation of capital, material and human resources. Engineers play a critical role in organizations, integrating technology with other corporate functions such as marketing, finance and human resources (NAE, USA 1988; White 1990). Several studies have concluded that engineering and engineers play a vital role and that new approaches to engineering education and training are critical in order to develop Australia’s international competitiveness (Endersbee 1985; Tegart 1989; APESA 1990; White 1990; BCA 1991; CTSC 1991).

Engineers have a special role in industrial organizations. They are the targets of many organizational changes, and are also at times responsible for initiating changes in technology, processes, methods and products (White 1990). As supervisors and managers, they are responsible for the implementation of organizational and technological changes and also perform the role of managers of change. As a representative of capital, they are responsible for the production and delivery of goods and services. They also act as labour in designing and operating plant and equipment.
This duality of roles, representing both capital and labour, and as originators of change as well as targets of change, gives engineers a special position in organizations, especially when compared to other professions (Glover & Kelly 1987). In view of their special and ambiguous role, they are likely to be the most affected by the present change processes. It will have implications for engineers in terms of their skills, professional education, training, status, career paths and future opportunities for leadership positions (APESA et al 1992; Lee & Smith 1992a).

Changes such as workplace reform, de-layering, autonomous work teams, total quality management and re-engineering under a broad ‘reform’ agenda, are expected to have a dramatic effect on the position and roles of middle management. A survey of the change processes of 300 large Australian organizations identified middle management as a ‘central blockage’ to change programs and called for further research on the organizational problems associated with middle management and on strategies to manage them (Walden & Blackstock 1993). With engineers constituting a significant proportion of middle management in industrial organizations, an investigation of their role could make an important contribution to the literature on organizational change and engineering management.

Engineers are living and working in times of rapid and radical change and are continuously confronted with the task of adjusting their work roles (Nicholson & West 1988; White 1990; Hammer 1996). Boundaries between engineers and supervisory or managerial functions are increasingly blurred. In order to cope with the increasing complexity of organizational tasks and goals, engineers are increasingly doing additional tasks such as coordinating with external and internal people, managing interpersonal relationships and communications, and carrying out non-technical functions such as marketing, finance and personnel. In the majority of companies in the industrialised nations, specialist functional structures are increasingly being abolished and replaced by integrated professional groups whose aim is to ensure closer integration between the specialist functions (Smith, Child & Rowlinson 1990). Engineers are expected to redefine their roles to take
advantage of future opportunities and to reposition themselves in industrial organizations.

Engineering is a profession that is continually in transition (Lloyd 1991a). History shows that engineers have redefined and adjusted their work roles in line with social, technical and organizational changes. These organizational changes coupled with the rapid pace of technological change have accelerated the process of change and expanded the role of engineers in business enterprises by emphasising entrepreneurial and managerial skills rather than pure technical skills (White 1990; Hammer 1996). Against this background, the future role of engineers and their preparedness for that role take on a particular significance and urgency.

Apart from other factors, the number of engineers (or engineering density) a nation has is considered important, since it reflects the degree of industrialisation and economic development that that nation has achieved. Yet, as pointed out by several reports, there is no proper understanding and appreciation of the critical role played by engineers in industrial organizations and in Australian society (Warren Centre report, 1988; Williams 1988; OECD 1990; CTSC 1991; IE Aust. 1993).

The limited nature of research on engineers and their managerial role in Australia is another reason why this study is significant. Most research has been carried out in the UK and the USA. The few Australian studies are limited to engineering education and employers’ views on it. For example, Dunn and Fensham (1970) on diploma education; PE Consultants (1972) on the engineer’s role in industry; the review by Williams (1988) of engineering education; CTSC (1991) on the value added by engineers; APESA et al. (1992) on skills needed by engineers in the future; the study by Hessami and Eley (1992 a and b) on employers’ views on engineers; the market research by IE Aust. (1993) on the image of engineers; and the recent review of engineering education by IE Aust. (1996) are the only studies on engineers in Australia. Most of the studies focused on the content in engineering education; factors influencing the managerial roles of engineers were beyond their scope. A comprehensive attempt to understand these factors and the problems
faced by Australian engineers—from the individual engineer’s point of view—is, however, essential.

Most of the past studies considered engineers as a homogeneous professional group, and conclusions were drawn without taking into account the increasing diversity within the profession. Though some differences within the engineering profession have been identified in the literature, no empirical studies of them have been carried out. In view of the large number of engineers and the considerable diversity that exists in terms of the nature of their work, branch of engineering and type of industry, as well as their management qualifications, general orientation towards managerial work and responsibility levels, these differences need to be investigated in order to better understand the transition process.

Since their image, as revealed in past studies, is one of being conservative, hierarchically oriented, and possessing an authoritarian management style and poor interpersonal skills, the pressure on engineers for change is enormous. This negative image can be attributed, to some extent, to engineers’ difficult middle-management role as managers of change during the recent ‘restructuring and reform’ in Australian organizations. There is an urgent need for an examination of their role in organizations, and their education and training.

The outcomes of such research study on the factors influencing the transition are likely to assist both the individual engineers and their organizations in developing strategies to manage it. The research findings are expected to provide an insight into and focus on those areas that need to be changed to achieve an improved engineering education curriculum. The study provides a framework for a better understanding of the factors inhibiting the successful transition of engineers. The findings indicate how useful they might be from the individual engineer’s perspective, and also indicate areas for improvement.
1.3 Background to the research

The low utilisation of engineers' skills in Australia, the low engineering density, the low importance attached to engineering education by high school leavers, and the perception of employers that engineers are generally unsuitable for management positions are some of the reasons that made it imperative that a review of the role of engineers and their education and professional training be undertaken (Williams 1988; CTSC 1991; APESMA et al. 1992; Hessami & Eley 1992b).

With about 92,000 engineers of working age (Rice & Lloyd 1990), engineers are the second-largest group of professionals in Australia (teachers being the largest). Despite this apparently large number, the number of engineers proportionate to population in Australia is relatively low when compared with other developed countries such as the USA, Japan and the UK (Endersbee 1985; Lloyd 1988; Williams 1988; Rice & Lloyd 1990; APESA et al. 1992). It is generally believed that, in a way, low engineering density reflects low potential for industrial growth and technological development (EPAC 1986).

The engineer's role has continually changed, in line with changes in organizational structures and changes in management paradigms, thus establishing a strong link between engineers and management (Hoxie 1915; Urwick & Brech 1946; Urwick 1953; Calvert 1967; Noble 1977; Lloyd 1991a). However, over a period of time, engineering and management became two separate functions; the extent of this separation differs from country to country (Lee and Smith 1992a). While in countries like France, Germany, Japan and, to some extent, the USA, management is engineer-dominated and is considered an integral part of the engineer's role, in countries like the UK and Australia, engineering and management are viewed as distinct parts of the industrial organization (Glover & Kelly 1987; Lee & Smith 1992a).
Despite large number of engineers moving into management positions, several studies revealed that engineers generally lack 'soft' skills and are not considered suitable for top management positions (Williams 1988, Faulkner & Wearne 1989; Society of Manufacturing Engineers, USA, 1989; Hessami & Eley 1992a). Most of the literature assumes that professional engineers generally lack soft skills—skills that are so essential to succeed in managerial roles as well as in the presently expanded technical roles.

Within the limited nature of research on engineers in Australia, studies predominantly concentrated on engineering education and practically ignored other factors such as status, the nature of engineering work, organizational policies and systems. Though factors such as the status of engineers in organizations and in society, the beliefs and values of engineers as a professional group, individual personalities and occupational proclivities, the trends towards de-engineering in public sector organizations, career management policies in organizations, management of experience and organizational support are mentioned as ones possibly influencing the transition, their importance has been relegated to the background. A model integrating the influence of these factors on the transition of engineers into engineer-managers roles, and their interrelationships is necessary to provide conceptual basis.

Literature in this area reveals that most studies on the transition of engineers into managerial positions have viewed engineers from the outside and given advice on how to train engineers as managers. An analysis of the transition process based on the engineer’s point of view could yield rich insights into how it occurs and what occurs during the process in Australia. This would help in developing appropriate strategies for managing these transitions from both an organizational as well as an individual perspective.

Although the literature identifies formal business management education, training, and on-the-job learning as the popular strategies in managing these transitions, most of the studies concentrated on undergraduate engineering education. While
there is some recent recognition of experiential learning as an important factor in managing the transitions, the literature reported no empirical studies in general and in Australia in particular. A study of the strategies employed by organizations as well as individual engineer-managers to manage these transitions would make an important contribution to the literature on engineering management.

A review of the literature on the subject also highlights significant differences between Australian engineering and engineers and their counterparts in the UK and the USA, in terms of intensity of engineering and manufacturing, technology base, population of engineers, occupational identity and control, strong professional bodies and the status accorded to engineers by society and organizations. These differences, coupled with the lack of integrated studies on how engineers make the transition, mean that overseas findings cannot be applied in the Australian context and indicate the need for more research on engineers in Australia.

Studies on engineers, both here and overseas, have depended upon data collected across a broad spectrum of engineers, considering them as more or less a unified, homogenous group. Although, as mentioned earlier, there is some anecdotal evidence that differences exist between various groups of engineers—differences in the nature of their jobs, branch of engineering and other factors—no analysis of these differences has been undertaken.

This research therefore intends to address some of the issues apparently either not considered in the literature, as discussed above, or considered less important. Primarily, it intends to focus on the changing roles of engineers, in terms of the present expanded technical roles or 'generalist' roles as well as the managerial roles. This research study attempts to analyse these changing roles specifically in an Australian context, by reference to such influencing factors as engineering education, status, organizational systems and support, individual orientation, general image in society, postgraduate management education, experiential learning and type of employing industry. It views the transition as a process rather
than as an event with a definite beginning and an end. Importantly, it deals with the issues from the engineer's perspective.

1.4 Research objectives and questions

Based on the review of literature mentioned in section 1.3, and discussions with senior engineers and engineering managers in the profession, tentative research questions were formulated. They were framed so that, at the beginning, they were exploratory; they then lead to further questions as the research progressed from qualitative exploration to quantitative explanation.

The main research questions postulated in this study are:

What factors influence the transition of engineers in Australia and how is that influence exerted?

What are the differences between various subgroups of engineers in their attitude towards those factors?

Within these broad research questions, this study intends to investigate the influence of the following factors identified from the literature and engineer's attitude towards them.

* General attitude of engineers towards transition
* Changing nature of engineering and managerial work.
* Differences between engineering and managerial work.
* Differences between various subgroups of engineers.
* Engineering education.
* Status of engineers.
* Organizational systems and policies.
* Strategies employed in managing these transitions—both from an individual and an organizational perspective—postgraduate business management education, experiential learning, training and organizational support.

1.5 Research methodology and methods

Though similar studies have been conducted in the UK and, to some extent, in the USA, as described above, and in the literature review section of this thesis, this study is exploratory in nature and is set in the Australian context. A combination of qualitative methodology followed by a quantitative approach was used. In particular, case study methodology was chosen in the first phase to explore the factors influencing the transition of engineers and the strategies employed in managing them. Propositions were then developed from an analysis of the case study and the literature review and, using a survey methodology, were tested in the second phase for the extent to which they could be generalised.

Queensland Transport, a State government organization in Queensland, Australia, responsible for the infrastructure development and maintenance of roads and other transport services throughout Queensland, was chosen as the case study organization, in view of the access and resources they could provide. The experienced engineers who made the transition into management and/or generalist roles were the main units of analysis in this investigation.

Using the methodology suggested by Glausser and Strauss (1967), Yin (1989) and Dey (1993), data was collected as a result of personal interviews with several senior engineers and engineer–managers and documents from the case study organization. Using pattern-matching and content-analysis approaches, the data was evaluated against the relevant themes and/or propositions. From an analysis based on frequency of occurrence, strength or the extent to which they occurred and context, several propositions were further developed. These propositions were then
further validated with the help of a questionnaire survey of the general engineering population in Australia.

Since the main focus of the survey research was to analyse the transition from an individual perspective, the attitudes, beliefs and opinions of professional engineers formed the basis of the answers to the research questions. Accordingly, a five-point Likert scale instrument was designed following the principles of survey questionnaire design. It consisted of several statements concerning the engineers’ general attitude towards the transition into management, status, organizational systems and policies, the nature of engineers, engineering education and strategies for managing transition. The questionnaire was pilot-tested and tested for reliability and validity using appropriate techniques.

From the membership list of the IE Aust., 3000 engineers working in Australia, from civil, mechanical and electrical/electronics groups, were randomly selected as respondents, and questionnaires mailed out. There was an overall response rate of 27 per cent. The data thus collected was edited, coded and analysed using SPSS for Windows 6.1 software (Statistical Package for Social Sciences). Appropriate statistical techniques, such as exploratory data analysis, factor analysis, discriminant analysis and hypothesis testing were used to analyse the data and validate conclusions. A detailed discussion of the research methods employed and the justification for their selection appears in chapter 3, Research Methodology and Methods.

1.6 Outline of the thesis

The thesis has six chapters. The first chapter provides a brief introduction to the thesis, the significance of the study, the background to the research, the research methodology and research methods used, and the limitations of the research. The second chapter reviews the existing literature on engineers and the factors influencing the transition, and provides the basis for the study. Following analysis, gaps in the
literature were identified and broad research questions formulated. These research questions provide a framework for the exploratory case study.

Chapter 3 deals with the research design. It justifies in detail the choice of methodology and explains the approach adopted in conducting case study research and survey research. The fourth chapter focuses on the case study analysis. With the individual quotations and the author's interpretations appropriately intertwined, analysis and findings are presented under several themes and issues relevant to the study. The propositions evolving from the case study findings are summarised and presented in this section for further testing.

In the fifth chapter, an analysis of the survey data and interpretation of the results are presented. These give a summary of the findings from the research questions and subquestions on the attitudes of engineers towards the transition into management, engineering education, organizational support and strategies for managing transition. A conceptual model for the transition of engineers, proposed based on the analysis is explained in this section. The results of the analysis of the relationships between various variables using SPSS software such as cross-tabulations, discriminant analysis and factor analysis are presented later. A comparative analysis carried out using appropriate statistical techniques and the discussion of the differences between various subgroups of engineers are presented in the final section.

The final chapter, chapter 6, summarises the conclusions drawn from the study. It discusses the implications of the findings. Placing the conclusions in their proper context, the limitations of the research in terms of methodology and analysis are discussed in this chapter. The chapter ends with an outline of areas for possible future research.

1.7 Definitions, limitations and key assumptions

The study is concerned with employee professional engineers practising in Australia, and excludes those technicians, such as masons, welders, fitters,
machinists, electricians and mechanical fabricators, who are sometimes referred to as engineers. This research considered Lloyd's (1988) definition of 'professional engineer' for conceptual understanding and follows the definition of graduate membership by the Institution of Engineers, Australia (IE Aust.) for practical and methodological reasons. Thus, this research is concerned mainly with the employee professional engineer, and throughout the study, wherever the word 'engineer' is used, it refers to the employee professional engineer.

The term 'transition' in this research refers to the engineer's move into engineer-manager role and the terms 'manager' and 'engineer-manager' are used interchangeably throughout this thesis. It is assumed that engineers do not lose their engineering identity by becoming managers.

In view of the great variety of individual roles and specialisations within engineering and the diversity of opinions, the field study in this research is confined to civil, mechanical and electrical engineers, who constitute about 80 per cent of the total professional engineering population in Australia. The study is carried out in order to understand the transition process from the individual engineer's perspective; it does not, therefore, consider the views of employers and other members of the engineer's organization. Though their importance is not discounted, the study does not consider the perceptions of the employers, management and other non-engineers—the focus is on the individual engineer's perspective.

This study is primarily concerned about the role of engineers in contemporary organizational change, and does not address other issues such as change management strategies and their effectiveness and problems in implementation. Importantly, transition is viewed as a process with no definite beginning and ending, rather than as a single event. Practising engineers in different areas of engineering and in different positions were the population base for the study.
Some terms, such as 'status' and 'personality', are used in this study only as broad terms, from the meanings attributed in the literature review. Definitions and measurement of these terms as used in other disciplines such as psychology and sociology are beyond the scope of this study.

Though this study concentrated on the perception of practising employee engineers in Australia about the transition into managerial roles, engineering education, influence of their status, organizational support and policies, and the strategies employed in managing the transition, it is recognised that there are several other factors that influence the transition in a limited way. These factors were considered beyond the scope of this study: they include such issues as individual personality; the quality of engineering recruits, and primary and secondary education in engineering-related subjects; the appreciation and understanding of technology and its role in Australian society; and the value added by engineers to society.

1.8 Conclusion

This chapter lays the foundations for the thesis. It provides the framework for the study from the literature and introduces the research problem by detailing its significance and background. It outlines the main research question and the specific research questions investigated. The research is justified, explaining the significance and the need for further research in this area. It indicates the potential applications and usefulness of the research findings. The research methodology and the specific research methods employed in this investigation are briefly described and justified. A brief outline of the thesis provides an overview and structure, and the definitions used and the assumptions made in the research study are given. The limitations of the research are also discussed in order to identify the boundaries of the research findings. The next chapter is the literature review, and leads to the specific research questions investigated.
CHAPTER 2

LITERATURE REVIEW
LITERATURE REVIEW

2.1  Introduction

This chapter reviews the existing literature on issues related to engineers’ transition into management roles and identifies gaps in it. It will first discuss how the literature defines the word ‘engineer’ and the definition used in this study, and indicate the scope of this study. In order to demonstrate their significance, the extent of such transitions in Australia and the problems inherent in them are. Several issues that influence the transition have been raised in past studies made in the UK, the USA and in Australia, and these are analysed in order to identify those that warrant further investigation in the Australian context.

The discussion covers issues such as the changing roles of engineers, differences between engineering work and managerial work, the nature of engineering work, engineering education, individual personality and occupational proclivities, organizational systems and policies, the status of engineers, the trend towards de-engineering in public sector organizations in Australia, and strategies in managing transitions. Taking into account previous studies in Australia, the main research questions and secondary research questions that emerge from the literature review are presented in this chapter.

2.2  Definitions and scope

2.2.1  Definitions of the word ‘engineer’

This study is concerned with professional engineers. Since the word ‘engineer’ is widely used by other tradespeople in Australia and the UK, it is necessary to define its meaning as used in this research.
If one examines a history of engineering, the word ‘engineer’ was not used beyond the military context until the late 1700s (Lloyd 1988). About the middle of the eighteenth century, people engaged in construction and land drainage began to describe themselves as ‘civil engineers’ in the UK, distinguishing themselves from military engineers (Buchanan 1989). This designation also helped them to distinguish themselves from other craftspeople of the time, such as blacksmiths, carpenters and stonemasons. However, these same craftspeople today also claim the title ‘engineer’ in some powerful trade unions in Australia and the UK. In fact, as Lloyd points out, the uncontrolled use of the term ‘engineer’ by those not educated or trained as professionals gave rise to use of the term ‘professional engineer’ in the 1920s (Lloyd 1988).

In Australia, the nature of the functions of the professional engineer are described simply in terms of the qualifications needed to carry them out, as defined by the Institution of Engineers, Australia (IE Aust.). IE Aust. is a professional organization for engineers in Australia and was established in 1919.

The definition of a professional engineer, which appeared in the Professional Engineers Award in 1961 established by the Australian Conciliation and Arbitration Commission, is:

\[ A \ 'professional\ engineer'\ is\ a\ person\ who\ is\ employed\ to\ carry\ out\ duties,\ the\ \textit{adequate} \ discharge\ of\ any\ portion\ of\ which\ requires\ the\ possession\ of\ a\ \textit{qualification} \ recognized\ by\ IE\ Aust\ for\ Graduate\ membership. \]

This definition, for legal purposes, leaves the interpretation to the professional body of the engineers, the Institution of Engineers, Australia (IE Aust.) from time to time. However, a modern definition covering the important elements relevant to the occupation is as given below by Lloyd (1988).
Engineering is the profession in which knowledge of mathematics, science and technology are combined with the principles of management and applied in the practical application and management of technology and associated human, physical and financial resources for the creation and operation of products, processes and systems, and community works and services, in the fulfilment of commercial and social needs (Lloyd 1988: 9).

These definitions suggest that engineers are not only concerned with the work of machines and equipment but also with the management of technology and associated resources. Thus, according to those definitions, management of resources is considered to be an inherent part of engineering work. The objectives and ends towards which engineering is directed have remained the same, though the complexity of engineering and engineering knowledge and the means to achieve those objectives have changed considerably over time.

2.2.2 Other definitions used in this study

Other terms such as ‘management’, ‘engineering education’, ‘status’, ‘experiential learning’, ‘management education’, ‘de-engineering’, ‘generalist engineer’, ‘learning style’ and ‘soft skills’ are used in this research study. The definition of those terms are given in appendix I.

2.2.3 Population of engineers in Australia

Numbering about 85,000, engineers form the second-largest professional group in Australia. This group comprises various disciplines—civil, mechanical, electrical, electronics, metallurgical, mining, environmental, agricultural and others. About 85 per cent of engineers in Australia are in the civil, mechanical or electrical/electronics engineering disciplines. This study focuses on these three groups of engineers. A
detailed analysis of their population, diversity and comparative density is presented in appendix II.

2.2.4 Scope of the study

In order to properly design and develop research, it is necessary to define what type of professional engineers this study investigates. This is particularly so in light of the different disciplines and functions within the engineering profession. Engineering differs from the traditional perceptions of a 'profession'; unlike other professionals, such as lawyers and medical practitioners, engineers are predominantly employees in organizations.

As Larson (1977) points out, the sociology of professions tends to abstract its concepts from everyday life and supports its theories with evidence drawn from medicine, taking that as a parameter for other occupations (Larson 1977:49). In fact, professions such as medicine and the law have not developed in the organizational context, but have laid great emphasis on their professional independence and autonomy. In the engineering profession, on the other hand, there is relatively less emphasis on self-employment and professional autonomy. In Australia, most engineers are employees.

This research adopts Lloyd's (1988) definition of 'a professional engineer' for conceptual understanding and follows the definition given by the Institution of Engineers, Australia (IE Aust.) for practical and methodological reasons. However, the study is not restricted to members of IE Aust. alone; rather, it includes persons qualified for graduate membership of IE Aust. This research is concerned mainly with the employee professional engineer; throughout the study, this is the person described by the word 'engineer'. The population considered in this investigation comprises civil, mechanical and electrical/electronics engineers in Australia.
2.3 Changing roles of engineers

Engineering is a profession continually in transition: history reveals that the role of the engineer in industrial organizations changes in line with social and technological changes. A thorough analysis of the evolution of the engineering profession and its changing role is presented in appendix III.

This analysis argues that the engineer's role has been, throughout the nineteenth and twentieth centuries, influenced by different management paradigms (Noble 1977; Lloyd 1988; Smith & Meiksins 1995; Hammer 1996). In chronological order, starting with scientific management and progressing to the present 'Japanese' management approaches such as JIT and quality management, it reviews the engineer's role and argues that engineers played an important role in the introduction and diffusion of these management paradigms in industrial organizations (White 1990; Morikawa 1991).

Engineers are under increasing pressure to redefine their roles and adequately equip themselves in order to meet the imminent challenges of the twenty-first century (SME 1989; White 1990). As recommended by CTSC (1991), further investigation on engineers is necessary, "in order to provide a basis for analysing the development of engineers and the detailed assessment of the changing roles of engineers" (CTSC 1991: 56). This is important, in view of engineers' unique multiple roles in industrial organizations—as technical specialists, designers, developers and managers of system and system changes (Glover & Kelly 1987). With the boundaries between technical roles and managerial roles becoming increasingly blurred in modern industrial organizations in the 1990s, the changing role of engineers has considerable influence on their transition into management.
2.4 Managerial transitions

2.4.1 Introduction

This part reviews the literature regarding the extent of, reasons for and problems encountered in managerial transitions among engineers in Australia, the UK and the USA; this will help to establish the significance and scope of the study. The argument that management is an integral part of engineering work is discussed in the context of literature.

2.4.2 Extent of managerial transitions

Because engineering work generally involves the coordinated effort of people and other resources, managerial responsibilities come early in the career of a professional engineer. As early as 1949, Wickenden, in his report on engineering education in the USA, reported that two-thirds of all American engineers embarked on a healthy progression through technical work towards the responsibilities of management (Wickenden 1949).

Several studies in the UK, the USA and Australia have found that non-engineering activities consume a significant proportion of an engineer’s time and that this increases with age and experience (Gerstl & Hutton 1966; PE Consultants 1972; Faulkner & Wearne 1984; Wearne et al. 1984; Williams 1988; Young 1989; Doukas & Henshaw 1990). In fact, a study by Faulkner and Wearne (1979) concluded that the need for managerial skills and expertise vary with type of job, level of responsibility and age, with the last two being the most powerful indicators of the managerial content of a job.

For example, a study by PE Consulting group in Australia (1972) revealed that about 80 per cent of the practising engineer’s time was spent on non-technical/engineering work, the percentage increasing from 60 per cent of the time of an engineer in the age
group 20–24 to 85 per cent for engineers over 40 years of age (PE Consulting 1972:E-22). In a review of engineering disciplines in Australia, Williams (1988) indicated that about 45 per cent of Australian engineers were engaged in management, administrative and manufacturing duties, which included a fair amount of management of people and other resources. Similarly, Doukas and Henshaw observed that the majority of engineering graduates are usually in some sort of managerial or supervisory role within the first five years of employment (Doukas and Henshaw 1990).

Rice and Lloyd (1990) estimated that about 35 per cent of engineers in Australia are in management roles. Lloyd (1991a) argued that over 60 per cent of engineers in the 45–55 age group in Australia are middle or senior managers, and that their numbers will increase over the next ten years as their age group increases. Studies in Australia have revealed that many of the managers in Australian industrial and service organizations were neither trained in management skills nor possessed any tertiary qualifications in management (ESFC 1990; Kramar 1990).

A survey by the Engineering Council in the UK indicated that about 35 per cent of chartered engineers moved into management (Engineering Council 1989b:11). Studies in the USA have revealed that about 37 per cent of engineers have managerial duties during the first five years of employment, and about 70 per cent of engineers between the ages of 45 and 50 have significant managerial responsibilities (Engineering Manpower Commission 1982; Babcock 1991). In Canada, about 17 per cent of engineers move into management (Canadian Engineering Manpower Board 1989: 10). Perrucci and Gerstl (1969) observed that the popular stereotype of a successful engineering career in the USA begins with a technical education, progresses through engineering work and culminates in a high-level executive position (Perrucci and Gerstl 1969:93–95).

Badawy (1982) estimated that about 50 per cent of engineers move into management mid-career to satisfy their career goals; they have the strong motivation and potential
to manage. He also noted that about 35 per cent of engineers in the USA, who are undecided technologists, move into management for certain other motivating factors. It is this group of engineers, who have neither the potential nor the interest in management, that affects the organization. However, there are still many individuals who identify with the field of engineering as a lifetime commitment and remain in the technical field (Badawy 1982; Bailyn & Lynch 1983; Bain 1985; Bailyn 1991).

Thus, the literature points out that engineers, in general, have two career development routes: one into management or administration and the other into specialised technical positions with no administrative supervision of others (Albright & Glennon 1961; Bain 1985). Though there are differences in the definition of non-engineering activities, it is clear that engineers are increasingly carrying out managerial activities and that a significant proportion of engineers move into management roles.

2.4.3 Management—an integral part of engineering work

According to one historical tradition, management is an integral part of technological creativity. The construction of monuments such as the pyramids, the great cathedrals of Europe and the Great Wall of China are symbols of the great management and technological skills which then existed. In fact, it is a traditional view that management is a part of engineering work.

It is argued that engineering work involves a significant element of management, on two counts: the first by the fact that engineering, by definition, involves managing people and things; and second, by virtue of technical efficiency in a productive unit (Glover & Kelly 1987: 211). Reflecting those concepts in the 1990s, the Association for Professional Engineers and Scientists Australia (APESA) (1990: 5), included the following: the “ability, with experience, to direct technical operations and carry out associated managerial and administrative functions”, as one of the six important aspects of engineering work.
An historical study of management also reveals that engineers initiated the basic principles of industrial management and made a significant contribution to its diffusion and development (Urwick 1953; Noble 1970). While summarising the historical study of management in the USA, Rae (1957) stated then that the place of the engineer in the management of business is increasingly becoming critical.

During the American period of industrialism, management and especially top management positions were considered to be the realm of engineers (Calvert 1967). Similarly, the early civil engineers had considerable autonomy in managing the work of subcontractors on behalf of their employers (Calhoun 1960). As engineering had become more scientific and specialised, and as business management had evolved as an independent discipline, engineering and management became two separate functions.

However, the extent to which management is separated from engineering work is different for different countries. It is influenced by historical and cultural factors such as timing and the entry of each country into industrial capitalism, the integration of engineers into the organizational structures and the relative status of the engineering profession in that country, and the extent to which the technical culture is shared with the management and work force of that country (Lea & Smith 1992a).

For example, in countries like the UK and Australia, engineering and management are viewed as separate and distinct parts of the industrial organization, with engineers primarily concerned with the technical issues and the managers concerned with the profits, planning and controlling aspects (Glover & Kelly 1987). However, in Japan, France and West Germany, management is so engineer-dominated that management is considered to be an integral part of the engineer’s role (Lee & Smith 1992a; Lawrence 1992). Even in Anglo-Saxon countries, engineers are increasingly performing management tasks (Weare et al. 1984; Williams 1988).
Lloyd argues that the conceptual separation of engineering from management, in Anglo-Saxon countries such as Britain and Australia, is not in accord with the business model of engineering profession, whether the business is manufacturing, a government utility or a government department (Lloyd 1988). He observes that the “literature assumes that when an engineer becomes a line manager, he or she ceases to be an engineer and changes to a different life form, a manager” (Lloyd 1988: 18), a condition which, according to him, is not true.

Lloyd asserts that the line function of managing engineering work is itself engineering work. He blames the traditional professional model which ignores the need for engineers to be competent in both the relevant technology and management, in order to manage the technology and its application through human, physical and human resources. He criticises the professional model that has been adopted from the UK, and the professional institutions in Australia, for not promoting the managerial competencies needed in engineering employment in Australia (Lloyd 1988). Apart from some anecdotal evidence and arguments, the attitude of Australian engineers towards this aspect of their careers has not been analysed.

2.4.4 Reasons for moving into management roles

It is important to analyse why so many engineers move into management roles, leaving their engineering discipline partially or, in some cases, altogether. Although studies of this issue have not been carried out in Australia, some have been made in the USA and the UK. It is argued by some that the transition from specialist technical tasks into management is a wasteful abandonment of a significant educational investment (Finn 1989; Gomez-Mejia, Balkin & Milkovich 1990). For some engineers, it is an escape route from technological obsolescence (Badawy 1982: 40) and has nothing to do with their potential or interest in managerial roles.
However, anecdotal evidence suggests that in some cases engineers prefer to be in technical roles. A study of an American firm revealed that a majority of its engineers would prefer to be in a technical role, despite the fact that more than one in five was actually in a supervisory or managerial roles (Roberts & Biddle 1994).

Others, however, argue that an engineer’s move into management is the only route to continued mobility and earnings growth (Goldner & Ritti 1967; Bailyn 1982b; Jones 1983). In fact, Bailyn and Lynch (1983) noted that an engineer still doing engineering work by the age of 40 is considered a failure and that, in the corporate context, the success of an engineer is measured by his or her hierarchical movement into management (Bailyn & Lynch, 1983: 264).

Studies reveal that engineers move into management for reasons such as higher pay, status and prestige within organizations, the ability to influence policies and programs, and power and influence (Badawy 1971; Bayton & Chapman 1972 and 1973; Bailyn 1980; Roth 1982; Badawy 1983). Confirming the argument that engineers move for higher financial compensation, it is noted that engineers who become managers are better compensated than those who remained as individual contributors in their chosen specialist field (Northrup & Malin 1984). For example, Alden (1975) reported that the median salary for those engineers in supervisory positions was 33 per cent higher than for non-supervisory personnel (Alden 1975: 31).

Though some organizations provide a separate career path in technical fields, managerial paths provide much more attractive rewards in terms of pay, power and status. In view of the high status and rewards associated with management positions in organizations, engineers consider that moving into management represents career development and that returning to a technical field represents failure (Badawy 1981). In fact, many engineers tend to see management as a natural path for career progression (Badawy 1982). He claims that engineers’ analytical and problem-solving
skills and their orientation towards organizations help to make them more suitable as managers than professionals in any other field.

Confirming earlier studies, Ritti (1984) and Greenwald (1978) argue that engineers' moves into management roles are influenced by factors such as pay, prestige, ability to influence, and congruence of their goals with organizational goals rather than by dissatisfaction and frustration with the technical aspects of engineering. Based on a study in the USA, Rynes (1987) asserts that engineers are more likely to be 'pulled' by the attractions of management than 'pushed' by dissatisfaction with engineering (Rynes, 1987: 139).

Whether the moves by engineers into management are motivated by any particular factor, or are just a natural career progression or made at random, engineers are generally viewed to be unsuccessful in management roles in Australia. In the absence of any empirical studies in Australia, it is not known whether engineers are attracted to managerial positions or are dissatisfied with engineering work.

2.4.5 Problems in transition

It is well-understood in the literature that effective management of technology requires the understanding of socio-technical systems and human factors. In fact, many engineers find their advancement and career growth limited more by human factors rather than by their technical ability. Once the transition is made, many firms often find that their engineer-managers lack the interpersonal skills required for competent performance in their jobs.

Based on his studies in the USA, Badawy observed that the transition to management for engineers is a hard one and is, in fact, not even desirable for some (Badawy 1981, 1983). Finniston (1980), in his comprehensive review of the engineering profession in Britain, observed that the transition to management is much more difficult for
engineers than for most other groups in organizations, due to their background and training (Finniston 1980: 91).

It is also recognised from several studies that people management is by far the single most important and difficult issue for engineer-managers (Faulkner & Wearne 1979; Wearne et al. 1984; Williams 1988; Barclay 1989; White 1990). Based on a qualitative study of the transition of specialists into management roles in the USA, Hill (1992) observed that this transition profoundly transforms the way specialists think, feel and value. She concluded that this transformation is iterative, slow and difficult for specialists such as engineers. While specialists do not consider people management as the main component of a managerial role (Hill 1992), the literature generally identifies this as the main difference between a specialist like an engineer who makes an individual contribution and a manager who is responsible for getting things done by others (Kraut et al. 1989).

Hill points out that job descriptions indicating what management is rather than how a manager should do his or her work are responsible for the perception held by specialists. In her study, she noted that new managers were initially reluctant to give up their 'doer' role and mostly perceived their managerial role as "doing more of what they have been doing all along, with more power, control and accountability" (Hill, 1992: 28). According to this study, the specialists who moved into management positions did not know how to provide leadership to subordinates, particularly in managing group performance and context (Hill 1992: 120).

The study observed that these new managers were struggling to balance the conflicting aspects of their roles, such as fairness and equity with individual diversity, autonomy with control, and accountability with tolerance of deficiencies (Hill 1992: 153). Her study highlighted the problems specialists encounter in adjusting to their new managerial roles. The general perception of engineers being narrow technical
specialists fits this model well and the problems identified in this study are critical in an analysis of engineers’ transition into management.

Several independent studies have identified different problems in these transitions. They are the changing nature of engineering work, the nature of engineers as a professional group, the fundamental differences between engineering work and managerial work, engineering education, poor promotional systems and policies within the organizations, and individual personalities (Badawy 1982; Batley 1987; Rynes 1987; Shapira & Griffith 1990).

Reviews of the discipline of engineering have consistently concluded that engineers in general lack ‘soft’ skills and attributed this inadequacy to engineering education, particularly in the UK (Faulkner & Wearne 1979; Finniston 1980; Beuret & Webb 1983; Wearne et al. 1984; Engineering Council 1988, 1989; Faulkner et al. 1989; Batley 1990), and to some extent in Australia (PE Consultants 1972; Williams 1988; Tegart 1990; APESA et al. 1992; IE Aust. 1993a; IE Aust 1996). Though Williams (1988), in his review of engineering education, discussed the difficulties engineers face in functioning as managers, no empirical evidence is available about the perception of Australian engineers or engineer–managers about this. The following discussion reviews the literature on specific issues influencing the transition into management.

2.5 Issues that arise in the transition

2.5.1 Introduction

This part of the review discusses issues that influence the process of transition, as identified from several separate studies in the UK, the USA and Australia. It includes differences between engineering work and managerial work, the changing nature of engineering work, the need for ‘soft’ skills, diversity among engineers, engineering
education, organizational support systems and policies, status, the nature of engineers and strategies employed in managing transition.

2.5.2 Differences between engineering work and managerial work

It is believed that there are fundamental differences between engineering work and managerial work that make it difficult to reconcile one with the other. The nature of managerial work itself is quite distinct from normal engineering work—there is the emphasis on organizational goals, dealing with conflicting interests, and arranging to get things done rather than actually doing them—and this inherently creates problems for the engineer making the transition.

For example, Schein (1977) argues that engineering work requires application of technical knowledge, while management work requires an aptitude for interpersonal relations and a willingness to make difficult decisions affecting other people (Schein 1977). It is found that this lack of fit between engineers’ abilities and the requirements of a managerial job may lead to personal frustration (Bailyn & Lynch 1983) and poor performance (Badawy 1983).

Several authors have argued that managers have interpersonal, informational and decision-making roles to play (Mintzberg 1975); adopt linear approach to management (Stewart 1983); rely on more continuous informal and subtle methods to cope with their work rather than taking a linear approach to planning, organising and controlling (Kotter 1982); and that communication, people management and networking skills are the most important skills needed for them to be effective (Luthans 1988). A study in Australia revealed that Australian managers were more concerned about the implementation and practical aspects of managerial work rather than the traditional issues of planning and controlling (Barry & Dowling 1984).
Based on a study at MIT, Schein (1977) concluded that managers displayed abilities and interests in interpersonal competence, analytical competence and emotional stability, whereas the technical professionals were concerned almost exclusively with the technical challenge of the work itself.

There are sharp differences in learning styles between engineers and managers. Kolb has argued that engineering requires a highly developed capacity for working with abstract conceptualisations in the utilisation of advanced technology for real-world problems (Kolb 1984). On the other hand, when they move into management positions, he argued that the focus shifts much more onto the concrete realities of managing people, planning for various contingencies, setting priorities and handling administrative tasks—realities that generally require a substantial mix of competencies (Kolb et al. 1981).

He pointed out that engineering jobs require strong capabilities in symbolic and perceptual areas, whereas managerial jobs require highly developed affective and behavioural competencies (Kolb 1984). He argued that the career adaptation problems encountered by engineers stem from their overspecialisation, their scientific problem-solving mentality. Kolb termed it ‘professional deformation’ with, as a consequence, difficulties encountered in performing managerial tasks that require greater affective and behavioural competence. However, he argued that the problems of transition into managerial roles are also prevalent in other professions, for example, in social work and accounting, though for different reasons (Kolb 1984).

It is claimed that the nature of managerial work is changing rapidly and radically. New flexible organizational structures, de-layering, reduction of staff, the increasing use of performance-based rewards and refocusing on core business activities are some of the new challenges managers face. Consequent to these changes, managers must in the future learn to live with a whole range of new situations: loss of power and status as organizations flatten the hierarchy; loss of control over subordinates’ assignments,
rewards and careers; changes in the relationships of influence, from chain of command to peer networks; fewer differences between managers and non-managers; the need to develop abilities to work and think across boundaries to add value; the need to prepare for less employment security; the increasing emphasis on bargaining and negotiations; and the increasingly strategic role of managers at all levels (Kanter 1989).

According to Hammer, the founder of the ‘re-engineering’ movement, companies in the twenty-first century will be organised around processes rather than tasks or functions; managers will coach and design rather than supervise and control; employees will be process performers rather than task workers; and the company itself will be a dynamic, flexible organization filled with entrepreneurial zeal and focused on customer needs (Hammer 1996).

Thus those skills such as people management and communication, that are traditionally not viewed as strong points with engineers, are generally required in management roles. Recent studies, as discussed above, pointed towards a further increase in the importance of communication and a reduction in the dominance of power and status-related issues in managerial work. As it is, there is a gap between engineering work and managerial work and attitudes. The organizational changes that have recently taken place are likely to further widen this gap and make management roles more difficult for engineers.

Engineers making the transition into management primarily to acquire higher status and the ability to influence decisions might be dissatisfied with the current shift in the management paradigms. The widening differences between the nature of engineering work and managerial work as perceived by the engineers themselves are likely to influence their transition into management. With most previous studies having been conducted either in the USA or the UK, investigation in the Australian context is necessary in order to develop strategies for successfully managing the transition.
2.5.3 Changes in the nature of engineering work and the need for soft skills

It is argued that the engineer's role as a specialist is also changing. The increasing complexity of organizations and rapid changes in management structures and processes are forcing professional engineers working as technical specialists to increasingly carry out tasks such as marketing, finance, customer relations and human resource management along with their own specialist tasks.

In fact, engineers are increasingly doing tasks such as supervision of work teams, coordination with external or internal people, management of interpersonal relationships and communications in order to cope with the expanding scope and increasing complexity of their jobs (Nicholson & West 1988). The boundaries between general or supervisory managerial functions and those of the technical or professional specialist are becoming blurred (Kramar 1990; Gonczi et al. 1990).

Several studies have pointed out the need for a positive move towards 'generalist' engineers and argued that this move should focus on developing entrepreneurial, professional and personal skills (Tegart 1990; Lloyd 1991; Lee & Smith 1992; Seethamraju & Agrawal 1996). The term 'generalist' engineer used here refers to an engineering specialist who performs business-oriented, non-engineering functions, such as customer relations, marketing, human resource management and accounting in addition to technical functions.

For example, Tegart (1990) argued that against the background of rapid change in the world economy and its impact on Australia, the traditional approaches to engineering curricula must be reassessed. He suggested that there is a need to move towards producing 'generalists' rather than 'specialists', with specialisations picked up by continuing education (Tegart 1990).
Similarly, a study by the Society of Manufacturing Engineers on the outlook for change in the USA concluded that engineers in the twenty-first century will find themselves focusing as never before on the human and business sides of manufacturing. The study asserted that in the next century people skills and team skills will become more important to the success of the engineering profession than will technical skills (SME 1989). The report averred that these 'soft' skills will play a more important role in improving productivity, quality and innovation than will technology.

Advocating re-engineering, "a radical redesign of business processes for dramatic improvements", Hammer argued that engineers working in a re-engineered process-centred company must understand marketing, production, customer service, and how they work together, in addition to engineering (Hammer 1996). He argued that engineers of the twenty-first century will need team skills and the ability to visualise and understand a complex system so that decisions can be made in the face of ambiguity and incomplete information (Hammer 1996). Thus the need for soft skills has been identified in the literature, not only for engineers who are moving into management roles, but also for engineers who are continuing in specialist roles in modern times.

A study by the Centre for Technology and Social Change, University of Wollongong (CTSC 1991) observed that the current phase of industrial change in the form of advanced use of information technology, Japanese management concepts and techniques that emphasise operating autonomy and teamwork, brings challenges to engineers. These changes call for a redefining of engineers' roles irrespective of the area of their work.

Several reform initiatives such as commercialisation, open competition and workplace reform in public sector organizations have a dramatic effect on the status and roles of engineers. A study on organizational change in Australia by Waldersee and Blackstock (1993) identified middle management as a central blockage to change programs and
called for further research on the problems associated with middle management leadership. In fact, a study by the Institution of Engineers observed that engineers have attracted some of the criticism associated with the reform of the Australian workplace, as being those who have managed the process of such change (IE Aust. 1993a).

These changes, as discussed above, are expected to have a dramatic effect on the roles of middle-level professional engineers in engineering-based organizations, whether they are working as specialist engineers or engineering managers. (The term ‘specialist engineer’ is used here to refer to an engineer who has considerable expertise in a particular technical area.) These changes have major implications for all engineers and their roles in organizations in terms of their skills, training, career paths and future opportunities for leadership positions (White 1990). If the dynamics of such organizational changes are better understood, it will help engineers to balance stability and adaptability in a more enlightened way.

However, this does not mean to say that the technical element in an engineer’s job is not important or that it does not exist in managerial roles. In fact, it is argued that the technical skills gained through professional training and/or enterprise specific functional experience within organizations are equally important, even for managers in modern organizations (Katz 1974; Hill 1992). Katz (1974) observed that technical competencies are becoming crucial for all managers, even at senior level. He argued that potential managers should be exposed to broad technical challenges by experiencing them.

Highlighting the importance of the technical skills possessed by those specialists who move into managerial roles, Hill (1992) noted that technical skills are necessary for effective managerial performance. She observed that new managers who moved from technical roles relied upon their technical background as an expert knowledge base, a source of self-confidence when faced with self-doubt, and a base upon which to build credibility and exercise influence over others (Hill 1992).
As the discussion above points out, the nature of engineering work itself is changing. Engineers are under increasing pressure to redefine their roles and adequately equip themselves with 'soft' skills to meet the challenges of the future, whether they move into management roles or continue as technical specialists. It is necessary to understand engineers' perceptions of these issues and their preparedness for these changes in order to develop policies and strategies for engineering education, training and organizational systems.

2.5.4 Diversity within engineering work

2.5.4.1 Classification by nature of the job

Research indicates there are differences in the attitudes of engineers depending upon the nature of the work they carry out in their organizations and their individual personality characteristics (Bayton & Chapman 1973; Klimoski 1973; Bailyn 1980; Sedge 1985). Criticising earlier studies that combined all groups of engineers into one, Ritti (1967) argued that the diversity within the profession is considerable. Klimoski (1973), basing his study on life-history information, further demonstrated that it is possible to differentiate the groups in terms of R & D engineer, engineer in production/manufacturing, and engineering manager.

Klimoski (1973), in his study of 920 engineers in the USA, argued that it is possible to predict the career success of engineers based on their life history biodata (Klimoski, 1973: 112). Similarly, Albright and Glennon (1961) identified significant differences between scientists working in administrative positions and those in research positions. Sedge (1985) compared the career paths of engineers and engineer-turned-managers and concluded that it is possible to differentiate between these two groups. This study in the USA, on 70 male engineers and 86 male engineer–managers, concluded that the desire for achievement and conventional interests were predictive of job satisfaction
for engineer–managers, whereas investigative and artistic interests were predictive of job satisfaction for engineers.

In another study, Brown (1981) observed that the need for dominance and a mind disposed towards thinking along psychological lines (psychological mindedness) are factors that can distinguish between engineers and engineer–managers. Brown (1981) conducted a study in the USA on 76 subjects selected from three organizations, and identified three groups—engineers, engineer–managers and managers. The results showed that engineer–managers have a greater preference for acting upon and through other people, are more outspoken, socially oriented, confident, and comfortable in interacting with others, than are engineers but moderately less so than managers (Brown 1981: 262).

The report observed that the management style of engineer–managers is different from that of managers who were not trained in engineering, in that the engineer–managers depend “to a greater degree upon intellectual insight into the needs and motives of people and less on the pleasure of interacting with them” (pp. 263). The study demonstrated that the five scales in the CPI (California Psychological Inventory)—Dominance, Capacity for Status, Social Presence, Sociability, and Psychological Mindedness—can be used as discriminators among these function groups, engineers, engineer–managers and managers (Brown 1981).

In a later study, Hill and Roselle (1985) reported that interests in social, enterprise, and conventional areas are stronger among managers than among technical specialists. A Strong-Campbell Interest Inventory (SCII), a modified psychometric inventory questionnaire originally designed by Holland (1973, 1985) was used to collect data from 55 technical specialists and 55 R & D managers. From an interpretation of different responses to different themes in the questionnaire, it was observed that managers were likely to be responsible to authority and more comfortable in an organizational hierarchy than were technical specialists. Furthermore, managers were
more likely to be more interested in status, persuasion and developing people than the were technical specialists.

As far as the type of engineering degree is concerned, prejudice against manufacturing in Anglo-Saxon countries affects the choice of work to be done after graduation. Studies of the choices made by final-year UK engineering students show this quite strongly (Herriot, Ecob & Hutchinson 1980; Herriot, Ecob & Glover 1981). These studies revealed that research and development and design were often preferred over 'dirty production', and that most students in the UK felt that their lecturers, relatives and friends would prefer them not to work in production.

Though no specific analysis was carried out, some anecdotal evidence on the differences between engineers and engineer–managers was noted in Williams' study in Australia (Williams 1988). Past studies, as discussed above, have indicated that the attitudes of engineers are influenced by the predominant nature of their jobs. With the rapid technological progress of the 1980s and 1990s, and the restructuring initiatives in organizations, the diversity among these attitudes is being further widened. Therefore, it may not be appropriate to combine all engineers into a homogenous group and to form generalised conclusions.

2.5.4.2 Classification by type of employing industry

Whether engineers are working in the public sector or in the private sector is another differentiating factor within the salaried employee professional engineers group. In a study in Australia, Rice and Lloyd pointed out that about 40 per cent of engineers worked in the public sector and about 60 per cent in the private sector (Rice & Lloyd 1991). An analysis of private sector engineers by Davy (1987) revealed that a majority of private sector engineers work in highly dispersed locations, and have a greater affinity with their employers than do engineers generally. Davy (1987) argued that they are significantly different from the professional engineers employed in the public
sector, having a higher degree of entrepreneurial spirit and self-help. He pointed out that private sector employers deploy an engineer only when an engineer can produce a greater return than a non-engineer (Davy 1987).

An investigation of engineers working in large private sector organizations in Australia revealed that the employment of engineers in those organizations is a business arrangement based upon value for money and that the engineers are not committed to the professional associations (APSB 1987). Similar to those engineers working in small private sector organizations, these engineers are employed to do engineering work based upon rewards for performance, the APSB study noted.

By contrast, public sector engineers are observed to have a greater affinity towards the professional association represented by the Association for Professional Engineers and Scientists Australia (APESA) (Lloyd et al 1989), and the characteristics of self-help and entrepreneurial spirit are less often found. Based upon a study of 300 young public sector engineers, Lloyd et al (1989) concluded that: “it is difficult to imagine a similar age group of professionals such as medical practitioners, or accountants in private firms, or lawyers, exhibiting such stunted professional formation, overall lack of work challenge, low maturity, or low self-esteem” (Lloyd et al 1989: 205). He observed that “such attitudes reflect badly upon their educational formation and upon the culture of their work environments, reflecting the attitudes of senior colleagues” (Lloyd 1989 et al: 205).

The type of employing industry is therefore another factor that influences the attitudes of engineers. Except for the anecdotal evidence in the study by Lloyd et al (1989), no empirical evidence is available in Australia.
2.5.4.3 Diversity of engineers—a summary

The above discussion highlights the differences between engineers—in their attitudes, depending upon the nature of their work, their area of work and the discipline in which they are trained. Most of the anecdotal evidence comes from the USA and the UK and highlights the need for not treating engineers as a homogeneous group. In Australia, although Williams (1988) identified some differences between electrical engineers and others, no detailed investigation of these differences has been carried out. Considering the everchanging cultural, technological and social context in which engineers work and the increasing diversity within the profession, further research is necessary to investigate the differences between engineers such as those characterised by their differing nature of work, employing industry, gender, discipline of engineering and other variables.

2.5.5 Individual personality and orientation

It is argued that engineers’ moves into management roles are not determined by the money and prestige factors, but are dependent upon their individual personality characteristics (Bell & Bordin 1964; Ritti 1967; Holland 1985). A study in the USA indicated that some engineers have better potential than others to succeed in managerial roles due to their individual personalities, social backgrounds and attitudes (Sedge 1985).

However, later studies, while not discounting the importance of individual personality, argued that pay and organizational status associated with management positions play an important motivating role. For example, studies in Britain and the anecdotal evidence from West Germany, France and Canada, also confirm that pay and prestige issues are one of the important reasons for this career move by engineers (Lee & Smith 1992a).
From the individual personality perspective, a study in the USA by Bayton and Chapman (1977) observed three reasons for the difficulty in making the transition. Firstly, it is the differences in motivation between individuals, with some technically minded people preferring autonomy in their jobs, while those with leadership abilities might find the management role more satisfying. Secondly, the difficulty of some technical people to relinquish their technical skills and learn new managerial skills; and thirdly, a deficiency of management skills in an individual (Bayton & Chapman, 1977). Although engineers move into management positions for several reasons and motivations, the success of their move appears to depend upon the individual personality.

It is also argued that the decision by engineers to move into management is influenced by their occupational proclivities, and is taken well before they enter an organization. Many of those who initially chose engineering careers were inherently oriented more towards technical and professional objectives than towards meeting organizational goals (Bailyn 1982a; Shapira & Griffith 1990). This personal orientation coupled with a technically oriented education and training means that those who move into management often lack the skills necessary to be effective managers (Lea 1991).

It has been claimed that the differences between technical specialists and engineer-managers are not detectable mid-career, so there is a need to identify the occupational proclivities of engineering students. This notion has been supported by several theories on vocational choice. For example, Holland (1973) described vocational choice as an expression of personality and developmental history, which are relatively stable individual characteristics. In fact, Klimoski argued that the differences between technically oriented people and management-oriented people can be measured early in their career (Klimoski 1973: 112).

In a study in the USA, Rynes (1987) noted that most transitions into management are voluntary and can be anticipated from an early stage. Based on her research, she
demonstrated that the managerial and technical aspirants could be identified while they were engineering students. She could identify them by analysing their reasons for choosing engineering school and curriculum, their early career plans and intended career strategies, and their beliefs about engineering and management as occupations (Rynes, 1987: 151).

In fact, going back to the types of engineering recruits, Taylor in his study observed that the social and economic background of the recruits had a significant influence on their career choices (Taylor 1979). He argued that, in general, those of a higher social class perceive managerial advancement as a natural part of their career development, while those of a lower class are more oriented towards the technical aspects of engineering work.

Consistent with these findings, Taylor (1979), in a survey of engineering students in the UK, concluded that the career orientations of students differed depending upon their job choices. The study found that those students entering R & D or design had different career orientations from those entering ‘operations’ or from those leaving engineering (Taylor 1979: 41).

The above discussion reiterates the importance of individual personality characterised by orientation towards managerial work. In fact, it is argued that it is possible to predict occupational proclivities in the early stages of engineering education, and to avoid the enormous cost involved in moving into management those engineers who are neither interested in it nor have the potential for it. Most of the literature in this area comes from the USA; no studies have been conducted in the Australian context.

2.5.6 The nature of engineers

The beliefs and values espoused and shared by engineers as a professional group play an important role in their attitude towards management roles and towards broadening
their technical roles. Several studies have confirmed the professional culture among engineers in the form of shared common values and beliefs and noted that it is a problem in their successful transition into management.

2.5.6.1 Studies in the USA and the UK—stereotypes of engineers

While management is primarily concerned with people, it is argued that engineers, by training, and usually by disposition, are more interested in things (Watson 1954; Koplow 1967) that, when dealing with people, they tend to reduce them to objects (Beal & Bordin 1964); that they are reluctant to delegate authority and would like to do everything themselves (Moore & Levy 1951; Given 1955); that they cannot work effectively with or in groups (Goshen 1969); that they have an excessive need for evidence before making decisions (Dunnette et al. 1964); that they are more authoritative (Bailey & Jensen 1965; Elton & Rose 1966); that they come to engineering because it is interesting work (Loomba 1968); and that they look for extrinsic rewards in their job (Perrucci & Gerstl 1969). Engineers are also considered to be excessively concerned with technical details even when they are in a managerial position, when their time might be better spent on human relations and people management.

However, several researchers have pointed out that engineers are particularly suitable for top management positions because of their superior intellect and conceptual abilities (Harrison, Hunt & Jackson 1955; French 1959); their efficiency in handling day-to-day affairs in an organization (Moore & Levy 1951); and their inclination to place less importance on order and certainty, are not authoritarian and are more concerned for people (Glover & Bamber 1975).

Smith (1969) suggested that the quantitative emphasis which then existed in management in the USA, in the form of systems analysis, scientific management and information storage and retrieval, were particularly suited to engineers who had
training in analytical and number skills. With the changes in management paradigms and the consequent emphasis on human and organizational issues and group dynamics in management, engineers have in later studies been increasingly viewed as inadequate in management skills.

Several researchers in the USA have argued that a change in their thinking and attitude was needed when engineers become managers, in terms of transferring their loyalties from the profession to the firm (Bailey and Jensen 1965), from the pursuit of perfection to an attitude of putting together a workable package (Koplow 1967), and from motivations such as independence and recognition to pride of position and authority (Bailey & Chapman 1972). As must anyone moving up the ladder in an organization, engineers moving into management must be able to deal with their changed relationship with former peers (Bailey & Jensen 1965), and adopt a more generalist view of their managerial role (Bayton & Chapman 1972, 1973).

However, as pointed out by Medcoff (1985), none of these arguments has been well-supported by formal and controlled empirical studies and they must therefore be considered with some degree of caution. Similarly, Glover and Kelly (1987) refuted these arguments on the grounds of their poor research design and attributed the interpretation to the “prejudices of social scientists” (Glover & Kelly, 1987: 80). Some of the above studies apparently concentrated on the weaknesses of engineers with no contextual reference to their strengths; the conclusions, therefore were incomplete.

On balance, Badawy (1982) argued that the weaknesses of engineers outweigh their strengths and affects their managerial performance. He argued that the familiarity engineers have with analytical skills and their problem-solving skills are important in managerial problem-solving and decision-making. However, the definite bias that engineers have in making an objective measurement of everything, their tendency to wait for all the information to be in before making a decision, their fear of loss of intimate contact with their technical field, their preference to do things themselves
rather than delegate, their introverted nature and their poor interpersonal skills are the main reasons for their failure when they move into managerial roles (Badawy 1982).

2.5.6.2 Studies in Australia—stereotypes of engineers

In Australia, too, there is a common perception that engineers are analytical, are less concerned with the human side of their work and prefer working with things rather than people (Eckersley 1987; Williams 1988; IE Aust. 1996). A study by the Institution of Engineers Australia (IE Aust. 1993a) revealed that there was considerable negativity towards engineers in Australia. It found that most people in the community believed that engineers performed technical trade tasks, that more engineers were not necessarily better for Australia and that engineers did not make successful business people (IE Aust. 1993a: 4).

The study revealed that engineers were viewed by the community as aloof, conservative and old-fashioned, and operate in hierarchical structures which cause communications breakdowns between engineers and the broader work force (IE Aust. 1993a). It observed that the community views the recent engineering graduate as being more theoretical than practical.

It stated that "the nature of engineering work which required precision and accuracy also reflected the nature of them as people" (IE Aust. 1993a: 17). Respondents in the study saw engineers as blinkered, predictable, narrow and self-focused. The study concluded that that negative perceptions of engineers as old-fashioned and conservative were prevalent in industrial organizations. It also observed that engineers, being among those who have managed the process of change in the manufacturing sector, have collected some of the criticism associated with the reform (IE Aust. 1993a: 14).
This last observation is mainly due to the management role fulfilled by engineers in general, and by their role in managing the current structural change process in Australian organizations. The study noted that engineers are viewed as replicating outdated management styles of rigid, tall hierarchies, and that these negative views of engineers inhibit their workplace performance and affect Australian international competitiveness (IE Aust. 1993a).

Similarly, a survey conducted by the Victorian division of IE Aust. of Victorian engineering employers reported that “more than 97% of the respondents concluded that their current engineers did not have the necessary skills or experience to carry out their duties to ‘an acceptable level of competence’” to work in the niche demand areas of the future (Engineering Times (ET), August 1993, p.3). The survey reinforced a concern that engineers, although proficient in the technical areas of the jobs, were falling well short of necessary communication, management and entrepreneurial skills (ET, August 1993). The report noted that professional engineers were found lacking in commercial awareness and customer focus.

On communication skills, the report observed that many engineers had “difficulty putting thought to paper, frequently made errors in spelling, grammar and syntax and were unable to write a clear project report” (ET, August 1993, p.3). In an earlier study, a report on a review of the engineering discipline in Australia observed that engineers lack communications skills and are perceived by the general public as conservative (Williams 1988).

It is clear from the above that engineers are perceived to be authoritative and unwilling to delegate, and that they generally lack customer focus and commercial awareness, communication skills, team-working and entrepreneurial skills—skills so essential for effective managerial performance.
2.5.6.3 Organizational orientation of engineers

The extent of an engineer's orientation towards the organization and its requirements rather than towards the profession as a whole is identified as an influential factor in an engineer's transition into management. It is argued that engineering, though based on technical expertise, is not a profession (Kerr et al. 1977). Because it is subjected to organizational control, rather than occupational control like other professions such as medicine, the law and accountancy, it is not regarded as a true profession (Child & Fulk 1982). Engineers are seen as a group that subscribes more to organizational values rather than to professional values (Ritti 1971; Bailyn 1980).

It is argued that engineers, unlike those in the other professions just mentioned, subjugate their professional goals to the objectives and goals of the organization, and that they are organization people (Hindle 1981; Ritti 1967). An engineer's career advancement is clearly tied to the activities of the organization in the USA (Ritti 1967). With a sample of 4582 engineers, Ritti's study is considered to be representative of the general population of engineers in the USA.

Moreover, it was found that engineers' organizational commitment had a significant and direct effect on their job satisfaction and an inverse effect on problems (Baugh & Roberts 1994). As their work frequently depended on large corporations, "their own interests have dictated conformity and orthodoxy as the most appropriate intellectual postures and put them in the mould of organization persons" (Buchanan 1989: 96).

It is argued that the most important characteristics on which to base the definition of profession are: specialty knowledge, self-regulation, sense of honour and prestige conferred by membership, the possession of code of ethics, high financial rewards, and guarantees of competence for the client (Johnson 1972; Glover & Kelly 1987; Lloyd 1988). Engineering, though it possesses several of the characteristics mentioned above, presents a mixed picture.
One of the important factors that makes engineering a profession distinct from others, say, medicine, concerns self-regulation. In engineering, it is non-engineers, such as employers, contractors, accountants and marketing directors, who at least partly define the problems and, to some extent, the solutions. Moreover, because of salaried employment, engineers are not considered to be fully professional (Glover & Kelly 1987; Lloyd 1991a). This difference with other professions puts engineers in a situation where their professional satisfaction is clearly linked to and dependent upon their career advancement within their organizations.

2.5.6.4 Summary—nature of engineers

Most studies have been carried out in the UK and the USA. However, two qualitative studies in Australia (Williams 1988; IE Aust. 1993a), provided some anecdotal evidence confirming the overseas findings. As can be seen from the above discussion, some the findings are inconsistent with others. These contradictions in the nature of engineers, as identified in the literature, can be attributed to differences within the profession and the differences in educational programs, professional formation strategies and the status accorded engineers in various countries.

2.5.7 De-engineering in public sector organizations

Another factor that is influencing the transition of engineers into management in Australia is the de-engineering trend in public sector organizations. The term ‘de-engineering’ is defined as “the managerial approach whereby engineers are replaced in the management and leadership of professional engineering functions by non-engineers” (Lloyd 1991a: 11).

It is an established fact that the international competitiveness of Australian manufacturing business depends on its ability to produce high-quality senior managers
with technical backgrounds (EPAC 1989; CTSC 1991)). In spite of this, the place of engineers in the public sector in Australia has been threatened by an apparent de-engineering trend.

Managerial positions in engineering-based organizations have been increasingly perceived by government bureaucrats as having non-occupation specific requirements. In the Australian public service, for senior management positions even in technical organizations, no educational or professional qualifications are considered to be essential (APSB 1984). There is an implicit assumption that 'management' is different from engineering, and that senior managers with managerial and administrative abilities, even those from non-engineering backgrounds, are the best people to manage engineering organizations.

In contrast, an Australian Public Service Board (APSB) (1987) team, comprising engineers, in its review of the position classification standards in the Australian public service, recommended that professional engineering qualifications be retained for senior management positions that have prime responsibility for the management and leadership of engineering functions (APSB 1987). Reflecting the ideology prevailing among senior administrators in the government, an ideology that promotes corporate identity across service, rather than within occupational groups, this recommendation was rejected and the de-engineering trend apparently continues.

Opening up engineering positions to people whose expertise may be unrelated to the functions for which the positions are responsible has become a common phenomenon in the Australian public sector both at federal and state level (Vines 1986). By opening up these positions to people from other backgrounds, the leadership of these engineering-based organizations had gone to non-engineers.

Such administrative strategies, this 'de-engineering', have not been accepted by the profession on the grounds that "they are likely to lead to the diminution of the
engineering capabilities of the organizations concerned” and could in some instances jeopardise public safety (Lloyd 1988: 16). Lloyd observes that “the apparent strategy to de-professionalise engineering in many government undertakings in the name of increased efficiency and better management makes rhetoric about the importance of engineers in the economy a little short on credibility” (Lloyd 1988: 16).

The Institution of Engineers Australia (IE Aust.), expressing its concern at the de-engineering trend, responded with a policy statement. While supporting the notion that merit is the prime criterion for filling a position, IE Aust. stressed that “the efficient, effective and professionally responsible leadership and management of engineering functions requires the possession of professional engineering qualifications and experience” (IE Aust. 1987). Being careful not to be perceived as protecting the demarcation lines between professions, the Institution rejected the notion that non-engineers are required to effect economic measures and to control engineering functions.

While supporting the need to restructure and review engineering-based organizations periodically to ensure continuing economy, efficiency, effectiveness and relevance, the IE Aust. recommended the use of the word ‘engineer’ in all position titles, and the possession of engineering qualifications by engineering managers as a necessary prerequisite (IE Aust. 1987). Thus, IE Aust. responded to the de-engineering trend by issuing a statement emphasising its concern to protect professional identity as well its concern over the efficacy of professional leadership (Lloyd 1991a).

However, it was also argued that de-engineering is part of a public sector management reform in Australia (Codd 1991). Reviewing the history and current priorities of federal public sector management reform, Codd (1991) argued that the general push towards efficiency and economic rationalism in Australia challenged the traditional objectives and purpose of public sector institutions. The introduction of professional management practices in the public sector became increasingly popular in many state
and federal governments' institutions and departments. This trend resulted in the recognition of the need for professional managers in senior positions and the eventual elimination of barriers against others entering and competing.

For example, in many engineering-based organizations, senior management positions require engineering qualification and engineering experience as the minimum requirement to be eligible for consideration for promotion into senior management. Consequent to the reform process, these barriers (as they were perceived by senior bureaucrats and managers in the public sector) for selecting the most appropriate person were gradually eliminated. These reform initiatives, in terms of redefining job descriptions and job specifications in the public sector, also spread to state governments and many other autonomous and statutory authorities at federal, state and local government level (Codd 1991).

This 'de-engineering' trend, as it is viewed by professional engineers in the public sector, has been resisted to some extent (as discussed above) by the professional associations, IE Aust. and APESA, with no apparent success. This trend, in a way, affects the chances of engineers reaching senior management positions. Increasingly, engineering-based organizations in the public sector at federal and state government levels have been headed by non-engineers and career bureaucrats. This, together with the lower status of engineers when compared with accountants and economists in Australia, and the general perception, held by engineers as well as their employers, of their inability to hold senior management positions, has compounded the problems of transition.
2.5.8 Engineering education

2.5.8.1 Inadequacy of engineering education—current debates

That the engineering education curriculum is inadequate in imparting to engineers and engineer–managers the ‘soft’ skills required to succeed in their professional roles is well-established in the literature in Australia and overseas (Dunn & Fensham 1970; Beuret & Webb 1983; Williams 1988; APESA et al. 1992 and several UK studies). According to this literature, of all the relevant factors, engineering education by far seems to have the most significant influence on the managerial skills of engineers in organizations.

Debates in the literature on undergraduate engineering curriculum and its content are not new. From time to time, engineering education in Australia and in countries such as the USA and the UK has been criticised for not providing engineers with adequate knowledge and skills in planning, finance and business management (Finniston 1980; Beuret & Webb 1983; Faulkner & Wearne 1984; Williams 1988; Hessami & Eley 1992a; IE Aust. 1993). Consequently, upon employment, employers found that graduate engineers were not useful unless they were provided with extensive retraining at their expense.

This, together with the increasing complexity of engineering in terms of breadth and depth, has widened the differences in specific skills required for different enterprises, from discipline to discipline within engineering and also within the same discipline (Denning 1992). These emerging issues challenge the traditional approaches to engineering education. In order to better understand the debates involved in these changes, a brief historical review of the past debates on engineering education curricula is presented.
2.5.8.2 History of engineering education in various countries

In the UK and in Australia, the early training of engineers was by articled pupillage or apprenticeship under an established practitioner (Buchanan 1989; Lloyd 1988). While the first engineering department was established at Kings College in the UK in 1838, the first engineering school in Australia was established in the University of Melbourne in 1858. Formal education in engineering started in the USA in 1824. Though more colleges started around that time, pupillage remained the most common method of training British engineers throughout the nineteenth century (Lloyd 1988).

In Germany and France, a number of schools for civilian engineering were established during the eighteenth century (Lloyd 1988). After perceiving the need for formal technical training and the development of theoretical foundations and bodies of knowledge, a comprehensive program of higher education in engineering incorporating extensive laboratory work and research was established in the UK (Buchanan 1989).

In contrast, in the USA, engineering education grew in competition with the apprenticeship system. The debate between the ‘shop culture’ and the ‘school culture’ was often intense. Unlike schools of law and medicine, engineering schools in the USA were not established by practitioners; sponsorship for engineering schools came from government, academics and professional societies (Forman 1987). In his review of engineering education in the USA, Wickenden (1929) commented that engineers must add humanism to all the special qualities of the engineer, and thus signalled the need for the inclusion of liberal arts and other non-technical subjects into the engineering curriculum.

A comparison of engineering education in Japan, France and West Germany with engineering education in countries like Australia and the UK reveals some significant differences. For example, in Japan, employers provide engineers with experience by
intensive enterprise-specific training on the job and off the job, and contribute to the
development of their non-technical skills (Chung 1986; Kinmonth 1986).

It has been observed that engineering is the route to the top in Swedish and German
industry (Glover & Fores 1973). Similarly, in France, engineering education attracts
the best talent, by virtue of its superior status in society (Glover & Fores 1976;
Crawford 1989). French diploma engineers who have graduated from one of France’s
prestigious engineering grandes écoles are considered to be “high-powered, broadly
educated, and practical engineers with commercial, social, financial and political
awareness, skill and ability to act with discernment” (Glover & Kelly 1987: 79).

Commenting on the infrastructure and the attitude of educators in Australia, Williams
noted that engineering schools had been more responsive to changes in engineering
science and equipment than to changes in engineering practice, and were not interested
in the human element of technology (Williams 1988). Williams’ review stated that
engineering schools paid little attention to graduate rates and particularly to the large
drop-out rates in the first year—it is estimated that about 20 per cent of engineering
students drop out after or during the first year.

Six years after Williams’ review, a study conducted by the University of Technology
Sydney revealed that the equipment and tools in engineering schools were still largely
outdated and not in line with the technological development taking place. It called for
a thorough modernisation with huge investment (The Weekend Australian, 3 July
1994, p. 24). Despite the poor rating given by employers to the response by
engineering schools to industry needs, the report concluded that “Australia has a fairly
good system of engineering education which should be made better” (Williams 1988,
Vol.1: p. x).
2.5.8.3 The restrictive nature of engineering education

Engineering education in Australia has been criticised for its lack of concern with developing a student’s understanding of social and power relations in an industrial society (Lloyd 1988). The students are conditioned by the form and content of their education to hold narrow technical values that are at odds with the changing socio-technical environment in which they are eventually employed. With increasingly higher levels of education in the work force, from the highly skilled professional to process workers, engineers can expect to be called upon more and more to explain their work and to justify their decisions (Kichen et al. 1979; Williams 1988).

The criticism has been made that engineering courses do not normally provide any opportunities for students to reappraise their own value systems and that they are not exposed to the different values of people with whom they will eventually have to work (Williams 1988). The increasingly multicultural workplace in Australia can be difficult for the fresh engineering graduate. It is argued that the “anti-union attitude of engineers is a reflection of their education and its failure to give them an understanding of long-established, but changing, power relations in industrial society” (Lloyd 1988).

Though a move into management was the objective of most engineering students (Gilmour 1976; Goldberg & Irwin 1973), the “educational system overdevelops their analytical skills, while their managerial skills remain highly underdeveloped” (Badawy 1982: 43). Though Badawy’s studies were in the USA, a similar trend has been observed in Australia (PE Consultants 1972; Stringer 1982; Williams 1988; IE Aust. 1992; APESA et al. 1993; IE Aust 1996) and in the UK (Faulkner & Wearne 1979; Finniston 1980; Beuret & Webb 1983; Barclay & Hawkins 1986). Engineering education is seen to be restrictive in nature, underdeveloping soft skills and overemphasising analytical skills.
2.5.8.4 The professional mentality in engineering education

In professions like engineering, higher education encourages early specialisation which necessarily accentuates particular interests and skills (Stretton 1985). As a result, the process of socialisation into a profession becomes an intense experience that instils not only knowledge and skills but also a fundamental reorientation of one’s identity (Kolb 1984).

This reorientation, termed by Kolb the ‘professional mentality’, includes standards and ethics, personal ways of thinking and behaving, and the criteria by which one makes values and judges what is good or bad (Kolb 1984). Engineering education, influenced by its academic staff and their attitudes, old curriculum design, and traditional teaching and learning strategies, encourages a narrow, technical—and technically narrow—view among engineering graduates (Williams 1988).

It is argued that a university, by adopting an appropriate selection process, curriculum design and teaching and learning strategies, encourages this mentality in its graduates (Kolb 1984; Boud et al. 1991) and thus ensures social control over the quality of its professionals. However, at a time when people are more frequently changing their careers, fewer professional engineers remain in engineering for life.

Any professional specialist moving into a management role requires a set of competencies and a learning style that is significantly different from the convergent professional mentality (Gonczi 1992). This is especially so in the case of engineers. This process of socialisation through educational processes poses a dilemma. According to Kolb, the dilemma of emphasising intensive socialisation in the specialised role as against the choice for broader development has been central to much of the self-examination, social criticism, and student/alumni evaluation of professional education (Kolb 1984).
Schein (1972), for example, outlined seven problems of professional education that are related to the dilemma of specialised versus integrative education: an unresponsiveness to certain classes of social problem that require an interdisciplinary point of view; the rigidity of educational programs which do not give enough flexibility to students in career choice; the rigidity of entry requirements that practically restrict the entry of certain classes of applicants, such as women, older people and career switchers; the convergent nature of the growing base of knowledge that delimits innovations other than in the highly specialised content areas of the profession; the unresponsiveness of professionals to the needs of end clients or users; the inability of professional education systems to provide training and/or experience in teamwork and working with other professionals; the underutilisation of available knowledge in applied behavioural sciences; and the inability of people to learn continuously throughout their careers (Schein 1972: 59).

Altmeyer (1966) has dramatically illustrated the result of the accentuation process on cognitive abilities in his comparative study of engineering and fine arts students in the USA. The study observed that engineering students scored highest on analytical reasoning and the fine arts students scored highest on creative thinking. During the period of education in their respective fields, engineering students became more analytical and fine arts students became more creative. However, the surprising finding was that in the same period engineering students decreased in creative thinking and fine arts students decreased in analytic reasoning.

Studies in the USA asserted that the educational processes that accentuated one set of cognitive skills, for example, analytical skills among engineers, also appeared to produce a loss of ability in the contrasting set of skills—creative thinking. These studies signify how influential is the relationship between the educational processes adopted in teaching and learning engineering and the outcomes in terms of the skills acquired by students.
2.5.8.5 Learning style and processes

The learning styles of individuals and the present university educational processes influence educational outcomes. For example, research on individual learning styles in the USA concluded that incompatibility between the individual learning style and the emphasis in a particular educational process results in the student moving away from that course and career path (Plovnick 1971; Kolb 1984). For example, Plovnick (1971), observed that the students who were not fitted for the convergent learning style required in physics tended to turn away from physics as a profession, while those students having a convergent style tended to continue to specialise in physics, both in their course choices and their career choices. In fact, this incongruence between the preferred learning style of the individual and the learning style required for certain non-technical courses such as management and the liberal arts is cited as the reason for students’ general lack of interest in and resistance to attempts to broaden their interests (Kolb 1984).

Arguing that the learning styles of individuals tend to influence their career choices and paths before they enter the educational system, Witkin and his associates (Witkin et al. 1976) have shown that field-dependent students choose specialisations that favour involvement with people, such as teaching, sales, management and the humanities, whereas analytical or field-independent students choose areas that favour analysis, such as the physical sciences, engineering and technical activities (Witkin et al. 1976).

Kolb argued that educational techniques, though they tend to be highly sophisticated and creative in their own field, are much less sophisticated in the way they enhance learning (Kolb 1984). He pointed out that “the failure to recognise and explicitly provide for the differences in the learning styles that are characteristic of both individuals and subject matters” is the main weakness in all these techniques.
Several modern educational techniques, such as computer-aided instruction, experienced-based learning materials, programmed instructions, games, multimedia curricula and open classrooms, have been introduced in recent years in universities to assist the learning process. Kolb criticised them for their inability to provide individual learners with alternative learning routes based on their learning style. He suggested that the concept of learning environments developed by Fry (1978) provides a system of managing the learning process. According to Kolb, "any educational program, course design, or classroom session can be viewed as having degrees of orientation towards each of the four learning modes in the experiential learning model, labelled as affective, perceptual, symbolic, and behavioural, to connote the overall climate they create and the particular learning skill or mode they require" (Kolb 1984: 197).

Based on a study of learning environments in US universities, Fry (1978) identified four types of environments: ‘affectively complex, perceptually complex, symbolically complex and behaviourally complex’. He observed that engineering courses generally have a ‘symbolically complex’ learning environment, in which the learner is involved in trying to solve a problem for which there is usually a right answer. Some of the courses in liberal arts and management have a ‘perceptually complex’ environment, which emphasises the identification of relationships and the ability to research a question from different perspectives and the process rather than the outcome.

Kolb criticised traditional classroom teaching methods as too homogenous as learning environments, appealing only to a single learning style and thus discouraging others who would prefer to learn by alternative ways (Kolb 1984). He argued that a shift in the role of lecturer from dispenser of information to coach or manager of the learning process is the key to enhance learning in universities.

Commenting on the learning objectives in higher education, Kolb (1984) observed that the curriculum considers only the objectives of a course without indicating any objectives in terms of learning style and creativity, aspects that are essential in a
university education. He recommended a focus on integrative continuous development, where a student is self-renewing and self-directed in order to develop in each of the four learning modes: active, reflective, abstract and concrete (Kolb 1984). Kolb suggested that the central function for the larger university organization is to provide "the integrative structures and programs that counterbalance the tendencies towards specialisation in student development and academic research" (Kolb 1984).

However, it is difficult to make this shift to integrative continuous development and to take into consideration the individual learning styles of students in view of the entrenched specialisation and intense political rivalry between faculties in universities. The establishment of a truly interdisciplinary program of research and teaching is made yet more difficult by faculty reward systems, selection and evaluation criteria, disciplinary values, and the dominant academic culture. Increasing the non-technical content is therefore one of the strategies that has been suggested by several studies in Australia, the UK and the USA to counter accentuation of the professional mentality, the restrictive nature of engineering education and the entrenched specialisation in technical aspects.

2.5.8.6 The non-technical content of engineering education

The issue in this debate is not whether or not education in non-technical subjects is necessary, but how much should be offered to students. Historically, liberal arts and other non-technical subjects were considered part of engineering education curricula. However, the exponential growth in engineering knowledge and the increasing technical content of even the most elemental engineering education has inevitably changed the nature of that education, forcing out peripheral concerns and almost eliminating the liberal arts in the USA (Florman 1987). Inevitably, engineers have become less broadly educated and less wide-ranging in their background and interests.
After several years of studies, reports and deliberations, the Accreditation Board for Engineering and Technology (ABET) in the USA prescribed that 12.5 per cent of the curriculum should cover the liberal arts, which included the humanities, the social sciences, economics, management and industrial relations. Today, all the accredited engineering curricula in the USA contain a liberal arts component of at least 12.5 per cent. However, some schools such as MIT, Stanford and other private institutions require that a minimum of 20 per cent of the curricula be allocated to the liberal arts and social sciences/humanities (Florman 1987).

Inadequacy of management and human relations training was observed to be the main problem for engineers at their workplace in Australia (Dunn & Fensham 1970; PE Consultants 1972; Williams 1988; APESA 1992). A study by PE Consultants showed that universities simply teach engineers to solve problems by applying techniques in unambiguous situations, whereas in practice, major difficulties are in problem definition rather than solution. The study concluded that the academic environment does not prepare engineers well enough to handle practical situations, which are normally constrained by resources, data and time (PE Consultants 1972).

The same study concluded that the inadequacies in engineering education arose from the content and nature of the course rather than the total duration of the course. The study reinforced the general thinking that strong emphasis should be given to the development of skills in communications and practical problem-solving (PE Consultants 1972). The need to communicate effectively was a major concern expressed by a majority of engineers in the study. It recommended an increase in the non-technical content of the engineering curriculum.

More than a decade later, Williams (1988) concluded that engineers must improve their skills in the human side of technology if Australia is to become internationally competitive. This human side of technology, according to his review, includes
motivation of the work force, the mental and manual skills of the work force and the way those skills are brought together into the productive system (Williams 1988).

The study noted that the emphasis given to non-technical content, involving management of people, communication skills, industrial relations, management of costs and resources, economics and social sciences, is relatively less and unsatisfactory. It recommended an increase in the non-technical content from the present 4 per cent to about 15 per cent of the total class time in undergraduate engineering curricula (Williams 1988).

In order to obtain industry feedback since the time of the Williams review, Hessami and Eley (1992a) conducted a survey of employers to assess the changes in employers’ perceptions of new engineering graduates, the appropriateness of the engineering curriculum, and any changes that might have taken place since the publication of Williams’ report. Their research concluded that there was a need to improve communication and interpersonal skills for engineers; it also noted that there was no significant improvement in the perception of employers since Williams’ review in 1988 (Hessami & Eley 1992b).

A study by the Association of Professional Engineers and the Institution of Engineers Australia (APESA)(1992) observed that “even with the recent move by education providers to increase the proportion of management studies in undergraduate courses, skills in a broad spectrum of management, business, personal and interpersonal areas remain a pressing imperative for most engineering graduates as soon as they join the work force” (APESA et al. 1992: 18). This study also recommended the broadening of undergraduate courses in engineering to increase the non-technical content to 10 per cent from the level of 4 to 6 per cent that prevailed in different universities at that time. Considering the difficulties of extending the duration of an undergraduate engineering course beyond the present four years, the study suggested transferring
specialised technology subjects to postgraduate education and training in order to accommodate the increased non-technical content (APESA et al. 1992).

Similar problems with engineering education have been noticed in the UK and an increase in the non-technical content was recommended by various studies there (Finniston 1980; Beuret & Webb 1983; Hawkins & Barclay 1989). In fact, several studies conducted prior to Finniston on engineering and engineering education in the UK concluded that engineers there lack a broad knowledge of non-technical issues, and recommended an increase in the non-technical content of the engineering curriculum (Finniston 1980).

2.5.8.7 Impact of the changes in the engineering curriculum

Although increasing the non-technical content to about 10 per cent of the total was recommended by several researchers, the implementation of those changes and the effect they had on engineers' skills were not found to be effective. Although the effects of making the changes were debatable, it was an easy path recommended by researchers and professional associations. However, non-implementation of these changes in universities, the indifference shown by professional associations, the lack of students' interest in non-technical subjects, the use of engineers in sub-professional jobs by employers, and inappropriate methods of delivering the non-technical content were cited in the literature as some of the reasons for the failure of this approach.

On the issue of implementation, Locke (1984), Armstrong (1987) and Divall (1994) posited various arguments to explain the ineffectiveness. For example, Locke pointed out that throughout, the British have made inadequate provision for the education of engineers in management subjects, and that the quality of that provision was also far behind that of Germany and the USA (Locke 1984). Similarly, Armstrong pointed out that the majority of professional engineers in the UK who were critical of the failings
of their profession suggested that all that was required was a remedial training in managerial studies (Armstrong 1987).

In his analysis of management education for engineers in the UK, Divall (1994) observed that the anti-commercial values of the educated classes and the anti-intellectual attitudes of some employers obstructed the inclusion of managerial studies in engineering curricula (Divall 1994). Several critics in the UK suggested that the educational and institutional reforms of the past decade have failed to correct the deficiencies identified in 1980 by Finniston’s commission of inquiry into the engineering professions (Glover & Kelly 1987; Armstrong 1989; Lee & Smith 1992a).

Studies of practising professional engineers have also highlighted their marginalisation in their employing organizations as a result of their lack of certain ‘soft’ skills such as communications, people management and industrial relations (Cotgrove 1958; Gerstl & Hutton 1966; Stanic & Pym 1968; Sofer 1970; Bamber & Glover 1975; Faulkner & Wearne 1979; Lawrence 1980; Beuret & Webb 1983; Barclay 1986; Sorge & Warner 1986; Glover & Kelly 1987; Hawkins & Barclay 1990a and 1990b; Lee & Smith 1992a; APESA et al. 1992).

Despite the fact that, since Wickenden’s 1949 report in the USA, most reports have emphasised the issue of non-technical content in undergraduate engineering education, no significant improvement in the skills of engineers has been noticed in the UK or in Australia. The reasons for this could be many. It could be that the engineering schools did not increase the non-technical content of their undergraduate education to about 10 per cent. Secondly, students’ lack of interest and negative perceptions of those non-technical subjects and their usefulness might have made such an increase ineffective. Thirdly, increasing the non-technical content may not be enough to impart ‘soft’ skills such as communication skills, and interpersonal and teamwork skills. Finally, there could be other factors such as the perceptions held by professional associations and employers, and the methods of teaching and learning non-technical subjects.
A quick overview of engineering courses in various universities in Australia reveals that there has been some increase in the non-technical content of engineering education, with many universities introducing subjects such as industrial management, psychology for engineers, management for engineers, basic accounting and some liberal arts. A typical university in Australia has between four and six subjects with a non-technical content throughout the four-year engineering course with a student load factor of about 20 to 30 credits, with a total value of 320 credits for the course.

This amounts to about 6 to 10 per cent non-technical content, depending upon the branch of engineering, which is fairly close to the 10 per cent Williams’ review recommended in 1988. However, certain universities have failed to increase the non-technical content to the desired 10 per cent because the technical content was itself increasing at a rapid rate and faculties were struggling to keep pace with those changes alone within the four-year duration of the course (AAEE News 1994).

Engineering students’ lack of interest in non-technical subjects is another factor. It has been observed that in a four-year course, no more than six courses in either the social sciences and/or the humanities were taken by students in their undergraduate degrees. Most of the young engineering students want to take technical courses that will maximise their chances in the job market (Engineering Council 1988). They do not want to spend a dollar more than necessary in pursuing their degrees, and they were not convinced that the non-technical subjects like management, economics and other social sciences were relevant to their goals (Williams 1988).

It has also been argued that, as students, engineers neglected courses which they considered were not concerned with ‘real’ engineering, only to realize their importance once they had entered industry. For example, studies of practising engineers have revealed that they did not have any interest in non-technical subjects such as management, the liberal arts and psychology while at university, and only realized
their importance after experience on the job (Dunn & Fensham 1970; PE Consultants 1972; Beuret & Webb 1983; Faulkner & Wearne 1984; Williams 1988).

Divall (1994) argued that the professional associations and employers had a significant influence on engineering education and were partially to blame for these inadequacies, and not the universities. Pointing towards British employers, Armstrong argued that the managerial skills of the engineer, which concentrate on the production of goods, were less highly valued by the employers than those of other professional groups such as lawyers and accountants (Armstrong 1987). Consequently, he suggested that the engineers' lack of business sense resulted in their poor status within organizations in the UK.

Employers, despite their proclaimed interest in the non-technical content of engineering courses and for engineers to learn management skills, have been content to use graduate engineers in sub-professional jobs. Employers, while appreciating the importance of technology and the role of engineers in integrating with organizational structures and systems, do not seem to place a high value on the contribution engineers make when compared with other professional groups such as accountants (CTSC 1991). Similarly, professional associations, preoccupied with the development of ethical practices, accreditation policies, community relations and external relations, and the various activities of a learned society, no longer represent the general interests of the employee engineers (Lloyd 1991a).

In this context, then, to place the entire blame for the shortcomings of engineers on the higher educational system is not completely justified. However, the strategy to increase the non-technical content of engineering courses was also found to be ineffective.
2.5.8.8 Focus on the process of teaching and learning

The above discussion raises questions on the effectiveness of the strategy of simply increasing the non-technical content of engineering courses. With several studies in Australia consistently revealing the inadequacies of engineers in the area of 'soft skills', it may be argued that other factors are involved, such as the relative quality of engineering students, the process of engineering education, the socialisation of engineers into the profession, employers’ perceptions of engineers’ abilities and skills, the general underutilisation of engineers.

However, some isolated experiments are being carried out with a view to review the process of delivering engineering education. For example, Arizona State University has redesigned its core engineering curriculum to reflect the increased use of teams, recognising the need for team skills in the engineering workplace (Bellamy et al. 1994). Also in the USA, there are attempts to reposition engineering education to suit the changing world by re-examining faculty rewards, reshaping the curriculum, increasing the breadth of education, encouraging multidisciplinary research and a commitment to and support of life-long learning (ASEE 1994).

Recently, the National Science Foundation in the USA recommended a restructuring of engineering education, focusing the changes on encouraging multiple thrusts for diversity, a system of rewards and incentives to the faculty, a redesign of assessment and evaluation processes to encourage the desired outcomes for both faculty and students, and an increased use of experiential learning strategies (NSF 1995).

No empirical evidence is available in Australia that hypothesised and tested these factors. Stressing the inadequacies of engineering education, past studies in Australia and overseas, although recommending an increase in the non-technical content of engineering education, are relatively silent on the delivery of that content.
2.5.8.9 Discussion—process versus content

The influence of learning styles and professional accentuation of certain skills, though they have been investigated overseas, are not debated as an issue in reviewing the engineering education curriculum. Although there have been a few attempts to review the engineering curriculum from the process perspective in some isolated universities in the USA, no such attempts have been made in the Australian context. Also, in the absence of any comprehensive studies covering all these aspects in Australia, it may not be possible to generalise and apply on a piecemeal basis the conclusions drawn from overseas studies, particularly in view of the differences between Australia and countries such as the UK and the USA.

2.5.9 Organizational support

2.5.9.1 Introduction and issues

Another factor that influences transition is the organizational support systems and policies. For example, Badawy has identified technical competence as a criterion for promotion to a managerial position, the dual-ladder system and support mechanisms (Badawy 1982: 44).

2.5.9.2 Promotion policies

Research has indicated that the most qualified and successful technical professionals are considered the best candidates for promotion to management (Badawy 1982). Engineers, once employed, believe that a better performance in technical roles will result in promotion to management (Thompson, Bowden & Prive 1975). However, research suggests that these individuals make the 'poorest' managers (Hughes 1968).
Research has shown that engineers in general were not satisfied with the managerial competence of their engineering managers (Bain 1985; Dalton & Thompson 1990). "Many engineer-managers are vastly less competent at managing than their subordinates are at technical work" (Badawy 1982: 44). This phenomenon is observed to be common among other groups of professionals, such as doctors, lawyers and professors (Drucker 1975), who apparently have a narrow technical focus in their professional formation.

Organizational incentives that motivate good, technically oriented engineers to become possibly mediocre managers in order to ensure a rise in salary reflect mismanagement of human resources (Crim 1978; Mayer 1989). This is compounded when those who do not want to make the transition leave the firm for technical jobs elsewhere, causing the firm to lose valuable technical resources (Baily 1982a; Sherman 1989). Some engineers who do not want to make the transition stay with the same firm and come to be viewed as technically obsolete (Dalton & Thompson 1971; Baily 1980b; Allen & Katz 1985; Tucker, Moravec & Ideus 1992).

These situations have raised management concerns over such aspects as technical ability, productivity and the effective utilisation of their employees. For example, General Electric, a large employer of engineers, introduced an aggressive training program when faced with the problem of engineers working below their capabilities and falling behind technically (Zukowski 1983). There remained, however, an inherent inequality between management and technical positions that motivated employees to move into management, although they might be more productive in technical jobs (Harker 1985).

One justification for engineers to continue making the transition into management, in spite of the above problems, is that a certain amount of technical ability is required to manage the work of technical employees (Seethamraju & Agrawal 1996). Therefore, it appears to be wise to hire managers and supervisors from among technically trained
professionals. However, the problem here is the identification of engineers who are both motivated and capable of becoming effective managers.

The early years of engineers’ careers provide management with an opportunity to observe them and assess their ability in various roles. If it is believed there is no relationship between their technical ability and their ability to manage successfully, it would be wise to choose potential managers from among those engineers who are the least able technically (Biddle & Roberts 1994).

Alternatively, it may be wise to promote the best technical engineer into management, although such a promotion policy may also result in a poor manager (Roberts & Biddle 1994). However, if it is believed that an engineer who is capable in technical roles tends to be a better manager, then it would be wise to promote the best technical engineers. This implies that the loss of good technical engineer may be more than balanced by the acquisition of a good manager (Biddle & Roberts 1994).

A study based on a nationwide sample of private sector engineers in the USA indicated that the more successful technical engineers had a greater probability of moving into management (Biddle & Roberts 1994). However, the only available measure of success in that study was salary but, if correct, it implies that “typical technical organizations routinely remove their best technical engineers from technical work, a policy which on its face seems wasteful” (Biddle & Roberts 1994: 91).

2.5.9.3 Dual-ladder approach

In the early 1950s, IBM, a large employer of engineers, implemented parallel career paths for technical and managerial personnel, known as the dual-ladder approach, as a means of addressing problems associated with underutilised engineers and scientists. Several other engineering-based organizations in the USA and the UK (and to some
extent in Australia) introduced this approach to motivate engineers to continue in their specialist technical field and career.

In the dual-ladder approach, two paths for promotion and advancement are created within an organization (Meisel 1977; Roth 1982; Harker 1985). Engineers have the opportunity for a successful career that involves either increasing administrative responsibilities and a path into management, or prestige and reward as a technical specialist (Miller 1986).

This system was designed and implemented in various organizations to provide technical professionals with the flexibility to choose between a technical career and a managerial career, both having equally attractive rewards. Badawy (1982) indicated that the following criteria must be met to make the dual-ladder approach work effectively and efficiently: (i) The ladders must be equally be attractive in terms of salary, status and non-economic rewards; (ii) neither ladder should be used as a dumping ground for individuals who are unsuccessful on the other ladder; (iii) criteria for promotion on the technical ladder must be rigorous and based on high technical competence and achievement; (iv) both ladders must have the full support of management; and (v) the system must be fully accepted by the technical staff (Badawy 1982: 45).

Badawy observed that each of these criteria were violated in many organizations. He identified several problems related to the implementation of the dual-ladder concept in that status, job responsibilities and role expectations were much better defined for the managerial ladder than they were for the technical ladder; that the managerial ladder was more consistent with the business culture; and that the technical ladder ran against the business psychology of success being associated with becoming the ‘boss’ (Badawy 1982).
Citing implementation rather than the concept as being the main reason for the problems, he observed that the dual-ladder approach has, in fact, reinforced and intensified the problem (Badawy 1983). Several studies conducted on the implementation and effectiveness of the dual-ladder approach in the USA have revealed that they were not effective and were beset with various problems (Moore & Davis 1977; Roth 1982).

For example, Roth, in his study of the dual-ladder approach in 20 organizations in the USA, found that “more rewards and status were generally conferred upon managers than upon technical specialists” (Roth 1982: iii). The study revealed that “technical ladders were used not to reward excellence in technical performance but to serve as a ‘dumping ground’ for managerial rejects” (p. iii). It has been observed that providing incentives and opportunities to the technical engineers who were individual contributors was difficult and ineffective in the USA (Shepherd 1958; Kornhauser 1962; Northrup & Malin 1984).

Much of the literature, as noted above, has grappled with the problems of protecting the integrity and credibility of these two career ladders. However, recent studies by Allen and his colleagues have questioned whether these two ladders can adequately satisfy the aspirations of many R & D engineers (Allen 1994; Allen & Katz 1995).

These studies suggest that many R & D engineers and scientists find little attraction in either increased managerial power and responsibility or the enhanced prestige of the technical specialist buttressed by titles such as ‘consultant’ (McCormick 1995). Instead, interest and motivation is found in a progression of interesting projects (Allen & Katz 1995). With the current trend of de-layering and empowering employees at the lower levels, there are widespread moves in several organizations to improve the utilisation of employees at every level (Waldtersee & Blackstock 1993).
2.5.9.4 Other strategies

With de-layering, the opportunities for promotional advancement up the career ladder no longer exist. The new restructured organization focuses on recognition through teamwork, there is a loss of the traditional managerial control function, there is defunctionalisation, and managers become facilitators. Adapting to these changes means that engineers must radically realign their career expectations and measurements of success. Those who plan to move upwards and still believe in neat and well-ordered career structures are increasingly likely to be disappointed (Allen & Katz 1989).

For example, a study by the Institute of Management observed that sideways or downward moves among managers more than doubled during the period 1980–82 to 1992, from seven per cent of managers in 1980–82 to nearly 15 per cent in 1992 (Institute of Management 1993), reflecting the effects of de-layering and new patterns of career development in organizations.

In view of these trends, it is argued that the “organizations should have a process for encouraging, planning, and investing in the engineers' professional development” (Baugh & Roberts 1994: 113). A recent report by the Industry Task Force on Leadership and Managerial Skills in Australia observed that very little support and resources are provided by organizations in managing transitions from specialist to managerial roles (Callan 1995).

Career transitions are normal and expected aspects of an employee's career development. However, the rate of change in business strategies and organizational restructuring and the reform processes sweeping through organizations make the engineer's role transition a complex one. All career transitions create role ambiguities, risks and exposures for engineers, that often result in perceptions of a loss of control and stress (Morrison & Adams 1991). It needs an effort both at the individual level
and at the organizational level to design and implement systems that assist these transitions.

2.5.10 Status

2.5.10.1 Issues

The status of engineers in a particular society influences perceptions of their transition into management roles and thus could contribute to the success of the transition. Status, as defined by Glover and Kelly (1987) refers to lifestyle and patterns of consumption, and is generally conferred in ways which legitimise existing differences in power and wealth (Glover & Kelly 1987: 24). Measured in status terms, engineers are not highly regarded in Anglo-Saxon countries (Collins et al. 1989)

2.5.10.2 Status in society

A study conducted by Congalton (1969) in Australia showed that engineers ranked ninth below medical doctors, professors, solicitors, company directors, architects and business owners. In the literature, not much survey data is available on the status of engineers in Australia other than Congalton’s work and Watson’s comparative analysis. Engineers in the USA, West Germany, Japan, France, Sweden, Canada, and the then Soviet Union, and in developing countries such as India, Indonesia and Taiwan were regarded more highly than in Australia and the UK (Watson 1976). Watson (1976) reviewed numerous studies of occupational prestige in most of the industrialised countries and concluded that engineers have a lower status in Anglo-Saxon countries such as the UK than they have in any of the others, and pointed out the national differences.

An international comparative survey of the background of senior managers in industry in the UK, the USA, West Germany, France and the Russia found that the
undergraduate qualification of senior managers in West Germany, France and the USSR was engineering, while in the UK and the USA it was the liberal arts (Swords-Isherwood 1979). For all countries except the UK, engineering was the most preferred postgraduate course studied by managers, whose aim was to understand technology better and to upgrade their knowledge of technology (Swords-Isherwood 1979). In fact, in Japan, France and West Germany, "management is so engineer-dominated that it barely exists in its own right there" and was considered to be an integral part of the engineer’s role (Glover & Kelly 1987: 211).

The Finniston report in the UK highlighted the contrast between the poor status of engineering there with the greater prestige accorded science, medicine and the liberal arts (Finniston 1980). In the UK, engineers were rated below medical practitioners and accountants in terms of career prospects and, in doing this, respondents seemed to equate engineers with ‘draughtspersons’. It is estimated that about 20 per cent of the British public do not have any idea of what engineers do (Finniston 1980).

McCormick (1992) observed that the status of engineers is high in Japanese society and engineers participated in the decision-making process in Japanese organizations. Based on a comparative study of British engineers and Japanese engineers, McCormick (1992) attributed the Japanese engineers’ higher status to their broad-based education and their enterprise-specific skills built through training by the corporations. In West Germany, the status of engineers has been consistently high. Several studies observed that this is mainly due to engineers’ generally high remuneration and good access to higher management positions (Hutton et al. 1975; Hutton, Lawrence & Smith 1977; Lawrence 1992).

In those countries where engineering is regarded as a high-status occupation, management is considered to be an integral part of engineering, and engineers are perceived to be capable of holding senior management positions. As pointed out by Wilensky (1986) "the social power and status of the engineering graduate is,
ironically, greatest in those countries where engineering is regarded primarily as a business (Japan) and lowest when it is more commonly defined as a profession (Britain)” (Wilensky 1986). Accordingly, the perception held by top management of the ability of engineers to occupy senior management positions is also different.

For example, in countries like Sweden, running factories has traditionally been considered a route to the top of Swedish society, not just Swedish industry (Glover & Fores 1973). Similarly, in Japan, the USA, France and Germany, the majority of company directors and chief executives are engineers.

Glover and Kelly (1987) argued that the relatively low social and academic status of engineering in Britain and to some extent in other industrialised Anglo-Saxon countries such as Australia might have influenced the perception of engineers as authoritarian, narrowly technical and conservative and thus not suitable for top management positions. They observed that engineers, by defining themselves as narrow specialists (as well as their employers defining them as such), seem to operate a self-fulfilling prophecy. Glover and Kelly (1987) attributed this lack of confidence to the engineers’ engineering education and its bias against the commercial and human realities of practical engineering.

It has been argued that a “near total absence of engineers from top decision-making levels of the Civil service, the City, the Parliament and the Armed Forces” has contributed to the low status of engineers in the UK (Beuret & Webb 1983). This report observed that engineers in the UK were defined as narrow specialists, by themselves as well as by their employers. This lack of intellectual and social confidence was attributed partly to the engineering education system, which had a bias towards theory and against practical engineering and its commercial realities (Beuret & Webb 1983).
Although there are no further studies on the reasons for the low status of engineers in Australia, it is widely believed that their lack of business skills makes them unsuitable for senior management positions (IE Aust. 1993a). Reasons for this apparently low status, reasons that have been cited by several writers in Australia, include the predominance of science over engineering, inadequate recruits, high drop-out rates in the first year of engineering, the reluctance of graduates to cope with the often crucial non-technical aspects of engineering, the low self-image of engineers and employers’ perceptions of them; and the low priority given to technology (Williams 1988; CTSC 1991; Warren Centre 1991).

It has also been argued that engineers’ overfamiliarity with technology tends to devalue their endeavours and overvalue the contribution made by other professions, such as medicine. For example, Florman (1994) argued that engineers are their own worst enemies; driven by the urge for perfection in their engineering achievements, they are harsh critics of them. He pointed out that engineers do not seem to understand the value-adding qualities of engineering and consequently are underpaid when compared with other professions. This underpayment for the contribution engineering makes to society and the great amount of work and effort required to acquire engineering skills combine to make engineering a less attractive profession with a consequent low status in society.

2.5.10.3 Status within organizations

Studies in the UK have suggested that British engineers are employed as technical specialists whose assumed lack of wider knowledge and social skills make them unsuitable for promotion to senior positions in which knowledge of finance, markets and the general commercial and political environment is needed (Lawrence 1977). Reflecting the poor status of engineering within organizations, studies concluded that finance, marketing and personnel functions offer easier routes to the top than production and related functions (Glover 1978; Melrose-Woodman 1978; Swords-
Isherwood 1979; Mansfield et al. 1981; Child et al. 1983, 1986; Glover & Garbutt 1986; Sorge & Warner 1986; Whalley 1986). For example, an international comparative study of engineers by Swords-Isherwood (1979) in the UK, USA, the West Germany, France and the Russia concluded that engineering in Anglo-Saxon countries in general, and in the UK in particular, lacks prestige and status compared with engineering in Europe and Japan (Swords-Isherwood 1979).

In the UK, the line between mental and manual, conception and execution, does not neatly demarcate engineers from craft and production workers (Whalley 1986: 67). In fact, employers in the UK view all their technical employees including engineers as the same, with some differences in pay and grade (Whalley 1986). Consequently, employers do not view engineers as potential candidates for top management positions or leadership positions, whereas in the USA, engineers prepare themselves for management positions right from the early stages of their careers.

Based on a population analysis, Rice and Lloyd (1990: 3) opined that “there has been no improvement in the relative popularity of professional engineering as a career for at least the last 15 years, as the incentives for students to opt for engineering are no more effective now than they were 15 years ago” (Rice & Lloyd 1990: 3). However, a Time-Morgan poll (The Courier Mail, 18 April 1994) of 23 occupations found that about 50 per cent of respondents viewed engineers as honest and ethical.

Though this poll does not reflect the occupational status of engineering, it indicates the common public perception of one aspect of engineering. Even then, according to this survey, engineers are ranked below medical doctors, dentists and schoolteachers. A study by the Institution of Engineers Australia (IE Aust. 1993) on the public image of engineers revealed that the general public do not have enough knowledge of what engineers do in organizations and treat them as being no different from technicians (IE Aust. 1993).
2.5.10.4 Salary—indicator of status

Salary is another indicator of status. Based on an analysis of salary trends for public sector engineers, Lloyd observed that salary rates remained constant in real terms, while the Average Weekly Earnings (AWE) advanced by 67 per cent between 1962 and 1984, which reflected a lack of parity and a general failure by the profession. However, further analysis revealed that the rates for engineers classes 1 and 5 have fallen drastically, while the median salary level for all engineers has been maintained at approximate parity with the average weekly earnings (Lloyd et al 1989).

However, there is a counter-argument here. For example, Armstrong (1989) argued that the engineering profession in the UK is “obsessed with its ‘low status’”, despite the fact that engineers’ earnings are said to compare well with those of other professions (Berthoud & Smith 1980; Finniston 1980). Similarly, a recent analysis of engineers’ salaries in Australia revealed that engineers come third after medical practitioners and dentists (Engineering News, April 1996), which would seem to be fine if salary is viewed as one of the measures of status.

2.5.10.5 Status in Australia

Although there are no detailed studies on the status of engineers in Australia, anecdotal evidence indicates it is relatively low in both the perception of the general public and in that of organizations. Whether it is the lack of business management skills that has perpetuated this low status within organizations or the systematic neglect of engineers’ contribution to those organizations and to society in general, is not evident from the literature. However, the literature has established that the perception of low status reinforces the unsuitability of engineers for top management positions, by both senior management and the engineers themselves.
2.5.11 Strategies for managing transitions

2.5.11.1 Overview

Recognising the need for the acquisition of management skills for a successful transition into management and good managerial performance, several strategies have been adopted by individual engineers and by organizations. Some of them include postgraduate management qualifications, curriculum changes in engineering education, experiential learning, organizational training and support systems. Although according to the literature, learning takes place on the job through experience, postgraduate management education and enterprise-level training are the most popular strategies.

2.5.11.2 National differences and similarities

Although it is the responsibility of both the individual and the organization to manage the transition, some generic differences between various countries were observed. A comparison of Japanese engineers and companies with Western engineers and companies shows that the Japanese engineering career is a much more managed affair, where management takes the initiative in directing their engineering labour force through work assignments, training and career development (Sakakibara & Westney 1985).

By contrast, the Western engineering career is said to place much more responsibility for career development on the individual engineer, with consequently more devolved responsibilities for training and skill formation. No such evidence, either anecdotal or empirical, is available in the Australian context for this aspect to be discussed further. However, managerial skills for engineers have been found to be essential to a greater or lesser degree at all levels of responsibility and in all roles, whether the engineer is a practitioner, specialist, an engineering manager or a general manager, with no
differences detected between the UK, the USA and Australia (Wearne et al. 1984; Barclay 1986; Society of Manufacturing Engineers 1989; APESA et al. 1992).

2.5.11.3 Postgraduate management qualifications

A study by APESA in Australia revealed that about 25 per cent of postgraduate students in management education in Australia were engineers (APESA 1994). Considering the engineers' interest in this, they designed an MBA program specifically tailored for engineers; this program has the highest enrolments in Australia. Though the effectiveness of such education is not yet measured in terms of improved skills, most engineers in Australia appear to have indicated their preference for postgraduate management education. Earlier, Williams (1988) also observed that a majority of engineers were either doing postgraduate studies in management or were planning to do it. A report on managerial skills in Australia observed that learning undertaken in formal education is the most effective, if it is done at critical stages of an individual's career (Cattegno & Millwood 1995).

In the UK, acquiring a postgraduate management qualification has been the most popular way of acquiring management skills and knowledge (Byrt 1989). In America and to some extent in Britain, the acquisition of a degree in business management has increased the chances of an engineer going on into management (Glover & Kelly 1987). Whalley, in his study of British engineers in two large organizations, commented that general management is increasingly seen as a separate occupation from engineering, and that fewer senior management positions are available for engineers unable or unwilling to acquire an MBA (Whalley 1986: 191). Moreover, engineers are forced to obtain MBAs in the UK in order to move into general management, because of the anti-technical culture that prevails in British management (Smith & Meikisins 1995). Management qualifications and the acquisition of management skills also appear to be an important strategy for engineers in Australia.
2.5.11.4 *Experiential learning and organizational support*

It would be normal to expect considerable learning to take place through on-the-job experience, as managers would spend about 99 per cent of their working time on the job and about 1 per cent, at the most, in formal training. Although experiential or experience-based learning is commonplace, its significance and potential has not been fully recognised until relatively recently (Boud 1989). While it has a much broader meaning in that it also involves learning through experience gained throughout one’s life, experiential learning is defined in this context as individuals learning by doing, by applying, and by experience in the context of the job, as opposed to being instructed or reading about particular topics (Boud & Griffin 1987).

Dewey is considered to be the first person to argue that there is a strong relationship between the processes of actual experience and education. Several other authors such as Schon, Kolb, Honey and Mumford are considered to be the leading researchers in the area of experiential and self-directed learning by adults.

Experience as a source of learning is considered better than formally organised training and classroom teaching, since it is relevant, not isolated from actual work situations and occurs on an everyday basis (Bunning 1992; Cohen et al. 1994). Kolb pointed out that experiential learning is a continuous process grounded in experience and emphasis on the process of learning rather than on the behavioural outcomes, wherein learners continuously modify their concepts, ideas and habits with concrete experience. Thus, according to Kolb (1984), experiential learning is an active, self-directed process that can be applied not only at the workplace but in everyday life.

Most of the past research agreed on the value of experience on the job in preparing an engineer for the transition into management. It has been argued that management experience before promoting engineers into managerial roles and close cooperation with their superiors are essential and important for evaluation and learning purposes.
(Given 1955; Elliot 1958; Overton 1969; Hill 1992). However, this has to be carefully managed if it is to be effective. For example, it has been argued that, without careful planning, evaluation and a constructive feedback system to discuss failures and successes, this strategy might prove counterproductive (Michael 1961; Sanders 1966; Archer 1968; Moore 1973). On-the-job experience facilitates understanding and the absorption of attitudinal information essential for the new role.

Akin (1987), in an investigation of how managers learn to manage, observed that most powerful learning experiences rarely happen in a classroom. Several activities, such as watching, listening, emulating mentors, receiving feedback from peers, trying out new situations and ways to solve problems, reading and interpretation of theoretical knowledge, observation and experimentation, help managers learn and master the skills they need (Boud et al. 1985; Akin 1987).

McCall et al. (1988) pointed out that the challenge in developing managers lies in making better use of on-the-job experience. He argued that the development of managerial skills is too often viewed as a bagful of devices. It is instead a conscious effort on the part of organizations to provide their managers and potential managers with opportunities to learn, grow, and change (McCall et al. 1988). Several organizations made a direct investment in the development of potential managers through such strategies as employing young staff members to manage small businesses, creating executive assistant positions, and the formation of task forces and project teams to give those with high management potential experience in acquisitions, joint ventures, new product and market developments (McCall et al 1988).

McCall et al. (1988) argued that business organizations created valuable learning experiences for their managers, accepting suboptimal returns for the sake of training. Based on a qualitative study, they stressed the importance of support systems in organizations, support systems that consist of a culture of encouragement and support for learning through experience, that have available and accessible the resources to
learn from, and that have a means of obtaining feedback and encouraging people to accept challenging assignments (McCall et al. 1988).

Kotter observed that the learning culture nurtured and supported by the organization is vital for management development (Kotter 1988). He argued that such organizations identify the exact developmental needs of their potential managers and meet them in several ways. Adding responsibilities to jobs, creating special jobs, transferring people between functions and divisions, mentoring and coaching employees, giving feedback on progress, and giving them direction on how to manage their own self-development are some of the ways organizations help their employees develop (Kotter 1988).

The increasing emphasis on experiential learning modes in the higher education sector is mainly due to the increasing number of adult learners, a widespread criticism by employers of graduates' ability to link theory and practice, a lack of skills in synthesis, rapid increases in knowledge limiting the amount that can be covered in a university course, an emphasis on continuous learning, and a move towards competency-based approaches that emphasise learner-centred and workplace-based education (Bunning 1992; Gonczi 1992). In addition, changes at the workplace that encourage teamwork, communication and a broader organizational perspective as opposed to the narrow specialist perspective (OECD 1994; Karpin 1995) are reinforcing the importance of learning through experience on the job.

In Australia, a study by APESA revealed that most engineers have in the past enhanced their skills through ‘experiential learning’ that included job rotation, work rotation, special assignments, delegation and coaching from a superior (APESA et al. 1992). The study pointed out that the most common method of experiential learning is through delegation and coaching, sometimes integrated with short courses (APESA et al. 1992: 54).
Advocating organizational support systems to enable the continuous professional development of engineers, the study suggested that employers should develop focused skills-enhancement strategies for their engineers at the enterprise, operational and individual levels (APESA et al 1992: 12). The study identified the need to manage the learning process through experience, to make it more effective and useful both to the individual and to the organization.

A study in Australia by the Task Force for Leadership and Management Skills reported that learning for managers occurred mainly through their work role and work relationships rather than through training and development opportunities or from formal management education (Cattegno & Millwood 1995). The study observed that the developmental pathways such as learning from the day-to-day challenges of the job and relationships with the boss as a coach or mentor appeared to be preferred over more distant pathways such as learning from experts or role models.

Several other studies have also recommended various modes of experiential learning for engineers making the transition into management. For example, job rotation as a means of learning about management and the functions of the firm in general has been recommended by a number of writers (Watson 1954; Cavanaugh 1956; Michael 1961; Archer 1968; Rosenthal 1969; Moore 1973; Badawy 1983). Frequent interactions with senior management so that new managers become aware of the broad range of problems is another strategy recommended by some authors (Archer 1968).

Some of the later researchers recommended careful design and insertion of short experience-based projects or exercises into training courses (Bunning 1992; Callan 1995). Bunning (1992) recommended action-learning programs, which aim to foster learning from real projects conducted over a period of time, rather than one-shot training courses. In order to ensure that employees learn from each other, he suggested fostering an organizational climate that encourages them to engage in regular reflection, to present their thoughts to their peers for constructive reactions and
feedback and to encourage networking so they can exchange ideas and experiences; employers should also encourage staff meetings and committees to pay attention to their processes rather than just to issues regarding content (Bunning 1992).

2.5.11.5 Organizational systems and policies

The value of on-the-job training or experiential learning can be enhanced by proper management. While pointing out that engineering graduates acquire behavioural and affective competencies through experiential learning on the job, Kolb stressed the need for a good organizational climate to support this learning process (Kolb 1984). In another study, Sims (1981) found that on-the-job learning is helped by an organizational climate characterised by good supervision, the potential for advancement and autonomy, and the chance to grow and develop. His study observed that on-the-job learning is inhibited in organizations whose climate is not supportive of learning and development. He reiterated the importance of the organizational climate and the existence of systems to channel learning experiences into a useful development of the individual. Earlier studies by Margulies and Raia in the USA recognised the critical role the organizational climate plays in encouraging effective learning on the job (Margulies & Raia 1967).

An international comparative study carried out by Handy et al. (1987) focused on the assistance to be provided to the individual in transition. Based on extensive surveys carried out in France, West Germany, the USA, Japan and the UK, the study observed that in many organizations there is no clear path to management. It noted that most of the 90,000 new managers studied had neither a formal introduction to management issues nor received any training (Handy et al. 1987). It pointed out that any training, although provided for only a minority, was at the mid-career stage. The study recommended off-the-job training, financial assistance for self-education and a system of experience-based learning (Handy et al. 1987).
Badawy (1982) offered a traditional approach focusing on competencies to be learnt by engineers before moving into management roles. He emphasised the need to identify those engineers with management potential before promoting them into management roles. He suggested the effective design and introduction of a technical ladder with reward systems for engineering specialists equally attractive to that of managers to move along the technical path. He recommended support and training in management skills be made available to those engineers who are planning to make the transition (Badawy 1982).

Importantly, Badawy (1982) suggested a rewards systems be implemented for superiors who assist in the development of their subordinates, and recommended making the new manager's development a criterion for evaluating the performance of his or her superior. In addition, he suggested experience-based learning opportunities for new managers or potential managers in the form of projects, special assignments with managerial responsibilities, and rotational assignments.

A study by Cattegno and Millwood (1995) has suggested that the relationships new managers form with the people with whom they come into contact on a daily basis and the normal day-to-day challenges of carrying out their jobs are the most important pathways for their development and must be encouraged. Similarly, it noted that an effective coaching relationship can be constructed and maintained if there is a climate of trust within the organization. Thus, an organizational climate that is conducive in terms of encouraging self-development and a willingness to take risks and make mistakes, and a supportive management, are essential requirements for effective learning on the job. Considering the limited sample size, the selection process and the diversity of the respondents, it may not be appropriate to generalise the findings and apply them to engineer–managers. However, the study provided anecdotal evidence on learning in the workplace in an Australian context. As it stated, the key findings of the study need to be further researched and validated.
Earlier studies concentrated on prescribing training programs to teach engineers about becoming a manager or training programs just before their promotion to management. These programs, it has been argued, must reorient the thinking of the engineer by fostering a conscious awareness of the new role (Michael 1961; Elliott 1968; Karger & Murdick 1969).

Formal training courses, outside the organization as well as inside, have been recommended by several researchers (More 1973; Merrifield 1976; Badawy 1983; Hawkins & Barclay 1990a). Different approaches have been adopted by various trainers in imparting management skills to engineers, with the majority of them preferring a group discussion with some classroom lectures on management topics. For example, See (1961) suggested an approach whereby technical supervisors periodically discuss certain management problems in order to enhance the engineers’ awareness of themselves as managers, thus helping the internalisation of management attitudes and insights (See 1961).

Alsop and Lockwood (1975) suggested a course of lectures and group discussions which focused on problems encountered in daily work. A workshop type of approach with a facilitator to discuss the issues was suggested by Szilagyi (1975). Sanders, on the other hand, recommended evaluation of ongoing R & D projects as the basic learning tool (Sanders 1972; Sanders & Ryan 1976).

Based on an evaluation of earlier research and of several training programs, Medcof (1985) noted that programs that have group project work involving work-related problems are successful training tools. He noted that several writers do not support their recommendations with any empirical evidence, which is essential to develop reliable training systems for engineers. He pointed out that the most of the analyses of training for engineers look at the technologist from the outside, neglecting the engineer's point of view (Medcof 1985).
Barclay and Hawkins (1986, 1990) conducted a study of the problems and training needs of engineering managers and engineers in the UK. Their study revealed that most of the technical managers were spending a considerable amount of their time on people management and interpersonal activities, which are the most difficult tasks for them (Barclay & Hawkins 1986). The study observed that the amount of management time spent on aspects of people management, interpersonal relations and finance increases with growing managerial involvement and the number of staff supervised. However, from that study it was clear that it was perceived that the need for skills training progressively decreased as the management content of the job increased.

The study noted that "once the basic management skills have been acquired, increases in the staff numbers or responsibility bring little in the way of new problems that cannot be adequately handled" (Barclay & Hawkins 1986: 257). Importantly, this study pointed out the importance of timing of the training. Traditionally, it is believed that training in management skills is needed mid-career, just before moving into management. This study concluded that detailed management training must be made available to engineers in the early stages of their career, not mid-career.

A study by Hill (1992) on the transition of specialists into management positions found that new managers learnt people management skills through experience, by solving problems and from social situations (Hill 1992: 90). Commenting on aspects of training, Hill (1992) observed that changing attitudes is the most crucial aspect of management development, not the changing of skills and knowledge.

According to Hill (1992), management development should be a broadly conceived series of experiences that are meant to enhance an individual’s current and future effectiveness, with both the individual and the organization responsible for managing this development. She observed that “receptive methods such as lecturing and reading are not very effective in improving interpersonal performance or changing attitude and identity,” which are by far the most popular methods of training (Hill 1992: 269).
The study recommended concentration on role-playing, the use of the case methods and simulation exercises in training programs, instead of classroom sessions.

2.5.11.6 Summary

The literature review points out that business management education, training and experiential learning are the strategies normally employed in providing management skills to engineers. According to the review, not only is the training of management skills per se important, but its timing is equally important. Though a majority of the engineers learn and acquire management skills on the job through experience, anecdotal evidence from the USA and the UK revealed that management of experiential learning has been largely left to the individual. No evidence is available in the Australian context with regard to organizational support, the basis for promotions, the management of experiential learning or the extent of usage of these strategies. According to the review, the importance of a good organizational climate, reflected in terms of good promotional policies and support systems, is paramount in facilitating a smooth and successful transition.

2.6 Summary of literature review

The literature on engineers in general and engineers in Australia in particular, as it relates to their changing roles and their transition into management has been reviewed in this chapter. This literature review reveals that the engineer's role has been changing continually, in line with changes in organizational structures and changes over time in management paradigms. The review postulates that engineering work involves some aspects of management, such as supervision of resources and people, and that this management responsibility increases as an engineer's career progresses.

The review highlights the limited nature of the literature on engineers in the Australian context and focuses primarily on overseas research. Of the limited literature on
Australian research, studies predominantly concentrated on engineering education; other factors were relatively ignored. Importantly, many of the studies both in Australia and overseas treated engineers as a homogeneous group. Though some differences within the engineering population have been identified in some parts of the literature, no further studies have been carried out. For example, Williams (1988) observed some differences between civil engineers and electronics/electrical engineers in terms of their attitude towards the need for acquiring ‘soft’ skills through postgraduate management education. No empirical evidence in the Australian context is available that describes the differences between various groups of engineers.

As can be seen, most of the literature assumes that professional engineers generally lack the ‘soft’ skills that are so essential to succeed in management roles as well as in the present expanded technical roles. The literature points towards engineering education for this inadequacy, with the basic premise that education influences professional formation and inculcates this narrowly technical and technically narrow focus in engineers. Importantly, it focuses on the content of engineering education, relatively ignoring the influence of the process of education and experiential learning on the job. Consistently, studies in Australia and overseas recommended expansion of the undergraduate engineering education curriculum by increasing the management content. This review pointed out that the strategy of increasing the non-technical content did not result in any significant improvement in ‘soft’ skills among engineers.

Although several other factors have been mentioned as possible factors influencing the transition of engineers into management, they have been relegated to the background in the literature. These factors include the status of engineers in organizations and in society, the development of engineering as a profession, the beliefs and values held by engineers as a professional group, individual personalities and occupational proclivities, the de-engineering trend in public sector organizations, career management policies in organizations, and organizational management of experience. In fact, no conceptual model that integrates all the factors influencing this process of
transition, is available in the literature. A greater recognition of these factors and their relationships, and particularly the process of engineering education and organizational and individual management of experiential learning on the job, as well as the status of engineers, may have led researchers to modify some of their conclusions.

The literature identifies formal business management education, training and on-the-job learning as the popular strategies adopted by engineers in acquiring management skills. While there have been some attempts to investigate the process of engineering education and some recognition of experiential learning as an important factor in managing the transition to management, very few formal attempts have been identified in the literature reviewed, especially in the Australian context.

Overseas findings cannot be generalised to apply in the Australian context. Significant differences have been identified between Australian engineering and engineers and their counterparts in the UK and the USA in terms of intensity of engineering and manufacturing, technology base, population of engineers, occupational identity and control, unified professional institutions, status within society and within organizations and the industrial relations systems (Lloyd 1989). These differences indicate the need for more research on engineers in Australia.

Thus, this research intends to address some of the issues either not considered or considered of little importance in the literature. Importantly, it deals with the issue of transition to management from the engineer's perspective, viewing it as a process rather than as an event with some definite beginning and end.

This research study attempts to analyse engineers' transitions into management roles in a specific Australian context, by referring to the attitude of engineers towards such managerial transitions, engineering education, status, organizational systems and the general strategies employed by the individual engineers and by organizations. Thus the main research questions postulated in this study are:
What factors influence the transition of engineers in Australia and how is that influence exerted?

What are the differences between various subgroups of engineers in their attitude towards those factors?

Within these broad research questions, this study intends to investigate the influence of the following dimensions identified from the literature:

* General attitude of engineers towards transition
* Changing nature of engineering and managerial work.
* Differences between engineering and managerial work.
* Differences between various subgroups of engineers.
* Engineering education.
* Status of engineers.
* Organizational systems and policies.
* Strategies employed in managing these transitions—both from an individual and an organizational perspective—postgraduate business management education, experiential learning, training and organizational support.

2.7 Research questions

Based on the literature review and the exploratory case study analysis carried out in chapter 4, the following specific research questions were developed for further investigation. These research questions are used as a framework for survey research.

Research question 1

What factors influence engineers in making the transition and how is that influence exerted?
Sub-questions to research question 1

A. General attitude towards transition
1. What is the extent of these transitions in Australia?
2. Why do engineers move into management roles in Australia?
3. What is the attitude of engineers about managerial and technical work?
4. What are the problems and difficulties for engineers in transition?
5. What is the perception of engineers towards the importance of ‘soft’ skills?
6. What is the attitude of engineers about ‘generalist’ roles?
7. What are the career path options for engineers?
8. What is the influence of individual personality in transition?
9. What is the perception of engineers towards dual ladders?
10. Do engineers prefer to remain as technical specialists rather than move into management roles?
11. Do engineers derive more satisfaction doing technical work rather than business-related non-technical work?
12. Do engineers derive more satisfaction from career advancement within the organization rather than by peer recognition in professional circles?
13. Are engineers satisfied about their career choices?

B. Attitudes towards engineering education
14. What are the strengths and weaknesses of a university engineering education?
15. What changes are necessary to the engineering education curriculum in order to prepare engineering graduates better for managerial roles?

C. Organizational support
16. What is the extent of organizational support in making transitions? And how is it provided in Australian organizations?
17. What is the extent of the dual-ladder approach in Australian organizations?
D. \textit{Status}

18. What is the perception of engineers about their organizational status and status in society, when compared with other professions?

19. What is the perception of top management about engineers' status?

20. Would a higher status of engineers in organizations increase the probability of successful transition?

21. Is the lower tertiary entrance score for engineering courses in Australia due to its lower status?

E. \textit{Strategies for managing transition}

22. What are the strategies employed by the individual and by the organization in managing the transition?

Research question 2

What are the differences between various subgroups of engineers in their attitude towards those factors?

Sub-questions

23. Are there any differences between the various subgroups of engineers in their attitudes towards various aspects/questions?

24. What is the influence of the following variables on the attitudes of engineers towards various aspects of the study?

* Branch of engineering—civil versus mechanical; civil versus electrical; mechanical versus electrical.

* Postgraduate management qualifications.

* Predominant nature of the job—managerial or technical.
* Type of employing industry—consultancy versus manufacturing and manufacturing versus government sector.
* Gender

The next chapter outlines the research methodology followed in answering the research questions formulated above.

2.8 Conclusions to the literature review

The literature review provided an insight into past studies on engineers and their transition into management roles. Apart from one study, this research generally identified various factors such as engineering education, the general attitude of engineers towards transition, the changing nature of engineering work, status and organizational support policies and systems; also identified were the strategies employed by individual engineers and organizations that influence these transitions.

Based on the gaps identified in the literature, research questions are formulated for further investigation. From the literature review, and to the best understanding of the author, it appears that no comprehensive study on these transitions in Australia from the engineer's perspective has been carried out. Importantly, no investigation was reported in the literature on the differences between the different groups of engineers. In general, engineers were viewed as a coherent group and conclusions drawn on that premise.

In view of the extent of these transitions in Australia, the significance of engineers' and engineer-managers roles in industrial society, and the perceived abilities of engineers to reach and succeed in managerial roles, this study becomes significant. The next chapter outlines the methodology and methods followed in addressing the research questions.
CHAPTER 3

RESEARCH METHODOLOGY AND METHODS
3.1 Introduction

In this chapter, a research design will be developed. The literature review presented in the previous chapter identified the factors important to the general research questions. With the aid of the information gained from preliminary interviews and discussions, and the literature review on research methodology, the methodology and research methods suitable for this investigation were designed. They are explained below. A combination of qualitative and quantitative methodologies were employed.

Case study methodology in particular was chosen in the first phase to explore the factors influencing the transition of engineers and the strategies employed in managing them, in order to develop some propositions. A survey research methodology was used to test the propositions developed from the case study research and the literature review across the general engineering population of Australia.

This chapter justifies that choice of methodology and outlines the operational framework, the research methods and data analysis. Firstly, it describes the approach adopted in conducting the case study research, in both the data collection and data analysis phases and the process of exploring the factors influencing the transitionary process. The design and administration of the questionnaire and data analysis in the survey research are explained in the second phase. This chapter only gives the details of the process of research design and analysis, while the findings and outcomes are explained in chapters 4 and 5.
3.2 **Operational framework**

Although this study started with an exploration of the issues involved in the transition of engineers into management, the literature reveals that it is necessary to tentatively formulate research questions before developing the conceptual framework (Miles 1984; Cooper & Emory 1995). Developing a conceptual framework helped the researcher to identify the data to be collected and analysed in order to answer the research questions. A conceptual framework thus explains the main aspects to be studied, the key factors or variables, and the presumed relationships between them (Miles & Huberman 1984).

Based on the researcher’s own ideas and experience, preliminary interviews of engineers and engineer–managers, and a review of the literature on engineers and their changing roles, the following factors were identified for further investigation. A list of those factors, identified in the previous chapter, is given below.

* General attitude towards transition—reasons, problems, dual ladders, need for soft skills, de-engineering trend, changes in roles, technical orientation, lack of interest in engineering, and career satisfaction

* Engineering education—strengths and weaknesses, course content and process of learning and teaching.

* Organizational support—utilisation, support, promotional policies, technical career ladders.

* Status of engineers—within the organization and in society in general.
* Strategies for managing transitions—postgraduate management education, changes in undergraduate engineering curriculum content and process; experiential learning; organizational support systems; and individual development.

* Differences between various groups of engineers differentiated by variables such as job nature, branch of engineering, industry in which employed, and management qualifications.

3.3 Review of choices and selection—methodology

3.3.1 Theoretical framework in the selection

Selection of research methods is an important step in the research design. The decision is technical in the sense that some methods are better suited to certain research questions than others (Yin 1989). Also the access and availability of other resources in the available time determines to some extent the feasibility of particular forms of investigation. As noted by Patton (1980), “blessed are the poor in choice, for they will have no trouble making up their minds” (Patton 1980: 17).

Although the classic selection choice is between quantitative and qualitative methods, research design can incorporate both techniques. Often, practical aspects, the type of research questions and constraints on resources decide one or the other. As Poston put it succinctly (Postan 1971), “the penalty of being sufficiently concrete to be real is the possibility of being sufficiently abstract to be exact,” (Postan 1971: 32).

Both qualitative and quantitative methods have their advantages and limitations. For example, it is argued in the literature that qualitative methods give importance to the context and organizational realities, provide deeper insights into the phenomenon, and use multiple data sources that enhance validity, while quantitative methods are argued
to be strong in hypothesis-testing and generalisations and are highly structured, though they lack flexibility (Burns 1994; Bryman 1989; Cresswell 1994; Dey 1993; Yin 1989).

According to the literature, the type of research questions—what, why or how; the extent of control the researcher has over behavioural events; the degree of consideration of contemporary issues; ease of access to relevant data; and the availability of time and other resources for the investigation—determines the methodology (Caroll & Johnson 1990; Cresswell 1994; Dey 1993; Emory & Cooper 1994; Yin 1989).

For example, it has been argued that a qualitative case study can be used to answer the ‘how’ and ‘why’ questions about contemporary events and to generate hypotheses for further investigations (Hill 1992). The case study method is particularly suited to new research areas or areas for which theory seems inadequate (Eisenhardt 1989; Glasser & Strauss 1967). However, case study research is frequently criticised in the literature because of its subjective bias, its inability to generalise findings, insufficient methodological rigour ensuring reliability and validity (Burns 1994; Yin 1989; Dey 1993) and its inferiority when compared with methods based on random statistical samples of a large number of observations. Though some approaches have been recommended in the literature to increase the validity of case study findings (Hagg & Hedlund 1978; Glasser & Strauss 1967; Gummesson 1991; Normann 1970; Yin 1989), this research study employed case study methodology as a basis on which to formulate hypotheses for further testing, followed by a survey methodology.

3.3.2 Combination of methods—complementary nature

Though the qualitative and quantitative methods both have strengths and weaknesses, it is necessary to view them more as complementing each other rather than providing two alternatives for research design. For example, Sieber contends that “there are
many benefits to be gained from using both qualitative and quantitative information in the same study to produce more powerful analyses than either sort of information could have produced alone” (Sieber 1980: 444). And Reichardt and Cook point out that “the two method types can build upon each other to offer insights that neither one alone could provide” (Reichardt & Cook 1979: 21).

Using data derived from both qualitative and quantitative methods is methodological triangulation. Moreover, quantitative evidence in a predominantly qualitative research can keep researchers from being carried away by vivid, but false, impressions that may be given by the qualitative data. Quantitative evidence can bolster findings when it corroborates the findings from qualitative evidence (Eisenhardt 1989: 538) and it thus enhances the validity of the study.

In fact, it has been argued that a combination of methodologies in the study of a particular phenomenon would neutralise any bias inherent in certain data sources and methods (Denzim 1979; Jick 1979). Grant and Fine (1992) cited numerous illustrations from the literature that combined survey research and qualitative procedures. Several recent authors advanced the following five purposes served by combining qualitative and quantitative methods in research: triangulation—in the classical sense of seeking convergence of results; complementary—in that overlapping and different facets of phenomenon may emerge; developmentally—wherein the first method is used sequentially to help inform the second method; initiation—wherein contradictions and fresh perspectives emerge; and expansion—wherein the mixed methods add scope and breadth to a study (Cresswell 1994; Greene, Caracelli & Graham 1989; Mathison 1988; Swanson 1992).

Case study methodology was employed in some of the earlier studies on engineers, for example, studies on the transition of specialist sales personnel and financial professionals into management roles carried out by Hill (1991). Similarly, Whalley (1986) carried out a study of the social work of engineers in two British companies
using case study methodology and drew comparisons between them. Carter and Kirkup (1991) conducted a study on women engineers in the USA using case study methodology and in-depth interviews to investigate the role of women in the engineering profession.

Employing a combination of qualitative and quantitative methods is not uncommon in studies on engineers. In Australia, APESA (1992), in collaboration with the Institution of Engineers Australia, conducted a study on the future needs of engineers using case study methodology and a questionnaire survey. The literature review revealed that a majority of the past studies on engineers combined quantitative data generated from questionnaire surveys with qualitative evidence from group discussions and/or personal interviews (Dunn & Fensham 1970; PE Consulting 1972; Wearne et al. 1984; Whalley 1986; Hawkins & Barclay 1990; IE Aust. 1993; Williams 1988). Even the recent review of engineering education by the federal government and the Institution of Engineers Australia (1996) combined quantitative survey with qualitative interviews and focus group discussions.

The transition of engineers into management, as explained in the literature review, has not been investigated in the Australian context, though it has been studied in a limited way in the USA and the UK. In view of this limited research, it was considered appropriate to use case study methodology first to explore the issues involved in the transition. Also, the literature on research methodology suggests that, for research on a special group of people such as migrants or engineers, a less structured approach should first be used, supplemented by a more structured approach like the survey method (de Vaus 1994, Burns 1994; Creswell 1994).

Taking into consideration the above discussion of the various methods, that the research questions are of the ‘why’ and ‘what’ type, the contemporary setting of the study and its exploratory nature, a combination of case study and survey methodologies were used in this research. Considering the arguments in the literature,
and according to the model suggested by Creswell (1994), a research design named ‘dominant-less dominant design’ was taken as the basis for this study. This design involves “qualitative observations with a limited number of informants, followed by a quantitative survey of a sample from a population” (Creswell 1994: 177).

Though case study methodology is used here as part of research design, its main purpose is to develop some propositions about the phenomenon and identify variables that influence the process; it is not to undertake statistical generalisations.

The research questions attempted to explore the factors in the first phase, as well as to describe the incidence and the extent of such phenomenon in the general engineering population in Australia in the second phase. Thus, a combination of case study and survey strategy was considered appropriate to address the research questions.

3.3.3 Case study and survey methods

Case studies are considered to be valuable as preliminaries to major investigations because of their intensive nature and their ability to generate rich subjective data uncovering variables, phenomenon, processes and relationships (Burns 1994). In addition, case studies are expected to provide anecdotal evidence that illustrates more general findings. Importantly, it is argued that case study methodology may provide a basis to refute a universal generalisation, and can therefore assist in refocusing the direction of future investigations in the area (Dey 1993; Burns 1994).

In the first phase of this research, the case study approach was used as a means of identifying and explaining the variables that influence the process of transition, the relationships between those variables and the strategies adopted in an organizational context to make the transition successful. The expected outcomes are several strategies to successfully manage the transition, from the perspective of the individual as well as that of the organization, within the organizational context. While qualitative
methodology formed the basis for exploring the factors influencing the transition of engineers and developing propositions, quantitative survey methodology was employed to test the significance of those propositions across the general engineering population in Australia.

3.4 Case study

3.4.1 Selection of organization and objectives

In case study research and particularly ethnographic studies, the quality of information depends on trust, and sometimes on being able to blend into the background (Gardner 1991: 38). In this research, the researcher was in the unique position of being an engineer by profession, with longstanding experience in various industries as a consultant developing and implementing productivity agreements. The researcher’s engineering background therefore put him in a unique position for undertaking this research.

Access was provided to the researchers from the university in documenting some of the significant changes sweeping the Roads Department of Queensland Transport under the ‘road reform’ and ‘commercialisation’ initiatives of the Queensland Government. Taking advantage of this and identifying a suitable area for research, the researcher chose to study the ‘transition of engineers’ in the Roads Department, a department that has traditionally been managed by engineers and which has a strong engineering-oriented management approach.

The de-engineering of engineering positions, the commercialisation of road building and maintenance operations, an increasing demand for value-for-dollar spent by the government and the community, increased pressure for higher productivity and efficiency, the change in the engineers’ roles from technical engineers to business managers, a participative approach at the workplace and other changes within the
broad context of the restructuring and reform of industry in general—all of these provided an excellent contextual framework for the research.

The access provided for research and the organization’s traditional engineering-dominated approach in managing its work opened up a significant opportunity to the researcher to investigate the change process as it affected the engineers. The specific questions the researcher sought to answer through this case study are indicated in appendices IV and V.

3.4.2 Initial contact and permission to study

Queensland Transport initially approached the Dean of the Faculty of Business, QUT in June 1993 and explained that the ‘road reform’ was under way. In view of its uniqueness, involving significant changes to the organization at both the macro-level and the micro-level, the project manager of the project sought the involvement of researchers from the university. This information was passed on to the heads of school to seek researchers. Subsequently, the author, from the School of Management, Human Resources and Industrial Relations, and another lecturer from the then School of Communications and Organizational Studies volunteered to participate in the research.

Preliminary discussions were held with the project manager in July 1993. After that, the road reform team, along with the project manager, explained the objectives, methodology and the expected outcomes of the project. Later on, in the period October to December 1993, discussions were held with the individual team members to clarify the contextual and conceptual issues in road reform and other associated change initiatives at Queensland Transport. The aim of those discussions was to identify possible research areas and a focus for the researchers. The researchers also attended a workshop on road reform in September 1993.
This researcher approached the project manager in January 1994 to discuss the possibility of concentrating on the changes in the engineers’ work roles in Queensland Transport. A formal presentation was made to the project manager and management of Queensland Transport, explaining the objectives of the study, the methods to be followed in data collection, the sample size, and the resources needed. (This information was later on incorporated into the case study protocol (refer appendix V), prepared and submitted to the project manager in the middle of 1994.) In January 1994, formal permission was given by the project manager for the study to be undertaken and an officer from the road reform project was nominated as the point of contact for liaison. The main responsibilities of this executive officer were to arrange interviews with the respondents and to furnish any other data requested by the researcher.

3.4.3 Organizational reforms and dimensions of study

Queensland Transport is a state government department responsible for the infrastructure development and maintenance of roads and other transport services throughout the state of Queensland, Australia, and was predominantly managed by professional engineers. Details of its background, organizational and the issues in the study are given in appendix IV. The implementation of the reform programs such as ‘road reform’ and ‘commercialisation’ was expected to result in significant structural and cultural changes within the organization and lead to a change in the work roles of engineers.

District managers were responsible for roads program delivery, human resources, finances and customer relations; road reform, commercialisation and workplace reform have further expanded the managerial content of the district manager’s role. This group of engineer–managers was selected for investigation.

The second group of engineers considered for study were senior engineers working in Transport Technology Division (TTD). Here, as result of commercialisation and other reform processes under way in the department, the role of ‘specialist’ engineers had
changed and, in addition to their technical work, they had assumed a ‘generalist’ role that normally included customer relations, marketing and finance functions. This change in the work role of engineers, from that of ‘specialists’ to ‘generalists’, was another dimension under study.

3.4.4 Data collection—methods and instruments

Case study research typically combines data collection methods such as archives, interviews, questionnaires and observations. For example, Sutton and Callahan (1987) relied exclusively on qualitative data in their study of bankruptcy in Silicon Valley; Mintzberg and McHugh (1985) used qualitative data supplemented by frequency counts in their work on the National Film Board of Canada; Whalley (1986) used qualitative data generated through interviews and observations supplemented by documents analysis; Lloyd (1988) relied exclusively on archival analysis; Barclay and Hawkins (1989) relied on qualitative data generated through interviews; and Eisenhardt and Bourgeois (1988) combined qualitative data from questionnaires with qualitative evidence from interviews and observations.

Two types of research methods were used in this case study approach, semi-structured interviews and documents analysis. A questionnaire used by Hill (1992) to investigate the transition of specialists into managers was taken as a basis and modified to collect the data. This questionnaire was chosen as it deals with the transition as a process rather than as an event, and it also analyses the process of transition from the individual’s point of view.

However, on a few occasions, the researcher had the opportunity to be a non-participating observer during a workshop at which the objective was to understand the background to the reform process. In the first phase, the researcher collected the published material such as addresses by the Director-General, the Executive Director and the Director, working papers, memos, circulars and publicity material, in order to
understand the background. The organization subsequently made material available to
the researcher on a regular basis. At times, interviewees supplied the researcher with
material which was taken back to the researcher’s office, details noted and then the
material was returned to the interviewee.

One of the most important sources of case study information is the interview. There
are circumstances where it is quicker to ask than to observe, especially when the
answers are likely to be more reliable. This study is interested in finding out the beliefs
and attitudes of engineers, which cannot easily be observed. Moreover, they are rarely
written down and therefore cannot be found in documents. The interview is therefore
considered to be the most appropriate method for collecting the data directly from the
respondent.

Data from interviews can be collected through either a structured format or an open-
ended, unstructured format. A highly structured interview tends to be used in
hypothesis testing and is more useful in the acquisition of definitive data than
attitudinal forms (Emory & Cooper 1994). On the other hand, unstructured interviews
tend to be particularly useful for the development of ideas for analysis, eliciting new
information and assessing attitudes, and at times when the researcher is not sure what
the appropriate response categories are (Sutcliffe 1990: 89). However, the major
disadvantage of unstructured interviews is that they tend to yield large quantities of
data and responses which are difficult to compare and classify (Yin 1989; Dey 1993).

The open-ended nature of interviews allows the researcher to ask respondents for the
facts of a matter as well as for their opinions of things. In some situations, the
investigator may even ask respondents for their own insights into certain occurrences
and may use such propositions as the basis for further inquiry (Yin 1984: 89). Recorded
the unstructured interview is also another problem, with the researcher
working like a reporter and interviewer. Apart from these operational aspects,
interviews are also subject to methodological problems related to ethics, artificiality, observer bias and validity of the information gathered.

Considering the exploratory nature of the study, the unstructured interview with open-ended questions was used as a data collection strategy at the piloting stage of research. After conducting two preliminary interviews at this stage and after consultations with experienced engineers and other researchers at the university, a semi-structured questionnaire was designed for data collection.

A questionnaire used by Hill (1992) to investigate the transition of specialists into managers was taken as the basis and modified to suit local conditions. Thus, two semi-structured questionnaires, one for the district managers and another for the senior engineers in Transport Technology Division, were designed. Copies of these questionnaires are given at appendix VI and appendix VII.

Documents in case study methodology, in addition to providing insight into the organizational history, help to corroborate and augment evidence from other sources (Yin 1984: 86). A range of documents, such as letters, memoranda, agendas, minutes of meetings, written reports, formal studies or evaluations of the same ‘site’ and other administrative documents, were examined as a part of the strategy to understand the context of and the background to the reform process in Queensland Transport.

In management research, the context, contingency and creation of a document are intrinsic for an understanding of it (Ellem 1990: 49). The context and motivations behind the document and its likely audience are important considerations in document analysis. Most documents were produced for a specific purpose (other than that of the researcher) and a specific audience, something which must be fully appreciated in order to interpret their usefulness. The researcher must constantly ask questions about the context in which documents were produced.
A set of documents used for analysis were shown at appendix VIII. The usefulness of these documents, however, should not be overestimated, as their real use is dependent upon their accuracy or lack of bias in collection and analysis. As most of the documents used in this analysis consist of the addresses given by senior management, internal memos and other publicity material, the information from them was taken as indicative of history rather than as specific evidence to corroborate the findings. The inferences drawn from their analysis were treated only as clues worthy of further investigation and for comparison with the directly collected data from interviews, rather than as definitive findings.

3.4.5 Sampling and units of analysis (respondents)

The experienced engineers who made the transition into management and/or generalist roles are the main unit of analysis in this case study investigation. The engineers chosen for study were not representative of the general population; they were selected for a specific purpose. As Saddler (1985) indicated, the object of selecting case study sites is to "tailor the fit to the requirements of the situation". In establishing the number and types of cases needed, Glausser and Strauss (1967: 45–77) used a comparative method; their selection method is called 'theoretical sampling'.

In this study, theoretical sampling, as defined by Glausser and Strauss (1967), is used. According to them, it is an ongoing sampling process in which the researchers "simultaneously collect and analyse the data, and decide what to collect next, depending upon the suspected intrinsic differences between different cases, and/or on the diminishing marginal contribution of each additional case" (Glausser & Strauss 1967). Glausser and Strauss (1967: 61–62), called the method of determining the actual number of cases needed in a specific study, 'saturation'; it means the diminishing marginal contribution of each additional case. If the marginal utility of an additional case approaches zero, the researcher will have no need to continue with further cases.
This approach has been used in this research in selecting cases and limiting their number.

The study's emphasis is on the conceptualisation of the transition of engineers and the development of propositions, rather than their ability to be generalised. As Saddler (1985) pointed out, "while typicality of a particular case may be difficult to determine in abstract terms, the weight of directly reported and detailed action provides a firm basis for contrast and comparison between cases" (Saddler 1985: 145). The case study highlighted priorities and realities within an organization and acted as a basis to compare and contrast with other organizations and for broader survey studies, an approach adopted in many earlier studies of engineers. The primary objective of this research phase was to study in depth the subjective experiences of these engineers in making the transition, and to develop propositions for further testing.

District managers, all engineers-turned-managers, were identified as the key middle management group for the implementation of the road reform, commercialisation and the workplace reform at the district offices. Redefining the role of the district managers was a major aspect in the overall restructuring of the district offices, to make them efficient and effective. The senior engineers in Transport Technology Division were also chosen to be interviewed in view of the changes in their role, from specialists to generalists, as a result of commercialisation and other changes in the organization. Background information on the commercialisation concepts and the approach adopted by the Division was furnished to the researcher through the executive officer.

Considering this aspect, 12 district managers and regional directors (12 out of 15), who were engineers-turned-managers and whose jobs were predominantly managerial, were interviewed. Interviews were also conducted with 10 (from the top four levels, out of 15) senior technical engineers who had made the transition from specialist to generalist roles in the Transport Technology Division of Queensland Transport. To better understand perceptions of the transition from the organizational perspective, 10
other people were also interviewed. This group included administrators, staff and some senior engineer–managers who were given the responsibility of overseeing the strategy development and implementation processes on ‘road reform’ and ‘commercialisation’.

After conducting six preliminary interviews, each additional interview was analysed for its marginal contribution to the insights so far provided. Once the marginal contribution was found to be diminishing, as suggested by Glausser and Strauss (1967), the researcher requested no further interviews. Twelve engineer–managers, 10 senior engineers and 10 change-management team members were interviewed.

3.4.6 Case study protocol

A case study protocol is necessary as a strategy to increase the reliability of the research (Yin 1984). This protocol generally contains the instrument or questionnaire used for collecting the data and explains the interview procedures, confidentiality issues and general rules that should be followed in using it. Unlike other research methods, the case study approach constrains the behaviour of the researchers as they must cater to the interviewee’s schedule and availability, and also takes up the researchers’ time (Dey 1993). Also, with the nature of interviews being open-ended, interviewees may not necessarily cooperate fully in answering questions or may impose certain restrictions in answering them. This necessitates an explicit and well-planned field procedure, and guidelines to cope with this kind of behaviour, well before the data collection phase.

Taking into account the above issues, a case study protocol was developed explaining the approach to interviewees and the collection of demographic data about the respondents; the method of perusing and collecting documentary evidence; the procedure for audio taping, transcribing and validating the interview transcripts; and the procedure for getting assistance in case of problems. A clear schedule of the data-collection activities and a plan of action for unanticipated events, including changes in the availability and mood of the respondents, was also drawn up as part of this protocol. The case study protocol thus
developed was finalised after discussions with management on the issues of the availability of respondents, access, and liaison between the researchers and the respondents. A copy of the case study protocol is given in appendix V.

3.4.7 Interview process and validation of data

Having decided the data collection method, the approach to sampling and the protocol to be followed in data collection, the next step was to decide who to interview and the process of interviewing. It had been intended to interview all the district managers and senior engineers from the top four levels of the Transport Technology Division. However, in view of the diminishing marginal contribution of the cases to the study, some interviews were not carried out. The sequence of the interviews was determined purely on the availability of the respondents, and the time involved. The organization had been notified that an interview takes between two and three hours of a respondent’s time.

As the respondents were senior-level managers and engineers, scheduling their appointments was difficult. It could therefore be said that the sampling process and the sequence of interviews were in a way random, determined neither by the researcher nor by the project manager. In almost all instances, the interviewees were not aware of the number of people interviewed before them or subsequent to them.

Copies of the two questionnaires, one for interviewing district managers and the other for the senior engineers, were submitted to the project manager for his information and comments before interview schedules were planned. This was done to avoid any problems with the interview and also to assure the organization of the consideration given to sensitive issues.

A formal letter introducing the researcher and the research study, and the background paper submitted earlier seeking permission to carry out the study, were sent by the project manager to all the potential respondents and senior management within the
organization. This was thought to be a useful strategy to prepare the respondents for the interview and to identify any objections to the process adopted by the researcher. It should be noted that no objections of any kind were raised by the respondents before, during or after the data collection process. The cooperation was excellent and enabled the researcher to concentrate his efforts on the intellectual aspects of the study, rather than the operational issues and logistics.

Appointments were sought from the respondents through the executive officer and confirmations of the date, time and the venue were sent to the researcher by the executive officer, after consulting and taking commitments from the individual respondents. In case of the district managers, their availability during their short visits to head office was a problem which extended the time frame to six months.

The interviews were conducted from March to September 1994. The executive officer arranged interviews with six district managers in the conference room at head office, and with four district managers in their district offices. In addition, interviews were scheduled with three of the five regional directors, who were also engineer-managers. Regional directors were responsible for three to four district offices and the district managers reported to them.

Thus 10 district managers, three regional directors, and nine senior specialist engineers including the director were interviewed. The researcher proposed that the interviews be recorded to ensure the accuracy of the data collected, if the interviewees agreed. The project manager agreed for this in principle and decided to leave it to the discretion of the individual interviewee whether to agree or not.

Copies of interview questionnaires were sent to each of the district manager/regional director or engineers in Transport Technology Division prior to interview. The objective was to give the respondents time to ponder the issues to be discussed. In addition, they were asked to furnish certain background information, regarding their educational
qualifications, experience and training, prior to the interview in a pro forma designed by
the researcher. (A copy of this pro forma is enclosed with the questionnaire at appendices
VI and VII.) Only some of the respondents provided information on the pro forma; in
other cases, the researcher completed it himself by asking for information during the
interview.

Before each interview started, the interviewee was told about the background of the
researcher, the background to the selection of the case study, the selection of the
respondents, the objectives of the study, and the information the researcher was seeking.
The type of transition the researcher was investigating in the case of the district managers
and in the case of the engineers was explained to them.

The researcher explicitly indicated to each of the respondents that the answers to the
questions were voluntary and that they were free not to respond to any of them.
However, this had already been noted in the covering letter to the questionnaire.
Respondents were also informed that the answers would be kept completely confidential
and would not be seen by any body other than the researcher.

A guarantee was given in writing (in the questionnaire itself) that no individual would be
identified in the final analysis or otherwise named. Each respondent decided whether or
not to record his/her interview on audio tape, and could also switch off the tape recorder
at any time during the interview.

Respondents were told about the verbatim transcripts of the tape-recorded interviews,
and were informed that the researcher would sent them their respective transcripts so that
they could confirm their views and make modifications to the responses given during
interview. All the above information, recorded in writing, was read and explained to
each respondent before the interview started. At the close of the interviews, the
researcher thanked the respondents for their time and effort. The interview transcripts
were finalised after respondents had confirmed the details and then formed a basis for coding and analysis.

The three basic principles as suggested by Yin (1987) were followed in order to establish the construct validity and reliability of the case study findings. Using multiple sources of evidence, creating a case study database and maintaining a chain of evidence were the three principles Yin (1987) recommended. Though it is limited to some extent, this research involves documentary evidence and the interview transcripts to corroborate observations made. Documents such as memoranda, discussion papers, notes exchanged between the various participants, working papers and official publications were thoroughly analysed and used to analyse the interview responses. Using other sources of evidence, therefore, was expected to enhance the overall quality of the study findings.

Another principle is the creation of a database that reflects the organization and documentation of the data collected for case studies. As suggested by Yin (1987), the database should be created in such a way that, in principle, other investigators can review the evidence directly and not be limited to written publications. This should increase markedly the reliability of the study.

The case study database developed for this research study involved computer data files, backup copies on disks, handwritten notes of the interview, interview transcripts after correction by the respondents, letters of correspondence related to the study, audio tapes of the interviews, and copies of the published materials and documents used in the analysis. The documents used were presented in the form of an annotated bibliography; hard copies were filed away in separate files for future identification and retrieval purposes.

The third principle of maintaining a chain of evidence was used in the case study analysis and presentation of findings, and is expected to increase the reliability of the findings. The case study analysis chapter itself makes sufficient citation to the relevant
portions of the case study database; for example, the analysis chapter refers to the specific documents or interview transcripts using the coding system developed.

Based on these citations, it is possible to retrieve the manuscripts or the original documents, along with an indication of the circumstances such as place, date and time of the interview or document publication details. Each interview transcript and case study note describes the place, date, time and other qualitative observations. The case study database and the retrieval system for this study of engineers in Queensland Transport have been created in such a way that it is possible to "move from one portion of the case study to another, with clear cross-referencing to methodological procedures and to the resulting evidence" (Yin 1989: 103).

3.4.8 Data analysis

The data was analysed with reference to a broad descriptive framework based on the literature review. This framework consists of several aspects, as indicated below, which were used as a conceptual basis for categorisation of the data.

* Reasons for transition and problems.
* Factors contributing to the engineers' successful transition.
* Strengths and weaknesses of engineers.
* Strategies in coping with transition.
* Resources available for making the transition.
* The influence of beliefs and attitudes of engineers as a professional group.
* Influence of the individual personality.
* Organizational status of engineers.
* Influence of engineering education.
* Career choices and preferences.
Since finding meaning is the main purpose of analysis, the data have to be organised systematically so that comparisons, contrasts and insights can be made and demonstrated (Burns 1994). Classifying the material into themes, issues, topics, propositions, termed as ‘coding’ or ‘categorising’, is the first stage in analysing qualitative data (Burns 1994). It is possible to identify themes and so begin coding even during the data collection stage. As stated by Miles and Huberman, "coding is not something one does to get data ready for analysis, but something that drives ongoing data collection. It is, in short, a form of continuing analysis." (Miles & Huberman 1984: 63).

Based on the conceptual framework developed and the dimensions identified in the literature review, general statements about the topic that were related to the research question were developed. These statements or propositions were constantly refined, expanded and modified as further interviews were conducted, using the ‘explanation building’ mode of analysis. Explanation building is an iterative process of a gradual reciprocal building-up of theories and propositions (Burns 1994; Yin 1989), in which case study data are analysed by building an explanation about the case.

After six interviews, the researcher could develop some tentative propositions related to the main research question: “What factors influence the transition of engineers and how do they influence it?” In fact, later interviews were used, in a way, to test these propositions and to develop further ones. Following the ‘grounded theory’ concepts advocated by Glasser and Strauss (1967), theoretical propositions were created, revised and refined in the light of data collected from interviews.

Once the categories have been identified, the next step is grouping data into categories. It involves developing a set of criteria in order to distinguish whether observations are similar or related, that is, firmly ‘grounded’ conceptually and empirically. As qualitative research is often concerned with finding out how subjects experience and perceive situations and events, categories are developed as a result of a dialectic iterative process.
(Dey 1993). Content analysis was used here to systematically analyse data from interviews.

Content analysis involves developing categories to which particular statements or actions can be allocated for analysis and to interpret the final picture of the study (Gardner 1991). These categories were continuously refined and modified during the data collection and analysis phases. Accordingly, the categories/dimensions as identified at the beginning were taken as the first approximation of a category set through which the data was to be analysed. Subsequently, the criteria for classifying the data bits into categories were defined and recorded.

The cases were picked at random and each transcript was evaluated against the criteria for categorisation and placed in the appropriate category. While categorising the data, the researcher was continually making judgements about how to categorise data bits and also whether and how to modify the categories in view of the decisions made. Thus, it was a continuous iterative process of categorising, redefining the categories and recategorising until all the data bits were appropriately categorised for analysis. As all the interview manuscripts were in computer files, it was possible to carry out cut-and-paste operations in coded sections.

Based on the categorisation of the data, and analysis of the connections between them, an attempt was made to evaluate the responses of the different groups of respondents to the various themes. To demonstrate how the concepts and connections that were identified in the qualitative analysis were grounded in data, a comparison of typical examples of the data bits was carried out.

By evaluating whether responses were on the borderline, at the extremes, emanating from a single case or spread evenly across cases, it is possible to summarise frequencies and do some analysis. For example, Miles and Huberman (1984) recommend identification of themes or patterns by frequency of occurrence in the data. They argued
that counting is necessary in qualitative analysis to verify a hunch or hypothesis, to see rapidly what the data contains, and to keep the researcher analytically honest (Miles & Huberman 1984). Using some of the principles advocated by Miles and Huberman (1984), and the principles of content analysis suggested by Burns (1994), frequencies have been identified. Categories based on strategies adopted by individuals, perspectives respondents had about their situations and patterns of behaviours were used in the content analysis of the interview transcripts.

The assumptions required for a thorough statistical analysis were not satisfied by the way data was collected and analysed in a case study approach (Dey 1993). However, it was still possible to obtain a useful descriptive overview in summary form by counting the occurrences. As suggested by Burns (1994), making counts of items allocated to each of the propositions in them is one way of analysing the qualitative data. Moreover, as the findings from this analysis were only going to be used as propositions for further testing and analysis, it was found to be appropriate to categorise the data. Accordingly, the responses on several themes and/or propositions were classified and their frequency of occurrence identified. A summary of these responses on different themes related to the transition are given in appendix IX.

All the responses were categorised as ‘agree’, ‘disagree’ and ‘neutral/undecided’ with reference to a particular proposition. Conclusions were drawn from the analysis of these occurrences, strength of the argument, and their context. The number of occurrences was dependent upon the emphasis each respondent gave to a particular proposition. Therefore, a respondent may have had more than one statement supporting or opposing a proposition and thus the total number of occurrences will always be more than the total number of cases.

In the analysis and presentation stage, a multiple-case study reporting format, as suggested by Yin (1987), was employed. According to him, there would be no separate chapters or sections devoted to individual cases; instead there would be cross-case
analysis, with each chapter or section addressing a particular issue or dimension of the transition. As the study is exploratory in nature, this format would be appropriate (Yin 1989; Miles & Huberman 1984). Therefore, a format that discusses each of the dimensions identified one after the other with evidence from the case study data was used to report the case study findings.

While writing up the case study findings, the most desirable option, from the researcher's point of view, is to give details of both the case and the individuals. However, since certain factors were involved, such as the controversial nature of the subject, the sensitivity of the issues and opinions in certain areas related to the study, the identities of the individual participants could not be revealed (Yin 1989). This leaves the case itself to be identified accurately. To this end, the researcher obtained written permission from the organization to disclose its identity. Moreover, the published report on the case study findings were about the aggregate evidence, in which the individual responses were not disclosed. As promised at the beginning of the research while obtaining access for study, the researcher systematically converted the identities of the interviewees using a coding system. Therefore code numbers have been provided in the case study analysis chapter, where observations made by the interviewees on certain issues have been made.

In order to validate the study, the researcher sent a draft case study analysis for review by an informant in the case study organization. The objective of this review was to corroborate the actual facts of the case reported in the analysis chapter, not to obtain concurrence on the conclusions and interpretations. This review process enhanced the construct validity of the analysis, and enhanced the accuracy of the case study analysis and reporting.

Case study method is one of the most difficult and time-consuming research methods (Yin 1989; Burns 1994). The volume of data that is generated is enormous and needs significant effort to properly record, analyse and interpret it. No matter which case
study design is chosen, each case must be well-understood in relation to its context, and the validity of the findings must be ensured by using multiple sources of evidence to test and probe each question, as well as considering and eliminating rival explanations of the evidence gathered (Carroll & Johnson 1990).

The findings of the case study research were specific to the situation observed and it would be difficult for another researcher to check them independently. The problems of subjective bias, the validity and the reliability of case study findings, in addition to the time and information overload, are well-documented in the literature (Burns 1994; Yin 1989; Carroll & Johnson 1990; Cresswell 1994). In addition, the professional background of the researcher as a consulting engineer may also inject bias in the data-gathering, analysis and interpretations. Similarly, although the organization is accessible for research, the extent of the cooperation from the different respondents in the organization might not be the same and could influence the process as well as the outcomes of the study.

However, the researcher believes that, in spite of the above limitations of the case study method, certain factors can to a large extent overcome them (Gary & Diehl 1992; Yin 1989) and help researchers achieve their objectives. These factors are the combination of the methods chosen; the accurate description of the methodology and steps in conducting the study; the rigorous implementation of the basic principles such as chain of evidence, usage of multiple sources of evidence and developing a case study database; appropriate validating procedures such as informants' review of drafts; the iterative process of design, data collection and analysis; and thorough preparation and rigour in approach. Moreover, in this research, the case study method was primarily used to help develop propositions only, and not for any generalisations. The limitations of the case study method did not, therefore, affect the validity and reliability of the study outcomes.
Importantly, by combining the research method with the survey method, the study stresses the interdependence and mutual enhancement of apparently opposite approaches, and takes the view that the survey research complements the findings of the case study. This combination of methods should result in a more accurate account of the process of the engineer’s role transition. The results should be far richer than any that could have been obtained by either the survey method alone or the case study method alone.

3.5 Survey research

3.5.1 Introduction

Survey is the most commonly used method in business research. Survey research “entails collection of data on a number of units and usually at a single juncture of time, with a view to collecting systematically a body of quantifiable data in respect of a number of variables which were then examined to discern patterns of associations” (Bryman 1989: 104). In this research, survey is the method used to test the propositions developed from the case study among the engineering population in Australia. The main objective of this phase of research study is to describe the attitudes of engineers towards transition and towards various aspects influencing it, and to explain any relationships between certain factors and groups of engineers.

Survey method is considered to be an efficient way of collecting large amounts of data at low cost in a short period of time, and is an appropriate technique to provide information on beliefs and attitudes (Burns 1994; Cooper & Emory 1995). In the literature, a number of critical aspects that influence the process of transition were identified. The works of Badawy (1982), Bailyn (1982), Rynes (1987), Hill (1992) and Callan (1995) were considered for the basis for the questionnaire design. The different stages in the design and administration of the survey method used in this study are indicated below.
Step 1  Questionnaire design: based on the development of statements to measure the factors identified and the propositions developed from case study analysis and the literature review.

Step 2  Pilot testing of the questionnaire and refinement.

Step 3  Sampling and administration of questionnaire.

Step 4  Processing of data: data coding and data entry.

Step 5  Data analysis: statistical methods and approaches.

Step 6  Interpretation of the results.

The identification of the factors influencing the transition and the strategies employed in managing it based on a literature review and a case study analysis have been discussed earlier in this thesis. The following discussion explains the instrument (questionnaire) design process, pilot testing, sampling, administration, the processing of data and procedures employed for statistical analysis.

3.5.2 Sampling plan

The main focus of this study was to analyse the transition from the perspective of the individual. The attitudes, beliefs and the opinions of engineers on the transition in their roles in contemporary organizations were the basis for addressing the research questions. Keeping in mind the research objectives and limitations of this research, professional engineers in Australia who were registered as members of the Institution of Engineers Australia were considered to be an appropriate population for this study.
IE Aust. is the single peak professional body for professional engineers in Australia and plays an active role in maintaining occupational identity and developing the profession, and has occupational control through its membership.

Engineers with some experience in the industry would have a sound knowledge and/or experience of the transition from both an individual point of view and from the organizational perspective, and therefore were chosen for this study as respondents. Also, since it is the engineers’ perspective that this study is mainly concerned with, an understanding of the perceptions of working engineers in Australia was considered necessary to answer the research questions.

Considering the requirement of this study to investigate experienced engineers, it was proposed to concentrate on full members of the IE Aust. According to the IE Aust. rules, a professional graduate engineer becomes a corporate member of the institution if he/she has acquired about three years of professional experience in addition to a Bachelors degree or its equivalent as the basic qualification. Since this definition of a corporate member met the requirements of the research design, corporate members of the Institution of Engineers Australia, who were employed at the time of study, were chosen as the population for the study.

Engineering is a diverse discipline, with several branches of engineering within the profession. Since it is not possible to cover all types of engineers, the study mainly focused on three groups: civil engineers, mechanical engineers and electrical/electronics engineers. These three groups constitute more than 85 per cent of the total professional engineering population in Australia.

Considering the expected response rate, and the minimum sample size required to carry out valid statistical analyses and the limitations on cost and time, it was decided to contact 3000 professional engineers registered as corporate members of the IE Aust.. From the total population of corporate members, the number of unemployed
engineers, engineers working overseas and retired engineers was removed in order to obtain a valid basis for sampling.

A list of names and addresses generated randomly by the computer was obtained for a nominal fee from IE Aust. in October 1995 in order to conduct a postal survey. The list, from the professional membership register of the IE Aust. which has about 40,000 corporate members, consisted of 3000 professional engineers, 1000 each from civil engineering colleges, mechanical engineering colleges and electrical/electronics engineering colleges.

The sample was designed to be representative nationally, and large enough to provide good estimates of the engineers’ perceptions of the transition. Previous studies in Australia have taken a sample of about 2000 engineers and achieved a response rate of between 25 per cent and 45 per cent (Williams 1988). The literature on survey methods indicates that a 30 per cent response rate in a self-administered mail survey is satisfactory (Dillman 1978; Cooper & Emory 1995). Therefore, it was felt that a sample size of 3000 professional engineers was appropriate for the study.

3.5.3 Questionnaire design

3.5.3.1 Scale—dependent variables

Rigorous methods for constructing instruments to measure social science variables have been developed by several psychologists and social scientists (Likert 1967; Nunnaly 1967). The process used in this study was based on generally accepted principles of instrument design, and advocated by Burns (1994), Converse & Presser (1986), Cooper & Emory (1995), de Vaus (1995), Fowler (1993), Likert (1967), Oppenheim (1992) and Sekaran (1992).
Based on the discussion in the literature review, several representative measurement items for each of the issues were developed. The emergence of these items from the literature review has been documented in the paras 2.4, 2.5 and 2.6. The questionnaire thus consisted of several statements referring to the issues relevant to transition: general attitude, engineering education, organizational support, status, and strategies for managing transition. These statements thus defined the scope and meaning of each theme. Considering these themes and the basic principles of questionnaire design, a questionnaire with 102 items was designed initially.

To enable engineers to indicate their degree of agreement with each item, a 5-point Likert rating scale was used. As this study is mainly concerned with measuring attitudes and beliefs, a Likert method was considered the most appropriate (Burns 1994; Cooper & Emory 1995; de Vaus 1994). Research indicates that a 5-point scale is as good as any and that an increase from 5 to 7 or 9 points on a rating scale does not improve the reliability of the rating (Sekaran 1992). A typical questionnaire item is shown below where respondents can indicate the extent to which they agree or disagree with the statement.

*Engineers moving into management roles have better compensation than those remaining in technical positions.*

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

The literature suggests that a Likert scale is more reliable than the Thurstone scale, is easy to use in respondent-centred studies and also can be treated as an interval scale for analysis purposes (Burns 1994; Cooper & Emory 1995). Thus a questionnaire, using a Likert 5-point scale has been designed and used in this study. The questionnaire items were selected by the researcher in consultation with experienced
engineers, based on their relevance to the topic under study, potential for ambiguity, the propositions developed from the case study analysis and the literature review.

3.5.3.2 Independent and background variables

The questionnaire consisted of measures of independent variables such as the predominant nature of the job, the branch of engineering and type of industry in which engineers were employed, management qualifications and gender. In addition, it has some background variables such as country of basic engineering qualifications, age, experience, postgraduate qualifications in engineering, title of present position, and number of levels above or below the respondent.

The categories for each of the independent and background variables are briefly described here. This survey was carried out among three main disciplines of engineering—civil, mechanical, and electrical/electronics. Considering the importance of the nature of the job in engineering work, respondents were asked to self-classify themselves in terms of their job being mainly technical, mainly managerial or equally divided between the two.

The diversity of the engineering population in Australia comes from migration; about 21 per cent of the total engineering population comprises migrants. Respondents were asked whether they acquired their basic engineering qualifications in Australia or overseas. Although overseas-trained engineers came from different Asian, African and European countries, it was necessary to see whether there were any differences between Australian-trained and others.

The range of work engineers perform is wide and diverse. The knowledge, organizational culture and management systems specific to a particular industry were expected to have an influence on the professional formation of engineers. Therefore, information about the industry in which respondents were working was collected. The
classification used by Williams (1988) was employed in this survey. Accordingly, the manufacturing group included typical manufacturing, construction, chemical processing and mining organizations; the government group included local, state and federal governments and statutory authorities; the consultancy group included engineering consultancy organizations of all kinds; and the fourth group included the remaining service sectors such as teaching, training, research, transport, hospitality and health.

Age was expected to play an important role, from the literature review. According to the definition of respondent as a corporate member of the IE Aust., it was expected that they would have at least three to five years’ experience in the profession. Instead of directly asking the individual for their age, respondents were asked to indicate the age range into which they fell. The ranges provided in the questionnaire were up to 25 years, 26 to 30 years, 31 to 35 years, 36 to 40 years, 41 to 50 years, and over 50 years. However, for the purpose of analysis, these groups have been recategorised into five categories, namely, up to 30 years, 31 to 40 years, 41 to 50 years and over 50 years.

While there are several ways in which engineers can acquire management skills, postgraduate management education is by far the most popular strategy, according to the literature. Respondents were asked to indicate their postgraduate management qualifications. Eight categories were identified: associate diploma, advanced certificate, graduate certificate, graduate diploma, MBA, masters degree, PhD and others.

Some of the background variables include the highest qualification attained in engineering, whether they have bachelors degree or not, nature of their experience, levels below and above the respondents, and the number of people the respondent supervised.
In addition, respondents were asked whether they would be willing to be interviewed, and were asked to provide telephone number for future contact. They were also asked to provide some qualitative comments at the end of the questionnaire if they so desired.

3.5.4 Pilot Testing:

Once a questionnaire has been developed, it is important to pilot-test the questions and the questionnaire as a whole, before final administration. Pilot-testing means evaluation of the questions and the questionnaire in order to eliminate any irrelevant, unrelated or confusing questions and to enhance the standard of response. Pilot-testing helps the researcher to minimise the limitations of the questionnaire in addressing the research questions, and enhances its value as a critical tool with which to collect relevant and accurate data for analysis. As there would not be another opportunity to explain the intended meanings and objectives of the questionnaire to the actual respondents once the questionnaires were posted, this is considered an extremely useful and critical stage in survey research (Converse & Presser 1986).

Conducting pilot-testing on a sample similar but smaller to that to be used in the actual study is an important aspect of a pilot study, as it is expected to enhance the reliability and validity of the indicators (de Vaus 1995; Converse & Presser 1986). When a measuring instrument is developed, the subjects used should be those for whom the instrument is intended (Nunnally 1967; de Vaus 1995). Accordingly, a sample of 32 professional engineers were chosen as respondents in the pilot test.

In view of limited time and resources, the sample chosen for the pilot study were from the Sydney area only. All of the respondents were part-time students from various universities in Sydney and were studying various postgraduate courses in technical and management areas. However, all of them were practicing engineers and members of the Institution of Engineers Australia, and were similar to the sample to be used for
actual study. Before conducting the test, the objectives of the study was explained to the participants and accordingly they were asked to give their opinion about the questionnaire design, as well as their comments and responses to the items in the questionnaire itself. A brief analysis of the background of the 32 respondents chosen for the pilot testing is given in the following table.

Table 3.1: Background of the respondents participating in the pilot study

<table>
<thead>
<tr>
<th>Background of respondents</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch of engineering:</td>
<td></td>
</tr>
<tr>
<td>Mechanical engineers</td>
<td>12</td>
</tr>
<tr>
<td>Civil engineers</td>
<td>14</td>
</tr>
<tr>
<td>Electrical/electronics engineers</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
</tr>
<tr>
<td>Nature of job:</td>
<td></td>
</tr>
<tr>
<td>Predominantly technical</td>
<td>9 (28%)</td>
</tr>
<tr>
<td>Predominantly managerial</td>
<td>7 (22%)</td>
</tr>
<tr>
<td>Equally technical and managerial</td>
<td>16 (50%)</td>
</tr>
<tr>
<td>Total</td>
<td>32 (100%)</td>
</tr>
<tr>
<td>Age group:</td>
<td></td>
</tr>
<tr>
<td>Below 25 years</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>26 to 35 years</td>
<td>9 (28%)</td>
</tr>
<tr>
<td>36 to 45 years</td>
<td>22 (69%)</td>
</tr>
<tr>
<td>Over 46 years</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Total</td>
<td>32 (100%)</td>
</tr>
<tr>
<td>Type of employing industry:</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>12 (38%)</td>
</tr>
<tr>
<td>Consultancy</td>
<td>4 (12%)</td>
</tr>
<tr>
<td>Government</td>
<td>10 (31%)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (19%)</td>
</tr>
<tr>
<td>Total</td>
<td>32 (100%)</td>
</tr>
<tr>
<td>Bachelors degree qualification:</td>
<td></td>
</tr>
<tr>
<td>Australian</td>
<td>7 (21%)</td>
</tr>
<tr>
<td>Overseas</td>
<td>25 (79%)</td>
</tr>
<tr>
<td>Total</td>
<td>32 (100%)</td>
</tr>
<tr>
<td>Management qualifications:</td>
<td></td>
</tr>
<tr>
<td>No qualifications</td>
<td>18 (56%)</td>
</tr>
<tr>
<td>MBA/Masters/Grad Dip in Mgmt.</td>
<td>10 (31%)</td>
</tr>
<tr>
<td>Other non-technical qualifications</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>Total</td>
<td>32 (100%)</td>
</tr>
</tbody>
</table>
The information provided by the respondents was expected to help the researcher to evaluate the individual questionnaire items in terms of variations between responses, understanding of the intended meaning of the questions, redundancy of items, tendency of respondents to agree with the statement regardless of its content, and refusal to answer certain questions (de Vaus 1995). As expected, engineers commented on the appropriateness of items and their ease of comprehension and understanding, and suggested changes to improve their wording.

Though there are several well-established methods of testing the reliability of indicators, the best methods, however, apply only to measuring the reliability of scales (de Vaus 1994), where there are a set of questions to measure a single concept rather than single item indicators. As this questionnaire consisted of several single-item measures of various issues on the transition and propositions developed from the case study analysis, the test-retest method was suggested to test its reliability (de Vaus 1994; Burns 1994). Basically, this method consists of asking the same people the same questions at intervals and calculating the correlation coefficient between both answers (de Vaus 1995).

In this study, the 32 engineers chosen for the pilot study were asked to answer the questionnaire twice, at times four weeks apart. Carrying out the test-retest method resulted in a correlation of 0.89. The literature suggests that the questionnaire can be considered reliable if the correlation coefficient is higher than 0.7 (de Vaus 1995; Converse & Presser 1986; Oppenheim 1992). So this study, with a correlation of 0.89, is considered to be reliable. However, to enhance the reliability of survey research, the literature suggests multiple indicators (Fowler 1993; Converse & Presser 1986). Keeping this in mind, multiple indicators were used wherever possible to measure dimensions such as status, engineering education, general attitude towards transition, and organizational support.
Another strategy to improve reliability is to broaden the sample of items by adding similar questions. In the pilot study, six similar questions were added which reflected the same concept or issue, in order to test the difference in their response. Analysis revealed that the correlation between the similar questions was fairly high, with correlation coefficients ranging from 0.79 to 0.96 for the six questions. After the pilot study, these questions were removed while the final questionnaire was prepared. Cronbach alpha values are computed for an internal reliability test and found to be varying from 0.65 to 0.89.

Analysis of the data provided by the respondents revealed that certain items were similar in that there was no variation in the responses. For example, a statement that ‘an MBA is the only strategy for acquiring management skills’ got a very high negative response rate, with hardly any variation. Such questionnaire items were eliminated. Similarly, in order to see whether there was an ‘acquiescent response set’ in the data, three questions that were completely contradictory were included in the questionnaire. The tendency to agree or disagree with a statement, regardless of its content, is termed as the ‘acquiescent response set’ (de Vaus 1995; Converse & Presser 1986). Analysis of the data revealed no evidence of this.

Validity is an important aspect in survey research. While the external validity of research findings refers to their ability to be generalised across larger populations, internal validity is the ability of the research instrument to measure what it is purported to measure (Cooper & Emory 1995). The issue of external validity was addressed in the final analysis stage, while the question of internal validity was addressed at the design stage of the questionnaire and during the pilot study.

Although the researcher had taken considerable care in defining terms, the usage of the items and development of scale, a panel of engineers and engineer–managers known to the researcher was requested to thoroughly evaluate the questionnaire for its internal validity. The opinions of the panel on the validity of the questionnaire and the
practicality of the study were taken into account by rewording some of the questions, expanding some of the terms, and defining some words, and by eliminating some of the questions.

Following the pilot study and analysis, and the panel's evaluation, a revised questionnaire was designed in which the number of items was reduced from 102 to 85. In addition, the dependent variables, such as branch of engineering, job nature, age and other details were retained in the final questionnaire. The questionnaire was then printed, with a print run of 3000 (refer to appendix X for the questionnaire).

3.5.5 Administration of the survey

The approach taken in the administration of questionnaires affects the quality of sample surveyed, the layout of the questionnaire and the response rate. The literature suggests that it is possible to increase the response rate by several strategies, such as enclosing a covering letter, return envelopes and/or postage-paid envelopes, and anonymity and the length of the questionnaire. In order to maximise the response within budgetary constraints, the Total Design Method suggested by Dillman (1978) was used. In this approach, explicit attention is given to those points of the survey process at which response may break down. For example, Dillman identified some of the factors that would reduce the response rate: wrong address, low-rate postage, appearance of the questionnaire being similar to that of junk mail, lack of proper instructions for completion, and no convincing explanation why anyone should complete the survey (Dillman 1978).

Questionnaires were therefore mailed along with a covering letter and a self-addressed and stamped envelope. The covering letter explained the main purpose of the study and the importance of the respondent's cooperation, with a clear invitation to seek any clarification by telephone. The letter also indicated the approximate time that answering the questionnaire should take, about 15 minutes. After the benefits of
additional information that might be obtained by further follow-up were weighed against the cost of making repeated contact (and the limited budget), it was decided not to sent any follow-up letters. However, a reminder was published three weeks later in the monthly journal of the IE Aust.

It is generally argued that the non-response factor introduces bias into the sample in mail surveys, particularly when the sample is not representative of the population (de Vaus 1995). However, in this study, the risk of bias likely to be so introduced was not considered high, as the sample was representative of the general engineering population. Moreover, there was no general difference between respondents and non-respondents in terms of their educational level or experience, as the sample had been randomly selected. An overall response rate of 30 per cent was achieved.

To check the validity of the responses and to find out how representative the sample was, in November 1995 the researcher sought direct and indirect opinions from some respondents and a few non-respondents. From the list of respondents, 15 people selected at random were telephoned. Of those 15, eight of them had not responded to the questionnaire, and indicated lack of time as being the main reason. As the sample had been made at random and was fairly large, ensuring a good response, the effect of non-response was to some extent minimised. Though there could be some difference between non-respondents and respondents that could inject some bias into the findings, certain inferential statistical techniques were used to minimise any such influence on the analysis. The results of statistical analysis generally were validated and the sample was considered to be representative of the general opinion of the profession.
3.5.6 Date editing, coding and entry

3.5.6.1 Data editing

All the questionnaires received were systematically edited for accuracy, consistency with other information, and completeness. Each was given a serial number for identification. Of the 3000 questionnaires mailed out, the researcher received 792 completed ones.

The questionnaire was treated as incomplete if information on either or both of the demographic details or attitude had not been supplied or left unfinished. Even though some of the items in the scale had not been completed, the questionnaire was considered valid if it contained basic details about the respondents in terms of their branch of engineering, nature of their job, experience and qualifications, and if details had been given about some of the other questionnaire items. However, if there was insufficient or no information about the individual, the questionnaire was considered invalid. For example, if a respondent had indicated his/her branch of engineering, but had not given any information about the job nature or qualifications, that questionnaire was treated as invalid and was not considered for analysis.

3.5.6.2 Response rate

From the total of 792 questionnaires the researcher received, there were 756 valid responses. As indicated in the following table, 1000 questionnaires were mailed to engineers from each of the three disciplines considered for this study: civil, mechanical and electrical/electronics engineers.
Table 3.2: Number of valid responses from questionnaire survey

<table>
<thead>
<tr>
<th>Particulars of questionnaire</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate number of members in the IE Aust. Register</td>
<td>11,000</td>
<td>12,000</td>
<td>12,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Total number mailed</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>3000</td>
</tr>
<tr>
<td>Total number received</td>
<td>301</td>
<td>321</td>
<td>170</td>
<td>792</td>
</tr>
<tr>
<td>Blank responses</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Incomplete responses</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Returned questionnaires (due to change of address/incorrect address)</td>
<td>3</td>
<td>5</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Returned questionnaires (received by non-working engineers)</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Total number of valid responses</td>
<td>291</td>
<td>310</td>
<td>155</td>
<td>756</td>
</tr>
<tr>
<td>Percentage of valid responses</td>
<td>31%</td>
<td>33%</td>
<td>18%</td>
<td>27%</td>
</tr>
</tbody>
</table>

The overall response rate was computed using the formula suggested by de Vaus (1995).

Overall response rate = (Number returned) / [N in sample - (Ineligible +
Unreachable)]

= (792) / [3000 - (19 + 17)] = 27 per cent

Thus, an overall response rate of 27 was achieved. The response rate differed between the different branches of engineering; the response from electrical/electronics engineers was low (about 18 per cent), and that from mechanical engineers was high (33 per cent).

3.5.6.3 Data coding

In the next stage of analysis, coding was carried out, which involved assigning numbers to answers so that the responses could be grouped into a limited number of categories (Cooper & Emory 1995). For example, the variable ‘gender’ was coded as follows: 1 for male and 2 for female. Similarly, the branch of engineering was coded: 1
for civil, 2 for mechanical and 3 for electrical engineer. Categories were developed using the coding principles enumerated in the literature covering such aspects as exhaustiveness, mutual exclusivity, and single dimension (Cooper & Emory 1995; de Vaus 1995).

The coding system developed to make data entry error-free is presented in appendix XI. It explains the variables in the study and the specified application of coding rules to the variables. It contains the question number, variable name, code descriptors and categories, and software variable name. As each variable for each case should have a code even if a person does not answer a question, it is necessary to allocate a distinctive code to the missing data. The number ‘9’ was allocated as the code for missing data for all the variables except ‘experience’ and ‘type of industry’. For these variables, the code ‘99’ was allocated.

3.5.6.4 Data entry

Using SPSS for Windows 6.1 software, variables were created and defined on a database. The coding system was incorporated into the database with definitions of labels and category codes, including the codes for missing data. Each of the columns in the data file represented the variable; each row represents a case or respondent. The response of a respondent to each variable was entered in the respective column.

The last question in the questionnaire sought qualitative comments from the respondents about the transition of engineers into management, and a separate alphanumeric column was created in order to record their comments. In addition to answering this question, respondents were also given the opportunity to indicate their willingness to be interviewed in future, and could supply their name and telephone number. This information was also recorded in the database in separate columns.
Thus there were 14 independent variables and 87 dependent variables, and four columns that needed qualitative information such as comments, telephone number and name. In addition, the first column was reserved for indicating the record number: before entering the data, a record number was noted on the questionnaire itself for future reference. After that, appropriate codes were posted to each of the cells corresponding to the response given by a particular respondent. Thus, all the 756 responses were entered into the computer system and saved onto a database. The database file was also saved on floppy disks as backup and stored at a separate location. (The database was saved and stored in two separate places in order to ensure security of data and as a precaution against any untoward accidents).

The data entered in the computer system had been checked for error in data entry. By carrying out valid range checks, filter checks and logical checks, as suggested by de Vaus (1995), any errors in data entry were discovered and corrected. Further verification of the data and coding was carried out in the analysis phase.

3.5.6.5 Sample size

The size of the sample depends upon the degree of accuracy that is desired, cost and the time available. This accuracy is, in turn, dependent upon the extent to which there is variation in the population in regard to some of the key characteristics of the study, and the sufficiency of numbers for a meaningful subgroup analysis (de Vaus 1994).

As the objective of this study was to analyse various subgroups of engineers separately, it was necessary to have a sufficiently large sample to start with, so that when it was broken down into subgroups, there would be sufficient numbers in each subgroup. In this study, engineers were categorised into subgroups according to their engineering discipline, job nature, sex, age group, country of qualifications, management qualifications, industry group and experience.
It has been suggested that, at 95 per cent confidence level, 756 responses were sufficient to ensure a sampling error of less than 3.5 per cent (de Vaus 1995). Also, as engineers are generally considered to be homogeneous when compared with surveys conducted on the general public, the sample size required for a given sampling error is even less. Also, researchers suggest that a subgroup should have a minimum of 50 cases if meaningful conclusions are to be drawn (de Vaus 1995: 73; Hoinville et al. 1977: 61).

Except in the subgroup of female engineers, who only numbered 16 out of the total of 756 responses, all the other subgroups used in this analysis had more than 50 cases. However, when the analysis called for a grouping of engineers within a particular subgroup, the subgroup size was less than 50. For example, the subgroup of engineers who were employed in the consultancy sector who had a predominantly managerial job comprised 38. Similarly, the number of respondents who had an MBA qualification and whose job was predominantly technical was 32. In these cases, where the subgroup size was less than 50 cases, a five per cent significance level was considered the minimum acceptable level to reject the hypothesis, taking into account the type I and type II errors in analysis. Thus the sample sizes used in this study can be safely considered to be adequate for analysis and interpretation of the results.

3.5.7 Data analysis

3.5.7.1 Exploratory data analysis

Based on the position advocated by Cooper and Emery (1995), that the approach to data analysis in research must be problem-oriented rather than tool-driven, an exploratory data analysis was necessary to determine the appropriate choice of method and statistical tool. As suggested by Turkey (1977), exploratory data analysis is the first step in the search for evidence without which confirmatory analysis has nothing to evaluate. It involves careful examination of the data for mistakes, to identify and
eliminate errors in data entry with the help of SPSS software. In addition, the distribution of values for various groups can be examined with the help of descriptive statistics and tests for normality and homogeneity of variance can be carried out. This analysis was necessary to evaluate the appropriateness of the statistical techniques for hypothesis testing.

Histograms and stem-and-leaf diagrams provide useful information about the distribution of observed values. Data for all the variables have been analysed with the help of histograms to see the variability of data and the central tendency. The descriptive statistics chosen for univariate analysis depend upon the level of measurement (de Vaus 1995). For example, mode is an appropriate measure of central tendency for nominal variables such as branch of engineering and job nature, while median and mean were suggested as being useful for ordinal variables. Similarly, the standard variation and range were suggested as appropriate measures of dispersion for ordinal variables and interval variables. Accordingly, data have been explored and the mean, median and standard deviations were computed and histograms drawn for each of the variables in the data using SPSS software.

The next step in the exploratory analysis was the test for normality of the data and the homogeneity of the variance, as this was necessary to determine the appropriateness of certain statistical techniques in analysis. Since normal distribution is important for statistical inference, the assumption that the data comes from a normal distribution must be tested. As the population means and the variances of the data variables were not known, Lillefors test was used for testing the normality of the data (Norusiss 1993). If the observed significance level is small, say less than 0.01, the hypothesis of normality can be rejected at 1 per cent significance level. For testing the homogeneity of variance, Levene tests have been carried out on the data.

A test of normality for all the variables revealed that most do not follow a normal distribution. Details of the significance levels are indicated in the appendices.
However, it should be noted that when the sample size is large, any goodness-of-fit test will result in rejection of null hypothesis that the data follow normal distribution (Norusis 1993). Norusis (1993) argued that "it is almost impossible to find data that are exactly normally distributed" and one should observe the actual departure from normality in addition to the significance level to determine whether data were approximately normally distributed. Based on the observation of the normal plots, it was concluded that the data can be approximated to the normal distribution.

To evaluate the assumption that all groups come from populations of equal variances, several tests are available, most of them heavily dependent on the assumption of normality. However, the Levene test of homogeneity of variance, which is less dependent upon the assumption of normality than most others, was used in this study. Accordingly, analysis through the 'explore' procedure in SPSS was carried out to test the null hypothesis that all group variances were equal. The majority of the variables rejected this hypothesis.

3.5.7.2 Cross-tabulation

Next phase of analysis is to explore whether two variables are related or associated. Two variables are said to be associated when the distribution of values on one variable differs for different values of the other variable (de Vaus 1995). Cross-tabulations are a way of displaying data to detect an association between two variables. By generally placing independent variable across the table in columns and the dependent variable in rows, and examining the row and column percentages, the relationship can be studied. However, it is necessary to measure the extent of the relationship and to carry out statistical tests of hypothesis that there is no association (Norusis 1993).

In analysing the nominal variables, Chi-square test of independence with Pearson chi-square statistic is suggested as an appropriate statistical tool in cross-tabulations (Norusis 1993; de Vaus 1995; Bryman & Cramer 1994). Using the SPSS cross-
tabulation procedure, relationships between two sets of variables were analysed to test the hypothesis that the row and column variables were independent. Considering the possibility of type I and type II errors, a significance level of 0.01 for large samples and 0.05 for smaller samples was set. If the significance level is less than 0.01 for large samples, the null hypothesis that there is no relationship between the column variable and row variable is rejected. Similarly, if the significance level is less than 0.05 for small samples, the null hypothesis is rejected. In this case, a small sample is considered to be less than 50 respondents in any subgroup. As mentioned previously, only female engineers comprised such a subgroup.

Analysis of the following relationship can be carried out: between age groups and job nature; age group and branch of engineering; the nature of the job and management qualifications, job nature and type of employing industry; branch of engineering and type of employing industry; and job nature and the number of employees supervised.

3.5.7.3 Factor analysis

The literature review revealed that several factors influence the transition of engineers into management roles. Though some of them were identified broadly and stated, there were many subfactors that were not directly observable. Identification of these underlying subfactors from the variables expressed as several statements or propositions greatly simplifies the description and understanding of the transition phenomenon. Factor analysis is "a statistical technique used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables" (Norusis 1993).

Factor analysis helps the researcher to assess the factorial validity of the questions in the questionnaire, indicating the extent to which they seem to be measuring the same concepts or variables (Cattell 1966; Norusis 1993). It has been used in the past to explain complex phenomenon by reducing them to a more manageable number of
factors. A good example of this is the factor analytic approach used to describe 'personality' by psychologists such as Eysenck and Eysenck (1969), and to measure quality by Saraph et al. (1989) and Zeithaml et al. (1990) and others.

In addition to facilitating better explanation of the phenomenon, factor analysis also increases the operational convenience (Cattell 1966; de Vaus 1995) in analysing the differences between various subgroups of engineers. For example, if each question is considered a variable and the responses between two subgroups were to be analysed, the number of separate analyses to be conducted would be large, especially in this study, with 85 questions. Moreover, as indicated by Bryman and Cramer (1994), the more statistical tests were carried out, the more likely that some of them, by chance, would be found significant.

Therefore, factor analysis was considered appropriate to reduce the variables to a limited number of factors for each dimension influencing the transition: general attitude, engineering education, status, organizational support and managing strategies. However, it is important to keep in mind that regardless of the variables used, factor analysis produces a set of 'underlying' factors, whether they make sense or not. Therefore, while identifying those factors, sufficient care has been taken in the interpretation of the meanings and grouping of variables and, wherever necessary, judgement and knowledge of the literature have been applied in defining and forming factors.

Factor analysis was carried out in two separate stages for each of the six groups of variables identified under the headings: general attitude (34 variables); engineering education (16 variables); organizational support (eight variables); status (seven variables); and managing strategies (22 variables). The first stage involved evaluation of the appropriateness of the factor model, while the second stage involved factor extraction using principal components analysis and factor rotation and the identification of variables falling under different factors.
In the first stage, appropriateness of the factor model was evaluated with reference to the data, based on an examination of the correlations and other statistical tests. If the correlation coefficients between various variables are small, it is unlikely that they share common factors. It was assumed that if 50 per cent of all the correlation coefficients were equal or more than 0.3, then it was appropriate to continue with the factor analysis. A statistical test termed Kaiser-Meyer-Olkin (KMO) measure is used for testing the sampling adequacy. If the KMO measure is high (more than 0.6), the correlations, on the whole, are considered to be sufficiently high to make factor analysis suitable (de Vaus 1995).

For example, Kaiser (1974) characterises KMO measures in the 0.90 range as ‘marvellous’, in the 0.80s as ‘meritorious’, in the 0.70s as ‘middling’, in the 0.60s as ‘mediocre’, in the 0.50s as ‘miserable’, and below 0.5 as ‘unacceptable’. In this research study, a minimum KMO value of 0.65 was considered safe to proceed with the factor analysis. As indicated in the analysis, all the models fit the data with a KMO value higher than 0.65. Similarly, the Bartlett’s test of sphericity is another measure to test the hypothesis that the correlation matrix is an identity. If the observed significance level is very low (less than 0.01) and the value of the test statistics for sphericity is large, then it is appropriate to consider usage of factor model to the data (Norusis 1993).

In the second stage, the number of factors necessary to represent the data and the method for calculating them was determined. Using the principal components analysis method, factors were extracted from the variables. Examining the percentage of total variance explained by each factor, eigen value, communality, logical groupings of the variables, and scree plot, a number of appropriate factors for each dimension was identified. Thus, the number factors that were needed for a final solution were identified in the initial extraction stage.
Once the number of factors were known, the next step was to categorise variables into different factors. In order to increase the interpretability of factors, they were rotated using the varimax rotation method to maximise the loadings of some of the items. For the purpose of identifying the grouping of variables into each factor, conventionally, variables which have a loading value of less than 0.3 have been omitted from consideration (Bryman & Cramer 1994; de Vaus 1995). An alternative criterion is to allocate the variable to the factor where it has the highest loading value (Norusis 1993). As argued by Cooper and Emory (1994), interpretation of factor loadings and the grouping of variables under factors is largely subjective.

After identifying the number of factors, the ability of the data to fit the model can be tested with the help of a reproduced correlation matrix. If the residual, the difference between the observed correlation coefficient and the estimated coefficient from the model, is large, the factor analytic model does not fit the data well (Norusis 1993). Therefore, a reproduced correlation matrix was produced after identifying the factors to see whether the residuals were large. If the data fits the model well, at least 50 per cent of the residuals must have an absolute value greater than 0.05 (Norusis 1993). Examination of the residuals for all the six factor analytic models revealed that about 70 per cent have a value greater than 0.05. In order to test the internal consistency of the factors thus developed from analysis, Cronbach alpha values were computed for each of the factors. Alpha values range from 0.61 to 0.94. Thus the factor analytic models developed for all the dimensions seem to be fitting well to the data generated in the survey.

Therefore, in this analysis, the grouping of variables under a particular factor was finally determined based on a loading value of more than 0.30, interpretability, and the natural affinity of a variable with a group. Presented in a later chapter are the details of the factor analysis for each dimension, highlighting the number of factors identified; the variables falling under each factor; Bartlett’s test of sphericity; the KMO measure of sampling adequacy; the cumulative percentage of variance attributable to the
number of factors identified; and the percentage of residuals greater than 0.05 in absolute value in a reproduced correlation matrix.

Based on the information provided in the factor analysis, scales were constructed for each of the factors. The individual raw scores on each of the selected variables were added to obtain the scale score for each factor. Although it is convenient to compare the differences in mean scores between various groups of engineers, and to test the significance of those differences, by forming scale some of the individual information is lost. For example, even though two respondents have the same scale scores, it does not mean that they have answered particular questions identically. Though the score of two respondents may be similar in their overall attitude to one factor, they may differ markedly on particular questions.

Therefore, the benefits of factor analysis in reducing the number of variables into a limited number of underlying factors must be weighed against the loss of detailed information supplied for particular questions. Keeping these limitations in mind, this study used the summated scales to test the differences between different groups of engineers, while using the information from individual questions for analysis and general interpretation.

3.5.7.4 Discriminant analysis

In order to identify variables that were important to distinguish among the groups of engineers, a statistical technique termed ‘discriminant analysis’ was used in this study. Discriminant analysis was generally used as an exploratory tool (Norusis 1993), with the objective of identifying the ‘good’ predictor variables that distinguished different groups of engineers. This was used as a basis on which further statistical analyses could be carried out to see whether the response of those groups of engineers on various issues were significantly different or not.
For the linear discriminant function to be ‘optimal’, each group must be a sample from a multivariate normal population and the population covariance matrices must all be equal (Norusis 1993). As discussed in section 6.7.1, since the sample sizes were fairly large, the majority of the variables approximated normal distribution and therefore were used for this analysis. Moreover, as pointed out by Norusis (1993), when sample sizes in the groups are large, the null hypothesis that the covariance matrices are equal will be rejected even if the group covariance matrices are similar.

Descriptive statistics and univariate analysis can test the significance of the differences between different groups of engineers on certain variables. However, in discriminant analysis, variables are analysed together, not one at a time like in univariate analysis. Discriminant analysis can therefore consider several variables simultaneously and incorporate important information about their relationships (Norusis 1993).

Thus discriminant analysis provides critical information about the predictor value of certain variables such as management qualifications, branch of engineering, job nature, age, employing industry and gender. Discriminant analysis of these variables was carried out with two to five subgroups to see whether there were any differences between those subgroups when all the independent variables were considered simultaneously.

The percentage of cases classified correctly, Wilks Lambda, and eigen values were important indicators of the effectiveness of the discriminant function. If the number of cases classified correctly is high, the grouping variable has high predictor value. Similarly, Wilks lambda is another measure on which the test of null hypothesis, that there is no difference between group means, depends. In this analysis, small values of Wilks lambda were associated with functions that have wide variability between groups and little variability within groups, with lambda reaching the value of 1 when there is no between-groups variability (Norusis 1993). Similarly, large eigen values were associated with ‘good’ discriminant functions.
To test the significance of the discriminant functions at a one per cent significance level, analyses were carried out for several categorical variables, such as branch of engineering, job nature, employing industry, age, management qualifications and gender. If the observed significance levels were less than 0.01, the percentage of cases classified correctly were more than 70 per cent, the Wilks lambda less than 0.30 and with larger eigen values for a particular categorical or grouping variable, then this was considered a good predictor of the attitudes (Norusis 1993).

If all the three conditions were satisfied, we can say that it is unlikely that the engineers belonging to each of the categorical variables such as branch of engineering, job nature, employing industry, age groups, management qualifications and gender have the same means on the discriminant function. Further analysis using t-tests were carried out on specific factors in each dimension in order to see the differences between these subgroups of engineers.

3.5.7.5 Testing hypotheses about differences in means using the t-test

Several statistical tests were available to determine whether differences between two or more groups of engineers on certain aspects of transition were significant. The nature of the data and the level of measurement are important considerations in determining the appropriate statistical test. Generally, parametric tests are considered appropriate when the measurement is interval or ratio and when certain assumptions about the underlying distributions of the data are true (Cooper & Emory 1995). For example, the distribution of the data should be normal and the variances should be equal for parametric tests to be carried out. On the other hand, non-parametric tests involve much weaker assumptions about measurement scales such as ordinal and nominal, and the assumptions about the populations are less restrictive (Bryman & Cramer 1994).
Researchers in the social sciences differ over the use of parametric tests with ordinal measures. One argument is that the use of parametric tests is incorrect on both theoretical and practical grounds. As stated by Siegel and Castellan (1988), "if the measurement is weaker than that of an interval scale, by using parametric methods tests the researcher would 'add information' and thereby create distortions...".

At the other extreme, other researchers argue that parametric tests are usually acceptable for ordinal scales. It is argued that "the difference between parametric and rank order tests were not great in so far as significance level and power were concerned" (Anderson 1967). A view between these two extremes argues that, although there are risks in using parametric procedures on ordinal data, they are usually not great. For example, Kerlinger (1986) argues that "the best procedure would seem to be to treat ordinal measurements as though they were interval measurements but to be constantly alert to the possibility of gross inequality of intervals" (Kerlinger 1986: 396).

In fact, many attitude scales were presumed to be interval. The literature suggests that parametric tests can be used with ordinal variables if the sample size is large, samples are not of different sizes and the variances are equal (Boneau 1960; Games & Lucas 1966; Bryman & Cramer 1994). In several research studies that involve ordinal variables, parametric tests have been routinely applied and the t-test is found to be particularly robust when the sample sizes are sufficiently large (Bryman & Cramer 1994).

For parametric tests to be applied, the data must satisfy the following three conditions: scale of measurement must be of equal interval or ratio scaling; the distribution of the population scores must be normal; and the variances of both variables are equal or homogeneous. An attempt was made to verify whether the data met those conditions. Using the Lillifors test of normality, it was tested for normalcy using the explore procedure in SPSS and it was found that the data does not follow normal distribution.
for many of the variables. However, Levene's test of variance indicated that the significance level is large, and the variances of both the variables were equal in the majority of the tests.

However, because of its robustness, versatility and its general acceptance in the literature, parametric tests (for example, t-tests) are increasingly used with ordinal data, particularly when the data characteristics approach interval scale characteristics (Cooper & Emory 1995: 146). In this analysis, as the sample size was fairly large (a minimum of 150 respondents in each group), and the data characteristics were similar to interval scale, t-tests at five per cent significance levels were considered appropriate.

Two tailed two-independent sample t-tests were used to analyse the differences in attitude of various subgroups by testing the hypothesis that the means of those subgroups are same. The null hypotheses in these tests were that there is no difference in the mean score on various factors between two subgroups of engineers in the study. For example, if the difference in attitude towards engineering education between civil and electrical engineers is the factor that is compared, the steps and testing procedure are as follows.

\[ H_0 = \text{There is no difference in attitude between civil and electrical engineers towards engineering education.} \]
\[ H_{A} = \text{There is a difference in attitude between civil and electrical engineers towards engineering education.} \]

Significance level \(= \alpha = 0.05\) (two-tailed test).
Decision = If the calculated t-statistic is larger than the critical test value from the tables, then reject the null hypothesis and conclude that there is no difference between those two categorical variables--civil and electrical engineers--on their attitude towards engineering education.

Using SPSS procedure for parametric testing, these tests can be carried out to test for statistically significant differences on the attitude towards various dimensions, between different groups of engineers classified by the job nature, branch of engineering, management qualifications, age, gender and employing industry. In testing these hypotheses, it is argued that null hypothesis can never be proved and therefore cannot be accepted (Cooper & Emory 1995). Though the terminology of ‘accepting the null hypothesis’ has been used at times, it actually means that the test has actually ‘failed to reject the null hypothesis’.

3.5.8 Validity of conclusions

While considering the probability of drawing wrong conclusions, it is possible that null hypothesis can be accepted when it should have been rejected, and null hypothesis can be rejected when it should have been accepted, with the former termed a Type I error and the second a Type II error. Hypothesis-testing traditionally places greater emphasis on Type I errors than Type II errors (Cooper & Emory 1995).

The methods adopted in this research took considerable care to ensure that no errors were made. By setting up a high significance level of $\alpha = 0.01$, the probability of Type I error has been brought down to only one per cent, while drawing conclusions. In fact, the literature argues that, with large samples, the probability of committing Type I error is high, and so it is advisable to use the 0.01 level as the critical point (de Vaus 1995). Though this might increase the possibility of Type II errors, this is likely only with small samples (Bryman & Cramer 1994; de Vaus 1995).
The study has a large sample size of 756 respondents, with even subgroups used in the analysis not numbering less than 150, so the probability of a Type II error was significantly low. And, with a large sample size and $\alpha = 0.01$, the probability of committing both Type I and Type II errors was very low. Furthermore, the chances of error were minimised by the efficient random selection of the sample and the systematic analysis of data.

3.6 Conclusions and summary of research methodology

The methodology adopted was comprehensive and rigorous both in selection of the methods, application of statistical tools, and validation of the results. Triangulation was employed using multiple data sources in the case study analysis. Moreover, case study findings are only used as propositions, and not used for generalisation. While collecting data from the case study, the guiding propositions were modified taking into account the negative cases. Although the literature and personal bias influenced the guiding propositions to some extent at the initial stages of the case study data collection and analysis, the researcher realized this at a later stage and made the necessary modifications. Quotations from the case study respondents have been used to validate and support the findings and to develop propositions for testing.

The survey research was planned and implemented with systematic rigour. The questionnaire was designed, based on the propositions developed from the case study analysis and the literature review, and taking into consideration the principles of questionnaire design. Pilot-testing the questionnaire helped to eliminate confusing questions, clarify concepts and meanings, and enhance the response. By selecting the sample for study and administering the survey carefully, a response rate of 30 per cent was achieved.
Data was prepared for data analysis using appropriate data entry and coding systems. In order to explain the phenomenon better, appropriate statistical tests were carried out to explore the data, reduce the number of variables to a limited number of factors, identify powerful predictors of attitude, and to investigate the differences between different subgroups of engineers. The methodology and methods adopted in this research have a theoretical rigour and take a practical approach in answering the research questions. The next chapter presents the analysis and findings of the case study.
CHAPTER 4

CASE STUDY: ANALYSIS AND FINDINGS
CASE STUDY: ANALYSIS AND FINDINGS

4.1 Introduction

This chapter deals with the analysis of the case study data and findings. It discusses various issues of transition and presents the findings with the description taken from the data to illustrate and substantiate the assertions made. The time and length of study, the nature of the subjects and their selection, changes in the directions of the study, checks on data, attempts to gain reliability and validity, description and analysis related to the propositions are discussed in this chapter. The individual quotations (with the author’s interpretations appropriately added), analysis and findings are presented under several themes and issues relevant to the study. The chapter is presented in a narrative form that integrates the particular with the general and focuses on developing propositions to be tested using a nationwide questionnaire survey.

4.2 Case study organization

In view of the access, time and resources made available to the author, Queensland Transport, an engineering-based state government organization in Australia, was chosen for conducting exploratory interviews with engineers and engineer–managers about the transition and changes in the role of engineers. Experienced specialist engineers and district managers were the main units of analysis. Detailed information on the case study organization, change initiatives, the role of engineers, respondents for the study and the issues for investigation is given in appendix IV.

4.3 Analysis: approach and demographics

4.3.1 Approach

Data collected from the case study organization through personal interview and documentation was analysed with reference to a broad descriptive framework based
on a literature review and preliminary discussions with experts and senior engineers. The dimensions emerging from the literature review were used as a conceptual basis for categorisation and analysis of data.

The observations and findings from the evidence collected from the interviews are discussed. Wherever possible, evaluations of the individual responses on several themes/dimensions were summarised and presented to support the arguments. The findings were expected to provide a basis for further empirical testing and anecdotal evidence. The outcome of the case study analysis was a series of propositions to be tested through a questionnaire survey across the general engineering population in Australia.

4.3.2 Demographic details of respondents

Before discussing the findings of this study, the demographic details of the respondents in this study are explained. As mentioned in the methodology section, 10 senior engineers, 12 engineer-managers and 10 others were each interviewed for two to three hours. The following table gives a summary of the demographic details of the respondents.

**Table 4.1: Demographic details of respondents**

<table>
<thead>
<tr>
<th>Characteristics of respondents</th>
<th>Engineers</th>
<th>Engineer-managers</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>10</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Average age</td>
<td>46 years</td>
<td>47 years</td>
<td>50 years</td>
</tr>
<tr>
<td>Average technical/design experience</td>
<td>15 years</td>
<td>5 years</td>
<td>n.a.</td>
</tr>
<tr>
<td>Average supervisory experience</td>
<td>7 years</td>
<td>24 years</td>
<td>n.a.</td>
</tr>
<tr>
<td>With postgrad. mgmt qualifications</td>
<td>10%</td>
<td>30%</td>
<td>60%</td>
</tr>
<tr>
<td>With postgrad. engg. qualifications</td>
<td>70%</td>
<td>15%</td>
<td>n.a.</td>
</tr>
<tr>
<td>With outside experience (other than in case study organization)</td>
<td>10%</td>
<td>20%</td>
<td>40%</td>
</tr>
</tbody>
</table>
The average respondent in the managerial engineer category had experience in supervision of design and construction activities in the district offices and had grown within the department to reach this position. The average respondent in the technical engineer category had about seven years’ work supervision experience and 15 years of technical/design experience. The third category comprised senior administrators who were given the responsibility of overseeing the strategy development and implementation of the ‘road reform’ and ‘commercialisation’ initiatives. The group comprised four engineer–managers, one specialist engineer, two from the area of finance, two from human resources/industrial relations, one from general administration, and one change management expert.

4.3.3 Data analysis and results

As explained in the methodology section, an attempt had been made to evaluate the responses of engineer–managers and technical engineers (engineering specialists) on certain themes or propositions. These responses are classified into three groups: agree, disagree and neutral/undecided, with definitions as given below.

Agree = Categorised as ‘agree’ when respondents have given a specific positive endorsement to the issue.

Disagree = Categorised as ‘disagree’ when respondents have given a specific negative endorsement to the issue.

Neutral = Categorised as ‘neutral’ when respondents either did not give any opinion or did not commit either way, or did not want to make a statement on that issue.

During this process, typical examples of the response on a particular theme were counted to establish their frequency and presented in the form of data bits. As they represent data bits, and not the number of cases, the total number of data bits for each statement are not the same and do not match the number of respondents. In order to
minimise the dominating effect of a single respondent on the overall results, the number of databits taken from each case are linked to the strength of that data. In this process, data that is stronger or more powerful or influencing characterised by the articulation and level in the hierarchy, was given more weight than the others. As pointed out by Miles and Huberman (1984), strength of data is dependent upon the nature of the informants, the circumstances of the data collection, and the researchers’ validation efforts.

According to Miles and Huberman (1984), data from some informants has more strength or power than others as they are more knowledgeable, articulate and reflective, and enjoy talking about events and processes. Similarly, if the data is collected in an environment where the researcher is trusted, where the respondent is alone with the researcher, where the research is collected in an official or formal setting, and the respondents volunteered to talk to the researchers, then it is stronger. Appropriate validation efforts such as checking for researcher effects and biases, getting feedback from informants, triangulation of data and use of multiple sources of data can make the data quality stronger. These frequencies of data bits supporting a particular theme are expected to provide empirical evidence for the conclusions drawn from this case study research.

4.4 Findings and observations

Details of the analysis, findings and their implications are discussed next under various themes/dimensions.

4.4.1 Change imperatives and orientation

The study indicates that the move from ‘specialist’ to ‘generalist’ consequent to the commercialisation of their operations was viewed by engineers as an inevitable aspect of contemporary organizations. As pointed out by one respondent, “The outside imperatives such as Hilmer reforms and the legislation related to the
National Competition Policy are pushing these changes, and whether we like it or not, we had to change” (Respondent 1208).

Recognising the need to develop a national competition policy, a committee of inquiry headed by Mr Fred Hilmer was established in Australia in 1992 by the federal government in cooperation with nine state governments. Its main aim was to develop a national competition policy to promote and maintain the competitive edge and to increase efficiency and community welfare, and it addressed the combination of laws, principles and processes governing the conduct of firms in both the public and the private sector. It proposed specific policies and mechanisms on the reform of regulatory restrictions on competition, the structural reform of public sector monopolies, and competitive neutrality between government and private businesses. Queensland Transport, the case study organization here, is a state public sector organization. It is now being opened up to outside competition and ‘commercialised’ in delivering roads construction and maintenance services in the state, on which it previously had the monopoly.

When it assessed their reaction to this inevitable move, the study found that specialist engineers disliked the move away from technical issues in their new roles. It appeared that technically oriented engineers viewed the business side as secondary to technical matters, although they were aware of its importance. In fact, many of these specialist engineers attached very little value to the business side of their role. The aspect they disliked most was the move into intangible issues in management. One respondent stated that, “Moving away from technical areas in which I derived a great sense of satisfaction of seeing various projects come to fruition, into an area where there is no tangibility is the worst thing.” (Respondent 1204). Many technically oriented engineers felt no sense of satisfaction and achievement in business and management issues. In technical areas, they derived a great sense of satisfaction by seeing the project come to fruition.

Analysis revealed that the conflict between the technical issues and the political issues, and the innate inability of technically oriented engineers to grapple with
abstract issues and their tendency to look for logical steps, are the major causes of this dissatisfaction with a business-oriented work environment. In addition, the administrative work such as maintaining accounts, billing, and communications with customers are not considered to be interesting and challenging enough to derive any satisfaction. As pointed out by one respondent, "Engineers are satisfied by just doing the technical work; they don't particularly care whether that job is billed or not, accounted or not. It is a mindset people have and it will take some time for this 'commercial/business' culture to soak into their minds." (Respondent 1205).

Given a choice, technically oriented engineers prefer to remain as technical specialists rather than accept additional functions such as marketing, customer relations and human resources management. These engineers feel that by doing non-technical tasks, their technical competence is undervalued and underutilised. In fact, one respondent argued that "I am a specialist in...area at the top of the range in my profession. I think it is a dreadful waste of my time and skills, if I have to spend 80 per cent of my time on non-technical functions. I feel a total waste of...years of experience." (Respondent 1201).

It needs to be recognised that there has been a huge shift from the traditional outlook of their work, which was mostly demand-driven, to the contemporary organizational need for customer focus in an era of open competition, and that the shift from a "...highly inward-looking hierarchical power type of management culture, into an open empowered type of organization" can be extremely difficult (Respondent 1208). In fact, in the past, there was no need for engineers to understand and carry out any of those non-engineering functions, as they were performed in different divisions.

However, on the positive side, the study revealed that new work roles helped engineers in developing a much broader view of the organization and opened up new leadership opportunities within and/or outside the organization. On their new work roles, the majority of the respondents indicated that their ability to influence broader issues and a sense of achievement in their jobs are the best parts of their new role, compared with the previous one.
On the other hand, most of the management-oriented engineers, as might be expected, view management as an integral part of engineering work and their move into management as being a natural career progression. In modern organizations, it is clearly evident that no engineers, except those in design and research and development, are responsible for the management of resources right from the early stages of their career.

As pointed out by one respondent, "If you are a good construction engineer, you must be a good manager, because, you cannot plan, organise and control the projects in terms of time and cost, without having the necessary management skills." (Respondent 1107). Thus it appears that management in engineering organizations is considered a part of the engineer’s work and that, by becoming managers or ‘generalists’, engineers do not lose their engineering identity.

Engineering is a much broader profession than just mathematics and physics. As pointed out by one respondent, “Far too much has been said about the engineering aspects, relatively downplaying the management part, to the detriment of the engineering profession. But to say that is just that and nothing else, is not true. Because even when you are doing a very high percentage of the scientific aspects of engineering, you won’t be successful if you don’t marry that with sensible management.” (Respondent 1206). Similarly, in the words of another respondent, “Engineering is about managing human and other resources...and is a natural progression from the management of an individual project to the management of the organization itself.” (Respondent 1105).

Most respondents opined that a significant number of engineers working in their organization at lower levels would aspire to become managers and would expect that as a natural career progression. However, there may be a few with a predominantly technical orientation who would like to remain and progress in a specialist technical field. Engineers working in the field on construction supervision are more likely to aspire to management positions than those working in design and related technical
fields, the study noted. With the move towards commercialisation in technical divisions, there is the possibility that engineers with a management and business orientation can move into management positions even in technical specialised areas, such as the Transport Technology Division, the study observed.

4.4.2 Challenges and problems in transition

Uncertainty about the future, an inability to logically sort issues for analysis, dealing with and implementing abstract ideological statements rather than making logical steps towards transition, and operating in a matrix-type of organizational structure without any hierarchical authority level are identified as the hardest part of transition, especially for the technically oriented engineer. For example, one respondent felt that, “The hardest thing is that we have to influence people to do things, influence change and influence outcomes without really having any clear line authority.” (Respondent 1203). Another respondent opined that, “The hardest part of this is communicating with individuals for sharing of knowledge and information with all the levels without any line authority.” (Respondent 1210). Thus communicating with the other professional engineers within the department and convincing them about the move towards ‘commercialisation’, the need for such change and its imperatives are challenging for these senior engineers.

It can be argued that engineers are only interested in doing engineering work. The hardest part of the transition is to get engineers to do business-related, non-technical work along with their routine technical work. It might be hard because of “The mindset engineers have developed over a period of time, and it may take some time for the new culture to soak in and for people to realize the importance of such non-technical tasks in the overall functioning.” (Respondent 1205). This is observed to be a particular problem among junior engineers working in various teams in the Transport Technology Division, who may be considered to be mainly technically oriented.
Lack of multiskilling of engineers and their tendency to work in structural compartments within their own expertise is a problem in their making the transition. This is more to do with past practices than with the engineers themselves. Although, it is de-emphasised by introducing project works and encouraging customer focus in day-to-day operations, some engineers are still struggling with those adjustments in new roles (Respondent 1205).

The most challenging aspect to deal with in these transitions is ‘people management’. As noted by one respondent, “The inability to realize that people are different and have different strengths and weaknesses is the main problem I have to come to terms with.” (Respondent 1102). Lack of ‘soft’ skills is considered to be the main problem facing engineers; many respondents indicated that engineers generally do not have these skills. In the words of one respondent, “Being on unfamiliar territory, not having the necessary knowledge base and skills such as business management skills, people skills, and communication skills are the major stresses associated with transition.” (Respondent 1106).

Generally, engineers who worked in construction supervision have better management orientation and experience than specialist engineers, and their responses differ in that respect. For engineers with supervisory experience, the transition into management roles was just an addition of responsibilities in terms of the size of the project and the number of people, whereas for other specialist engineers, it was a significant change wherein certain non-technical functions were added for the first time.

Engineer-turned managers derived satisfaction in being able to make a difference by being a manager rather than an engineer. One reason cited for making the transition was that it gave them the ability to influence organizational outcomes. Importantly, the diverse nature of managerial work became an attractive factor. Most of the respondents indicated that the best part of their managerial work was developing strategies to get things done, and working with other people in achieving targets.
Thus these engineer–managers expressed their aptitude towards those managerial aspects of their job that involved dealing with people and making decisions.

Most of the engineers from all the categories (district managers, specialist engineers in the Transport Technology Division and the change management team members) said that moving away from technical work, where they had spent a lot of their working lives, was the hardest part of transition. As pointed out by one respondent, “The hardest part is walking away from technical work, from doing what I used to do previously, and entrusting it to somebody else, my subordinates.” (Respondent 1106).

A significant number said that they had the tendency to keep going back and checking the technical work carried out by their subordinates. This generally confirms the difficulties engineers allegedly have in delegating technical tasks to their subordinates when they become managers.

However, some indicated that the hardest part of transition was not lack of knowledge, but putting it into practice. As noted by a respondent, “We have tendency to get carried away with day-to-day activities and not stand back and do longer term things that we should do as managers.” (Respondent 1105). The apparent abstractness and people-management component of managerial work with the emphasis on ‘getting things done through others’, when compared with technical jobs that are individual-dependent, are the hardest parts to cope with.

The study revealed that learning to manage and interact well with people is the most challenging and difficult part of transition. In addition, engineers and engineer–managers believed that moving from familiar to unfamiliar conditions, the ability to handle uncertain and ambiguous situations, and the ever-broadening of the role as a result of the change process are the most demanding aspects.

The literature argues that technical knowledge is important for successful managerial performance in engineering-based organizations. Similarly, technical specialists cannot operate in a vacuum without considering the business aspects. One respondent noted that “There is still a lot of other aspects in the management side, where to
make the best decisions, you need to have that technical input.” (Respondent 1206). It is a matter of getting a sensible balance in one’s work. As pointed out by one respondent, in business units which are delivering technical services, it is important for the unit manager to be an engineer who can understand the language and requirements of the customer.

On their reasons for moving into management, most engineers in all the categories interviewed indicated that it is a natural career progression. However, there were some who indicated higher status and higher pay as the motivating factors. They stated that the status and prestige associated with managerial positions are much higher than that for specialist technical positions. One asserted, “I would like to go back to technical areas but, as they are not well paid, I am here in this position.” (Respondent 1109). Also, the ability to influence decisions and the impact they have on the development of local area/region, and the sense of achievement that goes with managerial roles are attractions for making the transition. One engineer–manager noted that “It opens up new leadership opportunities and now I have better chances of progressing within or outside the organization.” (Respondent 1101). In summary, it can be stated that engineers are more likely to be pulled by the attractions of management rather than pushed by dissatisfaction with their engineering roles.

On the suitability of engineers for managers’ roles, some respondents believed that an engineering background as such is not necessary to carry out a managerial role in the department, although the actual experience gained as an engineer is a big advantage. “In many circumstances, you don’t need to be a proper engineer or qualified transport analyst to be able to manage those functions”, noted a respondent (Respondent 1105). As management is about getting things done by others, the study observed that it is important for the manager to understand and recognise the skills and expertise of subordinates and make use of them in achieving goals.

Many of the engineers interviewed indicated that there was a huge increase in their workload due to transition and the change initiatives under way within the organizations. However, some of them opined that the problem is not the increase in the workload, but the inability of the engineer to delegate work (Respondents 1105
and 1401). A similar opinion was expressed by engineers and non-engineers in the change management team.

An overwhelming majority of engineers believed that communication and people skills are by far the key issues in management roles. The study clearly identified that engineers find communication and interpersonal skills the most important for successful performance in their new roles; they are also their main weaknesses.

4.4.3 Nature of engineers as a professional group

The beliefs and shared values of engineers as a professional group are considered a problem in making transitions. Though their analytical and problem-solving skills are viewed as useful in managerial roles, their generally poor interpersonal and communication skills are cited as the main factors that make them ineffective managers. It is observed in the study that there is a general perception among non-engineers, top management and the engineers themselves that they are not good in carrying out the non-technical aspects of work that require ‘soft’ skills. However, there are a few exceptions; a considerable number of engineer–managers expressed the view that this does not universally apply to all engineers.

It is argued by the respondents that engineers’ tendency to be very realistic and, away from political situations, their bluntness about what they see as problems, is often interpreted by non-engineers as being conservative, and criticised accordingly. As a result, engineers contend that their valuable inputs as a professional group tend to be ignored in organizational decision-making. Though this perception is changing in the case study organization due to the active role taken by some engineers in leading and implementing change processes, there is still that doubt in the minds of top management that engineers are “A bunch of stuffy old conservative people sitting in a corner who want to do nothing but be reactionary.” (Respondent 1207). Especially in the context of changes in the roles of engineers in organizations, many engineers and engineer–managers believed that it is possible to bring in engineers into the process once they are convinced of the benefits of such changes. As they are traditionally
goal-oriented, it is difficult for engineers to accept changes without being convinced of the potential benefits, the study observed.

The conflict between technical and business aspects of the work is a challenging aspect for engineers making the transition. According to one respondent, “The onerous part of the job is to resolve that conflict between what one might judge to be the best answer technically with what is essentially a political agenda.” (Respondent 1206).

Engineers like to make decisions and be in control of things. As pointed out by one engineer–manager, “Engineers would like to be in charge. But with the changes in our roles, engineers cannot keep control and they have to devolve and give it away.” (Respondent 1101). It is also difficult for engineers to accept the concept of devolving responsibility to others. “We always try to specify inputs and outputs, and try to paint things black and white and focus on inputs and outputs.” (Respondent 1402). It is difficult for engineers to shift their focus towards outcomes rather than inputs and outputs.

It is argued in the literature that engineers prefer to do things themselves rather than delegate them to subordinates. Some of the respondents indicated that it is the main problem for some engineer-turned-managers. Although they always referred to other engineer–managers, many of them agreed that it is a problem.

However, past research on engineers indicated that it is not possible to generalise and describe them as a homogenous group. It is argued that it is dependent upon the nature of the work carried out. This study also observed that there was disagreement among the respondents over generalising engineers as a group. For example, it was argued that engineers supervising construction have in mind the needs of the end-users, whereas engineers working in design, in isolation, tend to ignore the concerns of the people who are likely to use their services (Respondents 1105, 1402 and 1109). Consequently, the view was that engineers with some managerial component in their jobs are more likely to have better ‘soft’ skills than those engineers working in
specialist technical functions. Therefore, it is easier for the former type of engineer to make the transition into management than the technical one. The nature of the job thus has a significant influence on the engineer’s transition, the study found. The study points out the difficulty of characterising engineers as a single group, and indicates the need to classify them into various categories, depending upon their job nature, their discipline, and other variables which seem to have an effect on their perceptions.

4.4.4 Engineering education

The influence of engineering education on the professional formation of engineers has been well-acknowledged in the literature, especially its negative aspects. However, the positive strengths of engineering education that help in making these transitions, though limited, are not discussed much in the literature. This study, confirming importance and positive influence of engineering education on engineers and engineer–managers, revealed that an engineering education, with its emphasis on analysis and problem-solving skills, tends to help engineers become focused and goal-oriented. The study noted that engineers, influenced by their education, seem to focus on achievement of things and have a propensity to “...make things happen.” (Respondent 1303). Put succinctly by another respondent, “The strength of engineering education is its ability to develop an analytical approach to issues, and the weakness is a lack of emphasis on the softer aspects of education such as human relations and liberal arts.” (Respondent 1105).

On the negative side, it is argued that the nature of engineering education acts as a constraint in making the transition and makes it difficult for engineers to change. As observed by one engineer, “Engineering education does have a problem, in that it is very mathematical and science-based with lot of content in it.” (Respondent 1208). The study observed that their engineering education and specialist experience appear to constrain engineers to think within structural elements such as rules, codes and procedures, ignoring the softer, subjective and ambiguous issues in organizations.
There appears to be some conflict between what is observed from a technical point of view and the political reality in terms of change agenda (Respondent 1206). As pointed out by one respondent, “Engineering education makes it more difficult to make this transition, by nurturing and encouraging a narrow technical view towards various issues.” (Respondent 1303). “Engineering education takes me back towards the production orientation, whereas if I had been free of that, I might have been able to pick marketing, human resources and finance skills earlier”, stated one respondent (Respondent 1208). “Engineers are viewed as regimented in the way they do things and engineering education creates that regimented thinking in engineers”, another respondent pointed out (Respondent 1105).

Engineering education makes it difficult for engineers to make these transitions, in that it inhibits the development of broader perspectives. “It does not develop lateral thinking among engineers”, observed an engineer (Respondent 1106). It is considered to be technically narrow in its orientation, relatively neglecting the non-technical aspects in engineering work. Many of the respondents, however, indicated that engineers’ general lack of ‘soft’ skills could be because of inadequacies in the educational curriculum, lack of practice, or individual personality, and that it is difficult to pinpoint a single reason.

It was the general view of the respondents that the engineering education curriculum and content is heavy when compared with other undergraduate courses such as business/commerce, economics, arts and science. They felt that at the undergraduate level, there is no possibility of increasing the total content or the already lengthy duration of the engineering course. Respondents said that the compensation received by engineers is not worth its ‘hard slog and long hours’ and, in fact, “Their contribution to the organization and society is severely undervalued.” (Respondents 1402, 1203 and 1501). As such, the present rewards for engineer are not regarded as good and commensurate with the present four years of rigorous effort. Moreover, even in a limited way, it is difficult to increase the non-technical content without sacrificing the engineering content of the curriculum.
In order to broaden their thinking and equip them with the necessary 'soft' skills, increasing the business management content of undergraduate courses has been recommended in several past studies. In practice, however, there is a conflict between the need to update and improve the technical content, and the push to increase the non-technical content, all to be contained within the present four-year duration of the course. Respondents thought that, even in a limited way, it is difficult in four years to increase the non-technical content without sacrificing the engineering content.

Diluting the technical content in undergraduate courses would influence the analytical skills that it is expected to give students. The study points out that sacrificing engineering content for management content in the undergraduate courses is not an appropriate strategy to develop a technically sound engineer. Therefore, short of extending the course, it is not possible to achieve any significant improvement in the softer aspects of education (Respondents 1105, 1101, 1203 and 1402). Many engineers suggested that soft skills can be acquired through postgraduate education and better management of experiential learning on the job.

It was generally felt by the respondents that non-technical skills and knowledge can be imparted either on the job, and/or through postgraduate management education for engineers. An overwhelming majority of both technical engineers and engineer-managers indicated that their preferred strategy was through experiential learning modes. Although some of them had undertaken postgraduate management courses, it was the general belief that business management skills can be learnt on the job by carefully managing the initial experiences. In fact, the respondents felt that the most value can be obtained from management education when it is taken up after a few years of experience in organizations.

As pointed out by a respondent, the main purpose is "...to make a good technical engineer first and, if time permits, provide him/her with some business management issues. In any case, one cannot simply impart management skills as they are more experience- and action-based rather than knowledge-based." (Respondent 1203). In the words of another respondent, "It does not make much sense, teaching those
subjects at the undergraduate level, except to create some awareness of those issues so that they can intelligently choose at a later stage in their career.” (Respondent 1201). It is unfortunate, “...if the basic engineering course could be so diluted with other non-technical aspects, that they did not come out as good engineers”, a respondent noted (Respondent 1205). Using the notion of continuing education, management skills can be acquired by formal education at later stages of an engineer’s career. In any case, engineers do not get to do management tasks right from the beginning, and it takes some time for them to learn by experience the business context of engineering (Respondent 1205).

Respondents suggested that these subjects may be learnt at postgraduate level, which accords with the continuous learning philosophy well-accepted in the profession. The engineers enrolled in the MBA program and the Graduate Diploma in Management programs offered by the APESMA, the professional organization for engineers, constitute 25 per cent of the total number of MBA enrolments in Australia (APESMA 1995; Karpin 1995). This is an indication of the acceptance by engineers of the need for postgraduate management education and their endorsement of the continuous learning philosophy.

Management-oriented engineers contended that acquiring a tertiary qualification in business management as such only helped them counter the general perception of engineering being different from management, although it enhanced their chances for promotion into managerial roles. As stated by one respondent, “Studying a postgraduate diploma course in management is basically to get a formal confirmation that I have management skills.” (Respondent 1206). The main purpose was to assure top management that they had management skills, and as an insurance against being bypassed for promotions to management positions. However, in retrospect, many respondents felt that formal qualifications in management had enhanced their skills to some extent, and helped to place them in a sensible framework for effective use.
Commenting on business management education and the lack of knowledge by people who are delivering these modules in universities, one respondent commented that the "...lack of knowledge of non-engineering academic staff on the level of knowledge and education a graduate engineer has is surprising." (Respondent 1208). For example, the respondent cited an instance in the economics course material in which the first chapter explains how to read a graph, what is slope, etc. This is especially surprising, given that the course is specifically targeted to engineers. This example, though anecdotal, confirms that non-engineers lack an appreciation and understanding of engineering education.

It is argued that it is not possible for any institution to adequately train engineers so that they are immediately useful at the workplace, because of the differing needs of organizations. "You can be a civil engineer yet work such a diverse sort of range of things that an institution could never hope to prepare an engineering graduate for an industry." (Respondent 1205). Only through on-the-job experience can professional formation take place, the study noted.

On teaching and learning styles, and the processes in universities, respondents were critical of the traditional methods used. One respondent commented that there is no proper attempt to link theory with practice in universities, and that the attitude taken by most academics is that it is up to the student to acquire the knowledge. Basically, in engineering schools in Australia, "Students learn to pass the exams" rather than any effective learning (Respondent 1205).

The teaching processes in universities are not seen to encourage the development of 'soft' skills, according to the study. While technical engineers did not strongly subscribe to this argument, many of the engineer–managers argued that there is no emphasis on communications and teamwork in the undergraduate curriculum and that it created inadequacies in this area. One respondent commented that, "Engineers as a group don't come out as a very articulate group. They still are very reticent about expressing their points of view and they don't come out strongly in debating areas and presentation areas." (Respondent 1203). Graduates from other disciplines
such as commerce, humanities and even the sciences are considered more articulate than engineers. "When it comes to the real work scene, an awful lot of work involves an interpersonal context, communication and getting the point of view across, and engineers, when compared with other disciplines, still aren't terribly good at that." observed a respondent (Respondent 1204). The study noted that by increasing the use of learning and teaching strategies such as multidisciplinary teaching, field-based practical projects and group work/assignments in the undergraduate engineering curriculum, these generic competencies can be, to some extent, improved in engineers.

It is argued in the literature that one cannot know whether one can manage, or whether one will like doing it, unless one actually feel the responsibilities of management. The literature emphasises that early work experiences are crucial for learning. In summary, the study indicates that these 'soft' skills are best learnt on the job, as they are primarily enterprise-specific and experience-oriented skills, and changes in the engineering education curriculum do not help engineers much in these areas.

On the issue of acquiring these new business management and other related skills for effective performance in their new roles, the study revealed that engineers learn these things more by 'action' than through 'contemplation'. As pointed out by one respondent, "Though you have formal training on these skills, the real development of knowledge comes most with time on the job." (Respondent 1206). In this context, the study observes that the changes in the content of the engineering curriculum do not necessarily prepare graduates any better for handling their business management roles, particularly at the undergraduate level. Though this observation was not strongly supported by all the respondents, there was general dissatisfaction in the general trend towards increasing the managerial content at the expense of technical content. The majority of the respondents said that they learnt these skills on the job, and did not subscribe to the view that they can be taught at the undergraduate level. In fact, some of them indicated that the time of engineering students would be better spent if they were given the opportunity and support to broaden their generic
competencies such as communication, teamworking and interpersonal skills rather than by any change in the content of the engineering education curriculum.

One respondent felt that there is a need to ‘re-engineer’ engineering courses and move away from the traditional categories of mechanical, civil, electrical, etc. (Respondent 1208). Instead, courses should focus on the nature of functions, such as planning, design, production, maintenance and the environment. In fact, the current classification is “...about 100 years old and may need thorough review, dismantling these discipline barriers.” (Respondent 1208). In fact, the traditional differences between the disciplines, say, between electrical and mechanical, are no longer valid at the workplace, considering the fast technological changes in industrial organizations. In order to combine these two disciplines in a meaningful way, many universities have introduced mechatronics, another discipline.

In summary, engineering education plays an influential role in the transition into management. Importantly, engineering education in its present form seems to constrain engineers from making the transition. The heavy emphasis on content, and the relatively insufficient focus on the processes of teaching and learning, are inhibiting the development of ‘soft’ skills such as communication, teamwork and interpersonal skills among engineers. Conventional methods of increasing the business management content at the expense of an ever-increasing technical content are not, according to the respondents, effective. Instead, it was argued that the focus must be on managing learning on the job, with provisions for postgraduate business management education. In general, the respondents tended to believe that the first option is more effective than the second one. However, it is acknowledged that the perception that engineers are not suitable for managerial roles can, to some extent, be countered by their acquiring tertiary qualifications in management.

4.4.5 Organizational systems and policies

Organizational support systems and policies provided to engineers in making transitions are acknowledged as an important factor. The study noted that there is
inadequate support from organizations in managing these transitions, either in terms of providing an alternative technical career path or help in performing managerial roles.

Respondents argued that it is possible to reward a technical person who is senior in the organization with the highest level of reward while he/she is working full-time in a technical area. The compensation could be apportioned over three components: knowledge, skills and the business outcome, the last varying depending upon the business outcomes produced by the technical person. (Respondent 1208). The study noted that there are certain highly technical areas that need considerable expertise and that, under the present circumstances, it is not possible to reward that expertise.

Although all engineers may not want to move into management, and some might prefer to continue in a specialist technical field, it was contended by the respondents generally that there are not enough opportunities to grow in the technical field in Queensland Transport. It was generally believed, by the specialist engineers as well as by the management-oriented engineers, that one has to move into management to reach the higher levels either within Queensland Transport or elsewhere.

On the issue of whether the organization had a separate technical career ladder, respondents answered differently. Some stated that there was none, and that one should have been there to a limited extent, while others said that there was one, though it was not effective. It was generally believed that, if no such separate ladder exists, there is a possibility of specialist expertise disappearing from the organization. A majority of the respondents expressed doubts about the continuation of this technical career path, even in its limited form, in view of the changes taking place in the organization. One respondent observed that “Within our division, we have tried to maintain the distinction between technical excellence and managerial position. But the big question is how long will it sustain, given the current change agenda in the organization?” (Respondent 1202).
It was observed that engineers who become managers had better compensation and other benefits, apart from status and the prestige associated with their roles, than did those who remained as individual contributors in their chosen specialist field. Although this organization had the dual-ladder approach, many respondents felt that providing individual incentives and opportunities was difficult and not really practical. As pointed out by one respondent, "Though it is theoretically possible for technical specialists to move into professional SES (senior executive service) levels that have higher pay scales, it is almost practically non-existent in the organization." (Respondent 1201). Moreover, the implementation of such a dual-ladder approach in their organization was not seen by these engineers to be effective.

On the issue of organizational support, the majority indicated that there was no formal system of support for engineers. Most of the respondents asserted that it was their individual effort and determination, informally supported by their subordinates and superiors, that helped them in their transition. Reliance on peers in terms of exchanging information and ideas appears to be very low, the study noted. A significant number of respondents indicated that they acquired their management skills mainly through self-development and experience on the job.

On the issue of acquiring management qualifications, for example, most felt that the organization did not give any support, financially or otherwise. Those who were in the process of studying were doing it purely on their own initiative, with no formal support or encouragement from the organization. Also, as pointed out by one respondent, most people in the department were not doing any additional study, though they were aware of the need. This was mainly because "There has not been enough to motivate them to take time out and do some extra study themselves." (Respondent 1103).

However, the practice of acting in a senior positions during a superior's leave of absence was well in place in the organization and seemed to be working well. The majority of the respondents endorsed the practice of posting juniors into senior positions to act for a temporary period as the best learning opportunity. In addition,
training engineers in management areas was another strategy adopted. It was interesting to note that some managers had been given extensive training in management skills by being sent to external institutions for long periods, while for others, training had been very short and limited.

On the issue of promotions into management roles, the majority of the respondents indicated that attitude and people management skills are the most important determinants in promotions. Although technical performance and knowledge were considered useful, they were not rated essential in management roles. As noted by one respondent, "Good interpersonal skills, positive attitudes, rather than your technical brilliance, help a lot." (Respondent 1106).

4.4.6 Status of engineers

The status of engineers in society in general and within the organization in particular was expected to have a significant influence on transitions. According to the literature, the perception of senior management concerning the suitability of engineers for management positions is influenced by their general status in society, which differs between countries. According to the literature, the higher the status of engineers in the organization, the higher their chances of success in managerial positions.

Salary level is a measure of status in society. "To become a good engineer, one needs to put in lot of effort and time...but the rewards are not commensurate with that", noted a respondent (Respondent 1208). It was argued that there is a dilemma between higher compensation for engineers, and the quality of engineering recruits and the effort and time required for the course. If compensation is relative to the effort and time put in, there is a possibility that the profession would attract high-quality school leavers. For example, the medical profession, although it is also demanding and of a longer duration, attracts high-quality school leavers due to its high levels of compensation after graduation. The majority of the respondents thought that engineers were not well-compensated relative to their contribution to the organization.
and/or the economy. They also contended that engineering is not attracting high-quality people these days, because of low compensation and the general perception that it is a low-status profession.

It was observed that there was a fair amount of distrust of engineers immediately after amalgamation in the organization. In fact, "The public service board really hates engineers and never considers them worthy as managers", observed a senior non-engineer in the organization (Respondent 1404). Now that engineers were seen to be operating successfully at various levels within the organization, there was a growing recognition that engineers have the potential to hold senior management positions. The general status of engineers appeared to be well, according to the study. However, the majority of the technically oriented engineers believed that their status was relatively low and that they were not viewed as capable by senior management.

As noted by one respondent, "Skills that engineers have are seen as things you can buy, like going into a shop and buying a packet of biscuits, and there is no appreciation of the value adding engineers really do." (Respondent 1202). Put bluntly by one respondent, "It is almost a negative thing to write on an application form that you are an engineer." (Respondent 1103). Respondents believed that engineers are underrated in public perception due to their low earning capacity (Respondent 1106).

On the other hand, some of the management-oriented engineers were comfortable with their status and their influence in the organization. They contended that senior management had of late perceived them as being capable of holding senior management positions and that they had demonstrated their professional competence in carrying out managerial tasks (Respondent 1301). One engineer said, "Though it was different at the beginning, now top management thinks that engineers can, because engineers have delivered the change programs, while other non-engineers could not do it...Now, there is an appreciation in the higher levels that engineers can do it and are doing it well." (Respondent 1101).
Most of the respondents believed that the public perceives engineers as being lower in status than lawyers, medical practitioners and accountants. This is because of the inability of engineering to have a direct effect on the individual. One respondent noted, “Not many people can relate to engineers the way they can relate to a medical practitioner... But people drive roads; if they are unhappy, they complain, but they don’t give credit to engineers.” (Respondent 1101). Respondents believed that this low status was due to a lack of selling by the engineers and the profession in general (Respondent 1205).

Career preference had an influence on the perception of status. On being questioned about engineering as a career, most of the engineers preferred to remain in the engineering profession (as had been expected). However, some expressed concern about their future in view of the de-engineering trend and the lower status attached to the engineering profession when compared to their contemporaries in other professions such as medicine, law, economics and accountancy. Some stated that they would prefer to choose other professions such as medicine, accounting and law, generally acknowledging the higher status society attaches to those professions.

Though there was agreement over the poor status of engineers in the past, the study noted that perception of status differs between technically oriented engineers and management-oriented engineers. While the management-oriented engineers felt that their current senior management perceived them as being capable of delivering managerial outcomes effectively and efficiently, others did not seem to agree. The opening-up of positions to non-engineers at the management level seemed to have created this perception of low status among technically oriented engineers. On balance, it seemed that engineers were generally valued as good managers, based on individual performance, capability and successful outcomes, and not as a privileged group of professionals. Also, the perception seemed to be changing as more engineers took up management positions, thus providing anecdotal evidence supporting the view that the greater the number of engineers in management, the higher the probability of their achieving higher status.
4.4.7 **De-engineering**

De-engineering seemed to be a factor influencing these transitions, especially in the public sector organizations in Australia. Although there was no overwhelming response in support or otherwise on this issue, respondents in this study expressed diverse points of view. Some of the management oriented-engineers argued that there was no guarantee that an engineer would be a better manager even in an engineering-based organization like theirs. However, many of them believed that because they were in the technical services delivery area, having an engineer as manager added value to the organization.

While the removal of engineering qualifications as an essential requirement for district manager and other senior management positions in the organization had some effect on the morale of engineers at operating level, the effect did not seem to be great, especially at the senior engineers' level. However, the study indicated that the engineers at the lower level were generally apprehensive about their career opportunities. At the time, all the district manager and regional director positions were occupied by engineers and so the respondents had seen no threat of de-engineering. However, when compared with the past, when engineers occupied different positions right up to the chief executive level in the old Main Roads Department, some of respondents felt that the de-engineering trend in the public sector in general had some effect on engineers' promotional opportunities.

As pointed out by one respondent, de-engineering has effectively cut off the top levels of the organization. "**While some of the positions are demoted, some are actually cut off, with a consequent reduction in access to the decision-makers within the organization dramatically.**" (Respondent 1201). While acknowledging that the de-engineering trend had occurred because of their lack of management skills, some respondents blamed the engineers themselves. In the words of one engineer, "**We should have had the foresight to realize that our formal training has been purely technical and we really need some managerial training, and it is up to us to get it ourselves.**" (Respondent 1103).
Indicating that some engineers were justified in complaining about the de-engineering trend, one respondent said that it was "...hard to understand how some people get to some very important positions with absolutely no education at all, while engineers at least have some technical training. These situations hurt engineers a lot. Engineers had at least some project management experience, while the non-technical people appointed at the senior levels do not have any of that." (Respondent 1109).

On the other hand, some were of the opinion that de-engineering had had no significant effect on the morale of engineers. For example, one engineer–manager pointed out that "I don’t think this de-engineering had any effect on status and morale of engineers in this organization." (Respondent 1303). Another respondent indicated that though "...there is no guarantee that an engineer is a good manager, we have a sufficient pool of engineers around the place to be able to select those good managers out of it." (Respondent 1205). Similarly, it was also argued by some that there was no need to have an engineer as a manager, even in engineering-based organizations.

Many respondents did not object to the opening-up of positions to non-engineers; rather, they argued that there should not be any bias against the engineer. The approach advocated for engineers was to equip themselves with the necessary management skills, knowledge and business acumen, in order to place themselves in the best position when a vacancy arose (Respondent 1208). Ruling out an engineer for a top management position because he or she was an engineer was strongly condemned by many respondents. One respondent said, "I think it is a fallacy to have a rule that we won't have an engineer at the top because we have all engineers down there in the organization and let us get someone else for the top positions." (Respondent 1208).

On the positive side, many respondents argued that the best way to counter this trend, if there was one, was to be qualified to occupy senior management positions by
acquiring the necessary skills through training, tertiary qualifications and a change in the attitude towards managerial tasks. In the same tone, they agreed that there should not be a rule that, for example, a district manager position must only be filled by an engineer.

It was contended by the respondents that, everything being equal, an engineering background gives someone a big advantage in carrying out a managerial role (Respondents 1101; 1102; 1104; 1108; 1201; 1203). Implying that non-engineers were equally suited for managerial roles in the department, the study reiterated the importance of people skills in management positions, thus generally supporting past research.

Within Queensland Transport, there is strong recognition of the contribution that engineers can make to the organization, and the de-engineering trend did not seem to affect it significantly (Respondent 1206). It was possible for someone with good management skills in another area or profession to competently handle the management aspects of a district manager’s job. However, that person would not have that small but vital technical balance. “That is why a good engineer with good management skills would manage the job better, because he/she can bring that other component with him/her, rather than a good manager without an engineering balance.” one engineer observed (Respondent 1206).

As a professional group, the skills, knowledge and experience that engineers bring to an organization are very valuable, and disregarding that factor is a mistake for any organization. This has been highlighted in the USA, where the de-engineering process began sooner than in Australia, a process now being reversed. Similar trends can be seen in the Australian public sector, as perceptions seem to be changing, the study noted.
4.4.8 Generic professional competencies

The study revealed that generic professional competencies such as problem-solving, relating well to others and communication skills have become essential features that contribute to a successful performance in new work roles. The word ‘competency’ is defined by the National Training Board (Australia) as the ability to perform the activities within an occupation or function to the standard expected in employment. As indicated by the respondents in this study, flexibility in thinking, the ability to understand the big picture, interpersonal skills and communication skills are essential requirements for success in these new roles (Respondents 1203 and 1206).

The literature on competencies indicates that generic competencies such as problem-solving, communication, self-management, and management of human and other resources have become essential features of an effective performance in any profession (Gonczi et al. 1990). This is especially so with the present moves towards flat structures, de-layering, commercialisation and open competition. In fact, the Institution of Engineers has included ‘business and management, and communication’ as two of the five core units in the competency standards developed for professional engineers.

By recognising and incorporating these competencies right from graduation, the Institution of Engineers Australia (IE Aust.) demonstrated the critical importance it attached to them for the professional formation of engineers (IE Aust 1993b). It emphasised that the development of these competencies will generally require significant experiential and maturation time (IE Aust. 1993b). Though many organizations do not pay great attention to the development of their professionals’ competencies, other than sending them for a short course or training program, their importance has been well-recognised by engineers.

The respondents were of the opinion that the deployment of multidisciplinary teams is the most effective way to gain insight into one’s own profession and into other professions and functions, and into the way they interrelate within organizations.
They pointed out that generic competencies in areas such as self-management and people management are experience-oriented and work-based and should be learnt there on the job, rather than from changes in curriculum content in engineering education.

4.4.9 Individual personality

There were strong indications from the study that it is the individual that makes the difference between success and failure. Despite the respondents being fairly similar, sharing a common background in terms of educational qualifications, age and experience, there were significant differences in their perceptions of change processes and performance criteria. Most of the engineers believed that ‘soft’ skills such as people-management, communication and business skills are closely related to the attitude and personality of individuals which can help make them effective and successful.

The fact that some of them (although in the minority) did not seem to have any difficulty in making the transition indicated the influence of individual personality. Apart from time pressures, the need to implement change processes along with their routine work and inadequate administrative support systems, these respondents did not cite any issue causing stress or dissatisfaction. As noted by one respondent, “*Personality is everything; it has a major effect, so much so you can find engineers in full range of the spectrum with some leading the change/transition and some others back in the square.*” (Respondent 1208).

Although most of the time, one uses knowledge and skills developed based on past experiences and formal training, it is important that the individual uses his/her instincts in dealing with certain issues. “*My individual personality characteristics come in handy in handling those uncertainties and unknowns.*” (Respondent 1205). Personality characteristics have a significant influence on the transition. “*If you cannot get on well with people or if you have an ability to upset people, whether they are customers or employees, I don’t think one can succeed.*” (Respondent 1205).
According to the study, attitude was the single factor that differentiated the best-performing engineer/engineer-manager from the average engineer. Although all the other skills such as technical ability, knowledge and experience are important, every qualified engineer more or less acquires them through professional training and on-the-job experience. So the only factor that influences success or failure is attitude. Several respondents, when asked what differentiated the best-performing from the poorly performing engineer in changed work roles, identified attitude and people management as the most important aspects.

Once the need to change has been understood and communicated clearly, a considerable proportion of engineers seemed to have reoriented themselves fairly well and taken change as a challenge to be overcome with the help of their traditional engineering skills, such as analytical and problem-solving skills. In fact, the majority of the respondents feel that without their engineering skills, they could not function effectively, as they provided technological and engineering services to their clients.

4.4.10 Strategies for managing transitions

It is possible to learn management skills through training, tertiary qualifications, on-the-job experience and other kinds of self-development. However, most of the respondents expressed a preference for experiential learning rather than tertiary qualifications and training strategies. Although about 20 per cent of the engineers had acquired a management qualification, it was acquired to make their organization recognise that they were qualified to be managers, rather than because of a strong belief that management skills are and can be acquired through tertiary education.

This could have been expected, as a majority of the respondents were highly experienced in their profession and would have acquired their skills on the job over a long period of time. Therefore, it cannot be conclusively stated that tertiary qualifications are not important. As indicated by many respondents, organizational support by way of reimbursing fees, and relieving and special leave of absence to
continue studies, were not generally adopted strategies in this organization. Although most of the engineers who had moved into management positions appeared to have attended training courses, they had been short and specific in particular areas. Except for two or three district managers, all the others had only been given between three and 10 days of basic management training during their managerial career. Formal training, though necessary, is not about teaching everything you need to know to carry out the job. Instead it should be, in the words of one respondent, "...teaching the skills that allow one to use that knowledge as you develop over years of experience." (Respondent 1110). Though it was not viewed as effective, the majority of the respondents indicated that training in management skills should be given to all engineers whether they were moving into management roles or continuing in their specialist positions. They believed that ‘soft’ skills are generally necessary for all engineers.

On the issue of providing a separate technical career path, technical engineers strongly believed that such a structure would help to satisfy the career aspirations of technical specialists and ensure their continued contribution to the organization. On the other hand, engineer–managers did not see such a need, and instead considered management a natural career route for engineers. As one remarked, “At present, the technical career path stops at PO-6 level, so that the most attractive positions are really outside the technical path.” (Respondent 1201). Suggesting that there should be some balance, one respondent commented that “Staffing an entire organization with engineers only is wrong; similarly, staffing entire top layers of an engineering organization with non-engineers is also equally crazy and there ought to be balance of the two.” (Respondent 1202).

As managers spend 99 per cent of the time of their working time on the job, it is quite normal to expect considerable learning to take place on the job. Confirming previous research, most of the respondents claimed that managerial skills are gained during the early part of one’s career through self-development and on-the-job training, outside the routine technical working area. They pointed out that they learnt their skills
through their early experiences, by observing their mentors/superiors, by discussions and analyses with colleagues, subordinates and superiors, and by their own mistakes.

The majority of the respondents from all the categories stressed the importance of learning by experience on the job. The study noted that focusing on the initial learning experience of graduate engineers is an important strategy to develop well-rounded engineers. Without proper experience and professional formation, no organization is going to employ graduate engineers as managers. In fact, even the graduates from management schools are not directly appointed into managerial positions without some related experience and professional formation.

As one respondent observed, "You would never get engineers relevant to industry, because the need for each type of industry, each organization is absolutely different. When an engineer graduates, he/she has the knowledge and training to approach the problems, but no experience. It is up to the industry then to take his/her skills and get most out of it in the workplace and simultaneously provide the necessary professional formative experience." (Respondent 1209). Considering this reality, it is necessary to focus on the initial experience of the graduate engineer and convert it into a meaningful learning experience. The provision of the necessary facilities and an encouraging environment, resources and support are important if the graduate engineer is to take full advantage of new learning experiences on the job.

The study noted that engineers are acquiring these new skills by experience, trial and error, guidance and mentoring from superiors, discussions with peer groups, and by involvement in cross-functional or interdisciplinary group work. All these strategies are individual and depend upon the actual circumstances of the job, there being no formal mechanisms or systems in place within the organization to manage this learning process. The study observed that it is left entirely to the individual to manage this learning process. One respondent said, "Except for some short training courses, no formal encouragement or mechanism is in place to formalise learning on the job. We just learn from our mistakes and successes, and pick up good and bad points as we move along." (Respondent 1209). In spite of this, experiential modes of
learning are the most common strategies many engineers have in managing the transition. In view of this, it may be necessary to develop formal organizational strategies and systems to carefully manage experiential modes of learning.

4.5 Summary of the findings/propositions developed from analysis

Analysing the cases detailed above led to the following results. A summary of the findings and the propositions developed from analysis are presented.

* Respondents have been categorised according to their job nature, as technical engineers and engineer–managers, for the purpose of analysis. There seems to be a significant difference in the perceptions and attitudes of these two categories on various issues related to transition.

* Given a choice, technically oriented engineers would not like to carry out non-technical functions and would prefer to remain as technical specialists, whereas engineer-managers would always prefer managerial tasks.

* The inevitability of expansion of their roles was well-recognised by the engineers, in line with the other reform initiatives, and there was a general acknowledgment of the changes. The change imperatives seemed to have been well-recognised by the engineers and in general they did not have strong objections to the organizational changes.

* Unlike the case with their technical functions, technically oriented engineers did not generally derive a sense of satisfaction and achievement by carrying out business-related, non-technical tasks. However, management-oriented engineers continued to enjoy the limited technical functions in their roles and were observed to be comfortable in carrying out non-technical functions.

* Technically oriented engineers viewed the uncertainty and abstractness in management work as the hardest part of their transition, while management
oriented engineers perceived this as the challenging aspect of their job. In both cases, respondents realized that engineering work and management work were different and needed a different orientation.

* All the respondents generally claimed that the higher pay, ability to influence organizational decisions and the higher status associated with the management roles were the attractions for making this career move. Importantly, the study asserts that they are not pushed by dissatisfaction with technical aspects of the work.

* Both engineer–managers and technical engineers recognised the importance of ‘soft’ skills and asserted that lack of such skills made transition difficult either into management roles or into ‘generalist’ roles. Both categories identified people management as the hardest part of this transition.

* The study calls for a change in the process of engineering education, emphasising communication skills and teamwork, in teaching methods and in assessment patterns. It is observed that the present system, with its heavy emphasis on content, is underdeveloping the other generic competencies of engineers.

* It was believed by both categories of respondents that the heavy workload and content in the undergraduate engineering curriculum inhibited the development of ‘soft’ skills and the generic competencies needed for a well-rounded professional engineer.

* While engineer–managers stated that the present curriculum content acted as a constraint in making the transition, technical engineers did not share this view and remained fairly neutral.

* Learning business management skills was considered necessary for graduate engineers. However, the study notes that it is not possible to include business
management content without sacrificing some technical content in the present four-year undergraduate curriculum, and therefore suggests continuous learning while practising the profession.

* Technically oriented engineers felt that the quality of the engineer will suffer if the technical content is reduced in order to accommodate non-technical content in the undergraduate engineering curriculum. On the other hand, management-oriented engineers believed that the technical content must be reduced and made broader rather than specific, and include management content, in order to develop a well-rounded engineer.

* The study notes that these skills can be best learnt by managing the learning experiences on the job effectively. It points out that significant learning takes place on the job by informal strategies such as discussions with peers, guidance from superiors, interdisciplinary projects and actual work on the job.

* The study observes that, though generic competencies such as self-management, people management and communication skills are experience-oriented and workplace-based, there is no proper system of managing this experiential learning in organizations and nor any support mechanisms. It is mainly left to the individual to manage his/her transition with the help of superiors, peers, and education and reflection on their experiences.

* The dual-ladder approach, providing opportunities for growth to technical professionals, was not observed to be effective and, generally, management was viewed as superior in status to other technical specialist functions both within the organization and outside, according to all the respondents. No significant differences in the opinions of technically oriented engineers and management-oriented engineers were noticed on this issue.
* Engineers acquire the ‘soft’ skills mostly on the job, based on their experiences, rather than by any theoretical knowledge imparted through training and education. However, better management of learning from experience would enhance the value of learning to the individual and contribute to the organizational performance.

* The study provides anecdotal evidence implying that the transition into management roles enhances the engineers’ perception of their status within the organization. Generally, technical engineers in this study believed that their status was relatively low, while engineer–managers thought otherwise.

* All the engineers generally believed that engineers as a group lack the ‘soft’ skills necessary for successful performance in managerial positions.

* The study highlights the importance of individual personality in making a successful transition.

* Case study analysis highlights the influence of several factors on engineers’ transition and their influence on each other factors. Factors identified in this analysis include individual personality and occupational orientation; organizational policies, employers’ perception, experiential learning and its management; changing nature of engineering and managerial work in contemporary organizations; workload, content and process in current engineering education; postgraduate management education; secondary and primary school education; de-engineering trend; intensity of engineering and technology in a nation; and role of professional associations.

4.6 Conclusions to case study analysis

The study highlights the influence of various factors on transition and on each other, and provides anecdotal evidence to the potential for integration of these factors. Importantly, it stresses the need for generic professional competencies for engineers,
whether they continue in specialist roles or move into generalist roles/management roles. According to the study, acquiring business-related skills is important, particularly in the current organizational environment. The study observes that sacrificing technical content to increase the managerial content of undergraduate engineering education is not an appropriate strategy.

Though tertiary qualifications were viewed as a strategy for acquiring management skills, it was generally perceived by the engineers as more an attempt to change the negative perception held by senior management of their management skills, rather than a genuine attempt to learn really useful skills. The research emphasises that these skills can best be learnt on the job by effective management of the learning experience. Although most of the respondents acquired their business-related skills through experience, no supporting mechanisms or systems were in place within their organization. In fact, it was left to the individual to manage his/her learning process. The study observes that a systematic approach to managing learning through experience on the job would help engineers in the transition as well as help them subsequently perform well in their new work roles. If individual effort is not supported by concerted organizational initiatives, the consequences are significant.

The findings of this first phase of the research using the case study method were expected to provide a basis for hypotheses generation and anecdotal evidence. Accordingly, the propositions evolved from the case study findings (as summarised in section 4.5) are refined into statements or to be tested among engineers in Australia. The research questions or propositions thus developed are supplemented with some of the findings of the literature review and presented at the end of the literature review section (refer section 2.7). The next chapter discusses the analysis and findings of the survey research.
CHAPTER 5

SURVEY ANALYSIS AND FINDINGS
SURVEY ANALYSIS AND FINDINGS

5.1 Introduction and overview

This chapter presents the analysis of the survey research data. The first section elaborates the responses of the engineers as a group and highlights the findings of the survey study on various dimensions or issues concerning the transition, such as general attitude towards transition, engineering education, status, organizational support and strategies in managing the transition. A conceptual model for transition, depicting the factors influencing the transition, is explained. The hypotheses developed from the literature review and case study analysis are discussed in the context of the survey data and their results are explained with reference to the first research question and its sub-questions.

In order to answer the second research question, that is, dealing with the differences between various subgroups of engineers, the association of various nominal variables and the critical predictor value of them are determined with the help of cross-tabulations and discriminant analysis respectively. A comparative analysis of the differences in attitude between various critical subgroups of engineers is presented. In order to test the differences statistically, several independent variables are grouped into several factors using factor analysis and tested using t-tests. A comparative analysis of the differences in attitude towards various factors between subgroups of engineers is presented later. Finally a summary of the findings of this research study is presented.

5.2 Survey demographics

Several dependent variables used in this analysis include predominant job nature, discipline of engineering, age, gender, engineering qualifications obtained overseas or in Australia; management qualifications--MBA, no management qualifications or other postgraduate qualifications; engineering qualifications--Grad. Diploma, Masters,
PhD or no postgraduate engineering qualification; years of technical experience; years of managerial experience; industry in which engineers are employed—manufacturing, government or consultancy sector; levels senior to the respondents and levels junior to the respondents in their organization; and the number of employees supervised by the respondents. In this survey, respondents classified themselves, indicating the category to which they belonged. Detailed information in relation to the frequency and descriptive statistical characteristics of these variables are presented in appendix XII.

The survey was carried out among three disciplines of engineering—civil, mechanical and electrical/electronics engineers—from a total sample of 756 valid responses. The sample comprised 38 per cent (291) civil engineers, 41 per cent (310) mechanical engineers and the remaining 21 per cent (155) electrical/electronics engineers. These proportions approximately match the national proportion, which is an indication of the representative nature of the sample. This survey classified the predominant nature of the engineers’ jobs into three categories—technical, managerial or an equal mix of the two—and the respective proportions from among the respondents were 23.5 per cent (178), 23 per cent (174) and 53.5 per cent (404).

An analysis of the respondents by engineering discipline and job nature revealed that the proportion of the predominant job nature was similar among civil, mechanical and electrical/electronics groups of engineers. About 50 per cent of the respondents in each of the category had equal amounts of managerial and technical content in their jobs. A summary is shown below.

Table 5.1: Respondents by engineering discipline and job nature

<table>
<thead>
<tr>
<th>Job nature/discipline</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>69 (24%)</td>
<td>69 (22%)</td>
<td>40 (26%)</td>
<td>178</td>
</tr>
<tr>
<td>Managerial</td>
<td>71 (24%)</td>
<td>71 (23%)</td>
<td>32 (21%)</td>
<td>174</td>
</tr>
<tr>
<td>Both equal</td>
<td>151 (52%)</td>
<td>170 (55%)</td>
<td>83 (53%)</td>
<td>404</td>
</tr>
<tr>
<td>Total</td>
<td>291(100%)</td>
<td>310(100%)</td>
<td>155(100%)</td>
<td>756</td>
</tr>
</tbody>
</table>
5.3 Summary of analysis and findings

5.3.1 Findings about research questions/propositions

This section summarises the conclusions about various research questions developed in this research and provides an overview of the detailed analysis and substantiation to be followed. According to the study, job nature and management qualifications are the most important predictors of the attitude of engineers towards transition. The study concludes that transition is continuous and that its success is influenced by various individual, educational, organizational and societal factors. Importantly, the study asserts that reform of the processes of teaching and learning, rather than changes in content, is necessary in engineering education in order to better prepare engineers for a successful transition and good managerial performance.

The study found that engineers are not homogenous and that their attitudes towards transition, engineering education, status, organizational support and strategies for managing transition are influenced by their discipline of engineering, the type of employing industry and their gender. According to the study, electrical engineers are more oriented towards managerial roles, are more likely to acquire management qualifications, and are less likely to expect their organization to support them than are mechanical or civil engineers. A detailed discussion of the conclusions follows.

5.3.2 Change imperatives

In the case study, there is a general consensus and agreement among both groups of engineers about the change imperatives and the inevitability of an expansion in engineers’ roles (refer to research question 6 in para 2.7). However, survey research indicates that most technical engineers did not endorse the move towards generalist roles, and did not seem to realize the changing paradigms in organizations (refer to research questions 6, 22 and 23 in para 2.7). Their predominant technical orientation
and general dislike of managerial tasks seem to have created this perception and bind
them to their own assumptions about change. Rather than coming out and playing a
role in shaping their role changes, technical engineers preferred to remain in their
technical comfort zone. On the other hand, a significant proportion of engineer–
managers believed that this move is inevitable and welcomed such changes.

Interestingly, the study found that there were certain differences between electrical
engineers and other groups of engineers on this aspect of change (refer to research
question 23 and 24 in para 2.7). It appeared that the electrical engineers had realized
the inevitable aspect of these changes from specialist to generalist roles, and had
embraced them, accepting them rather better than had other groups of engineers. It was
also observed that female engineers had a more positive attitude towards these changes
than had male engineers.

5.3.3 Motivation for transition

It was generally stated that the main motivation for transition was higher pay.
Although this study endorses this as one of the reasons for transition, it also highlights
the motivating effect of status and the prestige associated with managerial positions.
The study found that engineers in Australia are attracted to managerial roles more by
their strategic influence on the organizational decision-making and the prestige
associated with them than by the extrinsic rewards such as higher pay and other perks
(refer to research question 2 in para 2.7). However, there was an overwhelming
consensus among the engineers that engineers who moved into management positions
had better compensation than those remaining in technical roles.

These findings, though significant, had a different impact on the various subgroups of
engineers. For example, technical engineers believed that the move was strongly
influenced by pay and perks rather than by any specific aptitude or interest in
managerial work, whereas engineer–managers believed strongly that they were
motivated by the future leadership opportunities presented and their interest in managerial work (refer to research questions 23 and 24 in para 2.7).

It is clear from the study that engineers do not move into management positions because of dissatisfaction with engineering work. Transitions are not an escape route from technological obsolescence, and the findings of the study strongly refute the findings of some of the UK studies. This study confirms the previous research in the USA on the transitions (Rynes 1987), and points out that engineers are 'pulled' by the status, prestige and higher pay associated with management rather than 'pushed' because of dissatisfaction with engineering work (refer to research question 2 in para 2.7).

5.3.4 Problems in transition

Confirming previous studies in the UK (Barclay & Hawkins 1990) and the USA (Badawy 1982), this study found that people management is the most challenging and difficult aspect of transition (refer to research question 4 in para 2.7). Importantly, people management is perceived as a problem by all engineers irrespective of their age and levels of experience, job nature and branch/discipline. In relative terms, more female engineers and engineer–managers appeared to recognise this as a problem than male engineers and technical engineers.

The literature argues that the people-management problem becomes more difficult to overcome as experience increases and with career progression, and suggests training before the person moves into management. This finding highlights the importance of training to impart managerial skills to engineers early in their career, rather than just before they move into management (refer to research question 21 in para 2.7).
5.3.5 ‘Soft’ skills

The study observes that the career advancement of engineers in Australia is, in general, more limited by the human factor than by technical ability (refer to research question 4 in para 2.7). Importantly, study found that the ‘soft’ skills are necessary at all levels of responsibility and in all roles, and lack of them makes transition difficult (refer to research question 5 in para 2.7). However, this opinion was more strongly expressed by the engineer-managers and the management-qualified engineers than by the technical engineers and those engineers with no management qualifications (refer to research questions 23 and 24 in para 2.7).

5.3.6 Natural career progression

This study found that engineers’ view of management as a natural career progression is influenced by factors such as their job nature, branch of engineering, and management qualifications. While case study research indicates that it is a natural career progression for engineers (refer to para 4.4), survey research points out that there are differences among subgroups of engineers.

It observes that the engineer-managers viewed the transition as a natural career progression and did not think that any significant change would occur in their roles through transition. Technical engineers, however, did not support this view and believed that there was a significant change in the nature of work (refer to research questions 23 and 24 in para 2.7).

Similarly, electrical engineers considered transition as a natural career progression, while most mechanical and civil engineers did not believe so. Engineer–managers in general, and electrical engineers in particular, strongly indicated that technical job knowledge is an important factor in managerial performance, when compared with the others (refer to research questions 23 and 24 in para 2.7).
This study does not support the claim that becoming a manager is the only way to progress in an engineering career. It does however acknowledge that a move into management is a significant step in a satisfying engineering career, thus underscoring the importance of the traditional view that management is an integral part of engineering work. The study confirmed that engineers do not lose their engineering identity by becoming managers (refer to research question 1 in para 2.7). As expected, this study found that management qualifications played an important role in shaping these perceptions, with management-qualified engineers having a more positive perception than those without management qualifications (refer to research questions 23 and 24 in para 2.7).

The study observes that government engineers and consultancy engineers were more concerned about losing their engineering identity by accepting a change than were those working in manufacturing industry (refer to research questions 23 and 24 in para 2.7). This may be attributed to the better integration of engineers into management structures in manufacturing industry than in other sectors.

5.3.7 Other issues in attitudes towards transition

The study highlighted the importance of individual personality in making a successful transition, both in the case study analysis (refer para 4.4) and the survey findings (refer to research question 8 in para 2.7). Significant differences were identified between engineers with similar qualifications, experience and professional formation, in their attitude towards various aspects surrounding transition—an indication of the importance of individual personality.

The study found that the apparent de-engineering trend was not perceived to be a threat by the majority of engineers. However, as expected, technical engineers and civil engineers were more concerned about it than were engineer-managers and
electrical engineers. Engineers working in the government sector also perceived this trend as a problem, in spite of having separate technical career ladders that were better than those in other employment sectors such as manufacturing (refer to research questions 23 and 24 in para 2.7).

According to the study, technical engineers preferred a separate technical career ladder for their career development, while engineer–managers believed that taking the managerial path is a natural career progression for engineers (refer to research questions 7, 13 and 17 in para 2.7). Confirming the US studies, this study found that in Australia technical ladders are less rewarding than managerial ladders.

Overall, it appears that engineer-managers and management-qualified engineers have a more positive attitude towards transition, either into management roles or into generalist roles. Among the different engineering disciplines, the study found that electrical engineers have a more positive attitude towards the transition than the other two disciplines, mechanical and civil engineers (refer to research questions 23 and 24 in para 2.7).

Although a large number of engineers considered management as the best way to achieve career progression and a general enhancement in pay and status, the study observed that a considerable number did not like to move from the technical aspects of engineering work (refer to research questions 1, 17 and 20 in para 2.7). According to study, this dilemma could increase the possibility of potential lack of fit between some of the engineers’ talents and attitudes, and managerial job requirements, and might result in personal frustration and poor performance.

The study observed that, even in the present times of organizational change, a considerable number of engineers were less concerned with the human side of engineering work, which confirmed previous research findings in Australia and the UK (refer to research question 18 in para 2.7). As expected, the study found that
technical engineers are more technically oriented, as reflected by their lack of interest in non-technical functions and their preference to remain as technical specialists, than engineer-managers, which confirmed anecdotal evidence found in the case study analysis (refer to para 4.4). The same applied to the management-qualified engineers, who were found to be less technically oriented than those with no management qualifications.

The study observed that engineers working in the government sector had a higher technical orientation than those in manufacturing and preferred to remain in specialist roles. Along the same lines, government engineers reported less enthusiasm for engineering as a career if they could make the choice again, than did those in the manufacturing or consultancy sectors.

The study found that engineers derive more satisfaction from career advancement within the organization than from professional recognition by their peers (refer to research questions 19 and 20 in para 2.7). This finding confirms past research and anecdotal evidence from case study that engineers are more oriented towards the organization than towards their profession, unlike other professions.

5.3.8 Engineering education

The study found that engineering education, with its present focus on quantitative and substantive issues, is in a way contributing to the problems encountered in the managerial transition of engineers (refer to research question 9 in para 2.7). Though there are some differences between the various subgroups of engineers on certain issues related to engineering education, study observes that in general the present system is underdeveloping generic competencies such as problem-solving, relating well with others, teamwork and communication skills.
The study found that less emphasis is placed in the undergraduate engineering curriculum in Australia on the development of communication and teamwork skills than in other similar professional courses (refer to research question 9 in para 2.7). In addition, the study notes that the heavier workload in the undergraduate engineering curriculum, when compared with other courses, inhibits the development of 'soft' skills among engineers.

The study concludes that the present engineering curriculum and teaching processes accentuate the analytical skills of the engineer at the expense of soft skills. The study overwhelmingly calls for a change in the processes of teaching and learning in undergraduate courses (refer to research question 10 in para 2.7). This study does not support the traditional strategy of increasing the managerial content of these courses.

In addition to the general thrust towards a greater focus on teaching and learning, this study observes that some differences in attitude are influenced by the nature of the job, management qualifications and gender. For example, engineer-managers, female engineers and management-qualified engineers strongly criticised the present curriculum for its lack of focus on process-related issues, whereas technical engineers, male engineers and engineers with no management qualifications felt less strongly about this. Similarly, management-qualified engineers, having experienced the teaching and learning processes during their management education, believed more strongly than did those with no management qualifications that a change on process-related issues was essential (refer to research questions 22 and 23 in para 2.7).

5.3.9 Organizational support

The study found that organizational support is an important factor in making a successful transition and that it is influenced by the nature of the engineering work and the type of employing industry. The study observes that the support provided by organizations in making transitions is insignificant, and that it is left entirely to the
individual in Australian organizations (refer to research questions 11 in para 2.7). Apart from some standardised training—and very few organizations provided such training—support is almost non-existent. The study reveals that the skills and knowledge of technical engineers are relatively underutilised, and confirms some of the past studies done in the UK and Australia (Whalley 1986; Williams 1988).

The study observes that a considerable number of organizations in Australia considered technical performance the basis for promotions into managerial positions. It is noted that, in general, success in technical roles increases the probability of success in managerial roles (refer to research question 15 in para 2.7). When related to the perception of management being an integral part of engineering work, technical performance was believed to be a good basis from which engineer-managers could aspire for higher management positions. However, the study notes that technical engineers’ perception of engineering is distinctly different from their perception of managerial work, and they are therefore more apprehensive about technical performance being a basis for promotion into managerial positions.

According to the study, very few organizations in Australia have some form of dual-ladder approach for career development of engineers. Confirming overseas research, the study found that technical ladders are less rewarding than managerial ladders and are also ineffective (refer to research question 8 in para 2.7). In fact, the study observes that a majority of these technical ladders are used as a ‘dumping ground’ for unsuccessful engineer–managers.

Importantly, the study found that civil engineers reported a higher incidence of technical ladders in their organizations than did mechanical or electrical engineers. This in spite of the fact that most civil engineers work in public sector organizations where the de-engineering trend is noticeable.
The study found that manufacturing organizations, in which a majority of mechanical engineers work, are more supportive of engineers' efforts than government organizations. As expected, a separate technical career ladder, though not seen to be effective, was more prevalent in the government and consultancy sectors than in manufacturing (refer to research questions 22 and 23 in para 2.7).

5.3.10 Status

Analysis of the study findings suggests that the general status of engineers, as perceived by engineers within an organization, is relatively low. This low self-image, together with the negative perception of engineers held by senior management, serves to perpetuate the low status of engineers in organizations (refer to research questions 13 and 14 in para 2.7). This perception of engineers' inability to reach top management positions plays a significant role in diminishing their importance in the organization. However, these perceptions of status vary between the different subgroups of engineers, and are influenced by the nature of their job, their management qualifications, and the type of employing industry.

Confirming past research in the USA and the UK, technical engineers consider their status to be low when compared with that of engineer–managers, a view shared by top management. The study observed that the higher the status of professional engineers within an organization, the greater the probability of their success (refer to research question 15 in para 2.7). Supporting anecdotal evidence from the case study (refer to para 4.4), the study notes that the more engineers there are in management positions, the better the perception of top management about their capabilities. There is a general consensus among the various subgroups of engineers that the only way to enhance their status within the organizations is to compete more and more for management positions (refer to research question 15 in para 2.7).
While technical engineers believe that their status is low, engineer–managers consider that their status has been enhanced because of their move into managerial positions. The study also observes that management qualifications influence the perception of engineers' status, with management-qualified engineers strongly believing that status can be gained by moving into managerial positions (refer to research questions 15, 22 and 23 in para 2.7).

The study found that engineers in manufacturing considered their status to be relatively high, compared with engineers working in the government and consultancy sectors. The perception held by senior management of the status of engineers was also observed to be high in the manufacturing sector when compared with the consultancy and government sectors (refer to research questions 22 and 23 in para 2.7).

A general belief prevails that the lower tertiary entrance score required to study engineering at university is due to the lower status of engineers in society, and this belief is strongly supported by this study (refer to research question 16 in para 2.7). An overwhelming proportion of engineers surveyed believed that the low societal status of the engineering profession in Australia contributed to high school leavers showing little enthusiasm for it. Unless this image is changed, the profession cannot attract the brightest students in Australia.

5.3.11 Strategies for managing transitions

The study highlights the importance of changes to the process of engineering education and emphasised the experiential learning strategy in managing the transition to management. This study concludes that the general lack of communication and teamworking skills among engineers can, to some extent, be alleviated by a shift in focus from the content to the process of engineering education (refer to research questions 10 and 21 in para 2.7).
It is generally believed that a heavy workload accentuates the focus on content, relatively ignoring the process of learning and teaching in education. Mirroring this concern, the majority of engineers suggested a reduction in the engineering content in the undergraduate engineering curriculum and a concentration on the development of generic professional competencies such as communication, teamwork and problem-solving skills. This study supports the policy of continuous, life-long learning for all engineers, as advocated by the Institution of Engineers Australia, in line with changes in the technology and needs of engineering.

The survey of engineers in Australia revealed that postgraduate management qualifications are the most popular strategy; engineers believe that they can improve their managerial skills. This finding, however, contrasts with that from the case study. The case study analysis indicated that a postgraduate management education is only helping engineers change the perceptions of top management about their management skills rather than directly contributing to an improvement in this area (Seethamraju & Agrawal 1996; also refer to para 4.4).

With no supportive data available regarding the effectiveness of management qualifications, it is not possible to draw a 'cause and effect' relationship between them and better management of transitions. While engineer–managers strongly supported postgraduate management education as a strategy, technical engineers appeared to be sceptical of the outcome of this. As expected, management-qualified engineers supported this strategy far more strongly than those with no management qualifications.

On the issue of organizational support strategies, the study reveals that providing support to those who return to technical roles and rewarding and encouraging superiors who provide assistance and guidance are the strategies most preferred by engineers in Australia (refer to research question 21 in para 2.7). This study highlights the need to support engineers who return to technical roles, given the perception that such a move
is regarded as a career failure by both the engineers themselves and by top management.

However, the significance of these findings is influenced by the variations between different subgroups of engineers. For example, electrical engineers were observed to differ significantly from mechanical and civil engineers on those aspects related to organizational support and management education (refer to research questions 22 and 23). The study found that electrical engineers concentrated on the individual strategies such as postgraduate management education, while mechanical and civil engineers preferred the option of seeking stronger and more effective organizational support by way of training and better management of experiential learning.

The study notes that engineers with management qualifications are more likely to regard postgraduate management education as a critical strategy, be more emphatic about changes being made to the educational processes in undergraduate engineering curriculum and be less dependent upon the organization for support than are those with no management qualifications.

Experiential learning strategies are by far the most frequently used strategies in managing the transition, whether or not they are supported by organizations. This study strongly emphasises the importance of experiential learning strategies such as job rotation, discussions with peers, and delegation and guidance from superiors, and confirms the overseas research findings of Hill (1992) and Badawy (1982). Though learning by interaction with superiors has been stressed in the case study (refer para 4.4), the survey findings do not strongly support this strategy. This may be due to engineers’ general perception of authority and power and their hierarchical orientation and generally recognised conservative approach to management.
5.3.12 Factors influencing the transition - a conceptual model

Based on case study and survey analysis, a model depicting the influence of various factors on the process of transition is proposed. These factors include individual factors (personality and occupational orientation), organizational factors (employment sector, organizational systems and policies, changing nature of work), educational factors (process, content and workload in engineering education, postgraduate management education, and secondary and primary school education) and societal factors (status of profession, professional formation, intensity of engineering and technology). Anecdotal evidence from this research suggests that these individual, organizational and educational factors simultaneously influence the process of transition, and affect each other, within the overarching influence of societal factors.

![Diagram of Factors influencing the transition](image)

Figure 5.1 A Model for the transition of engineers
This model helps in redesigning the engineering education at the undergraduate level incorporating variations in individuals and with specific consideration of the societal factors particular to a particular country. Similarly, it facilitates better development of organisational support mechanisms and management of experiential learning of the fresh engineering graduates by the engineering organisations. Understanding the interacting influence of these factors helps professional institutions like IE Aust and APESMA, in developing better links between the general public, engineering organisations and engineering schools and thereby enhance the public perception of the profession and value added by them to the society.

5.3.13 Differences between various groups of engineers

The most important contribution of this research is the observed differences between various subgroups of engineers. The study concluded that engineers are not a homogenous group and cannot be treated as such in developing policies and systems. Importantly, the study concludes that the job nature, management qualifications and the type of employing industry significantly influence engineers’ attitude towards managerial transition, engineering education, organizational support, status and strategies for managing transitions. The differences were discussed in the previous sections of this chapter, under appropriate subheadings.

In summary, the study concludes that engineers whose jobs are of a managerial nature, electrical engineers, engineers with management qualifications and engineers employed in manufacturing are, in general, proactive in anticipating changes and preparing themselves. They view transition as a natural career progression, consider people management as the most difficult and challenging aspect of transition, strongly support changes in engineering education, perceive their status in their organization as being relatively high, and take responsibility for preparing themselves for managerial positions.
5.4 General attitude towards transition

5.4.1 Introduction to analysis

The following analysis presents the responses of 756 engineers on various statements about the transition and answers main research question and its several sub-questions (refer to para 2.7). It analyses the responses of engineers on their general attitude towards transition centred on various research issues such as reasons for and problems in transition, 'soft' skills, career choices and preferences, and individual personality (refer to para 2.7). Their detailed responses to each of the statements in the survey questionnaire in terms of all five points in the scale—strongly agree, agree, neutral, disagree and strongly disagree—are given in appendix XIII.1.

5.4.2 Reasons why engineers move into management roles

On the issue of why engineers move into management roles, the literature review cited the increased pay and prestige associated with them as being the main motivating factors. From the answers to the research questions, the survey noted that about 69 per cent of engineers in Australia are attracted by the increased pay and perks offered with managerial positions. Furthermore, about 74 per cent felt that engineers who made the move are better compensated than those who remained in technical specialist positions.

Importantly, an overwhelming majority of the engineers indicated that a move into a management position in the organization opens up further avenues for career progression. While 87 per cent of the respondents felt that such a move would open up new leadership opportunities, about 79 per cent indicated that the ability to influence strategic business decisions at managerial level was an important motivator for the transition.
In the literature, some researchers in the USA and the UK argued that a dislike for the technological aspects of the work was a reason for the move into management. In fact, only about 12 per cent of the respondents felt that their move into management was the result of dissatisfaction with the technical aspects of engineering. Many engineers did not think that returning to the technical field following an unsuccessful managerial performance indicated failure. Also, about 62 per cent rejected the claim that the move into management was an escape route to avoid technological obsolescence.

This study therefore concludes that engineers in Australia are attracted to management more by its strategic influence, its status and the higher pay associated with the positions if offers than through dissatisfaction with the technical aspects of engineering work.

5.4.3 Difficulties and problems in transition

About 48 per cent of respondents felt that a move from the certainty of technical matters to the uncertainty of a non-engineering career was the hardest part of transition. A significant majority (76 per cent) said that people management is the most challenging and difficult part of their move into management roles.

In fact, people management was identified as a major problem for any specialist who made the transition into management. With about 80 per cent of the engineers involved in the supervision of people, it was not surprising that most of them indicated it as a problem. Importantly, the study found that people management was perceived as a problem by all engineers in Australia, irrespective of their age and levels of experience, and confirmed the previous research in the USA and the UK.
5.4.4 Importance of ‘soft’ skills—engineers’ perceptions

Although it is generally believed that ‘soft’ skills are rather more necessary in managerial roles than in technical positions and at higher levels of responsibility than at lower levels, the survey concludes that they are required at all responsibility levels and that all engineers should possess them. An overwhelming majority (90 per cent) of the respondents expressed the opinion that ‘soft’ skills are necessary at all the responsibility levels. Similarly, about 72 per cent of the engineers felt that ‘soft’ skills were necessary for engineering specialists working in highly technical areas such as design, R & D and technology. Most (about 66 per cent) of the respondents claimed that the career advancement of engineers was generally impeded more by their lack of skills with the human element than by their lack of technical ability.

The study therefore concludes that the general lack of ‘soft’ skills among engineers is a significant barrier for their career growth, whether they move into managerial roles or stay in engineering roles. This survey notes that the importance of having ‘soft’ skills has been well recognised in Australia and that engineers are generally well-prepared for change. It concludes that ‘soft’ skills are important for engineers at all responsibility levels and in all roles, whether they are specialist technical engineers, generalist engineers, engineer–managers or general managers.

5.4.5 Managerial work and engineering work

On the issue of their general attitude towards managerial/engineering work and its influence in making the transition, the survey revealed that about 54 per cent of the respondents were of the opinion that engineers move into management because of the higher pay rather than any specific aptitude and interest in managerial work. Nearly 46 per cent of those surveyed (28 per cent remained neutral and 18 per cent disagreed) did not confirm this opinion and indicated that they were more interested in prestige than other issues such as higher pay.
About 45 per cent of the engineers remarked that they saw no significant change after transition, as managerial tasks were considered to be an integral part of engineering work. However, a significant number of respondents (26 per cent) remained neutral and about 29 per cent completely disagreed with this view. There appears to be a diversity of opinion on these issues which is attributed to the differences in the nature of engineers’ work and other variables (refer to paras 5.10 and 5.11).

5.4.6 Natural progression

It is argued in the literature that management is an integral part of engineering work and that transition into management is a natural career progression. According to the survey, about 45 per cent of the respondents were of the opinion that there was no significant change even after transition, as management is an integral part of engineering work. The survey reveals that about 59 per cent of the respondents thought that it was a natural career progression, with another 50 per cent considering it the only way to achieve career progress. Consistent with this response, about 65 per cent of the engineers believed that it was essential to become a manager in order to have a satisfying career.

Though these responses are not overwhelming, the diversity of these opinions can mainly be attributed to the differences in their job nature, as explained in later sections (refer to paras 5.10 and 5.11). Analysis reveals that about 80 per cent of the engineers whose jobs were predominantly managerial overwhelmingly supported the statements on career progression, while only about 30 per cent of those with technical jobs supported them. Therefore, this study concludes that managerial engineers view management more as an integral part of engineering work and that transition is therefore a natural career progression.
5.4.7  Loss of engineering identity

Past research in the UK indicated that engineers fear losing their engineering identity by becoming managers. This study observed that about 56 per cent of respondents did not share this fear, with another 17 per cent remaining neutral. Only about 27 per cent believed that managerial work was alien to engineering and that engineers change and lose their identity once they become managers. Similarly, about 40 per cent of the engineers believed that their technical competence would be undervalued if they moved into management roles, while another 42 per cent did not believe so.

These findings seem to contradict the initial argument that management is an integral part of engineering. Because, if that is so, engineers moving into management roles do not necessarily lose their engineering identity and their technical competence is a sound basis for their management roles. Although these responses were not very strong, the diversity of opinion was attributed to the differing nature of the engineers' jobs and their employing industries, as explained in later sections (refer to para 5.10 for statistical significance).

5.4.8  Technical job knowledge

It is argued in the literature review that the technical skills gained through professional training and/or enterprise specific experience within organizations are equally important, even for managers. About 64 per cent of respondents felt that enterprise-specific technical knowledge was important for successful performance as an engineer–manager. This study confirms past research and points out the importance of technical job knowledge.
5.4.9 Timing of training in management skills

The survey reveals that the managerial content of an engineer's job increases with age and experience. This finding highlights the importance of training in management skills early in an engineer's career, rather than just before the move into management. Traditionally, training in management skills has been provided just before promoting engineers into management roles or when they are about to become engineer-managers.

This survey observes that about 79 per cent of the respondents suggested training at the beginning of an engineering career rather than just before moving into management roles. The perception is also established in the literature that there is less need for management skills training as the management content of the job increases. The study concludes that intensive management training for engineers is important and should be made available at the early stages of their career, not just before moving into management.

5.4.10 Move to generalist roles

Analysis of the responses indicated that about 69 per cent of respondents accepted the move to generalist roles that include non-technical functions. Though about 31 per cent agreed that they preferred to remain as technical specialists, about 40 per cent were undecided, reflecting the dilemma between the attractions of a management career and a technical comfort zone. According to the survey, while 64 per cent believed that engineers disliked the move, about 43 per cent of the respondents believed that the only way for their careers to progress was to become a manager. The fact that a considerable number of engineers still did not like to move from the technical side indicates the dilemma they faced.
5.4.11 Career path choices, preferences and satisfaction

Regarding career progression, 49 per cent felt that moving into management was the only way to achieve progress in their career, while 37 per cent held the opposite view. While about 59 per cent of respondents held the opinion that such a move was a natural career progression for engineers, about 65 per cent felt that a move into management was a significant step in achieving a satisfying career. This finding confirms the traditional view that management is an integral part of engineering work. However, about 39 per cent of the respondents did not share this view, with 22 per cent being undecided/neutral and only 19 per cent directly opposing it.

On career choice, the majority of engineers expressed a preference for engineering, as expected. About 61 per cent of respondents indicated that they would choose engineering if they had to make a career choice again. Interestingly, about 26 per cent expressed a preference for other professions such as accountancy, law, medicine and commerce, rather than engineering.

On the issue of engineers' professional satisfaction, the study observes that engineers derive satisfaction by advancing their careers within the organization rather than by external issues. The literature argues that, unlike other professionals, engineers are more oriented towards their organization than towards their profession. According to this survey, 68 per cent of respondents indicated that they derived professional satisfaction from career advancement rather than from professional recognition by peers.

This study therefore concludes that engineers in Australia are organization people, preferring career progression rather than professional recognition by their peers. However, on the issue of career path choices and preferences, the study does not provide any strong evidence and the variation in the responses can be explained by
analysing the differences between various subgroups of engineers (refer to paras 5.10 and 5.11).

5.4.12 Dual ladder

The literature review revealed that providing a separate technical career path is one of the strategies adopted by organizations in dealing with the transition. According to the study, about 44 per cent of engineers were of the opinion that engineers need a separate technical career path, while about 56 per cent remained neutral or disagreed. Further analysis of the engineers' responses revealed that engineers whose job was predominantly technical called for a separate technical path, while engineer-managers did not see the need for one. On the issue of rewards, the majority of the engineers (about 72 per cent) felt that technical ladders are generally less rewarding than managerial ladders in Australia. This study therefore concludes that the dual-ladder approach in Australia is ineffective.

5.4.13 De-engineering

De-engineering refers to the managerial approach whereby engineering qualifications as a specific requirement for management positions are no longer needed and the positions opened up to non-engineers as well. This trend apparently affected the chances of engineers reaching top management positions in engineering-based public sector organizations which are normally headed by career bureaucrats and other non-engineering professionals.

On this issue, only about 35 per cent of the engineers felt that an engineering qualification is a must for senior management positions in engineering-based organizations, while about 45 per cent of the respondents rejected this concept. This response could, in a way, also be interpreted as a reflection of the inability of engineers to influence change and their consequent acceptance of the changes implemented by
career bureaucrats and senior management in government. Further analysis of the responses revealed that the de-engineering trend is not an issue among engineers in general, except for the 10 per cent working in public sector organizations. This study therefore concludes that the de-engineering trend is not a significant issue in managerial transitions in Australia.

5.4.14 Nature of engineers

About 58 per cent of the respondents believed that engineers are better suited for management positions because of their analytical and numerical skills. However, 53 per cent indicated that engineers do not delegate tasks well, which is an essential skill for managers, according to the literature. Another aspect was the response to their concern with the human side of technology. The survey reveals that about 46 per cent of the engineers believed they are less concerned with the human side of engineering work, while another 34 per cent disagreed. This recognition of their weaknesses by the engineers themselves was well recognised in the literature and this study confirms the previous research findings.

5.4.15 Individual personality

The significance of the influence individual personality has in the attitude towards managerial transitions and in managing strategies is well established in the case study analysis and literature review. This survey reveals that an overwhelming majority (84 per cent) of engineers felt that individual personality played an important role in the success or failure of transition. Confirming the past research on occupational proclivities and general personality, the study concludes that individual personality influences the transition. Apart from the deployment of strategies for managing a successful transition, both at the individual and the organizational level, the success or otherwise of a transition depends to some extent upon the individual personality.
5.4.16 **Consequences of unwanted transitions**

The above findings, viewed in the context of a general trend of engineers progressing into management, highlights the problem of unwanted and unnecessary transitions. While engineers prefer to move into management in order to achieve the status, prestige and higher pay associated with it, their inherent dislike of managerial issues creates a dilemma. Consequently, there is the possibility of engineers who are neither interested in management nor have any aptitude for it eventually moving into managerial positions, with disastrous consequences for the individuals as well as for their organizations. Such a situation increases the possibility of a potential lack of fit between the engineer’s talents and the requirements of management, which is likely to result in personal frustration and poor organizational performance.

5.5 **Attitude towards engineering education**

5.5.1 **Introduction**

According to the literature, engineering education is one of the important factors that is expected to have a significant influence on the transition. In the research questions regarding engineering education, engineers were asked to indicate their perceptions of undergraduate engineering education and to suggest ways to improve it. Details of the responses are given in appendix XIII.2.

5.5.2 **Restrictive nature**

Engineers are a diverse group and their perceptions of engineering education are also diverse. Commenting on the utility of the present engineering course, about 59 per cent of the engineers believed that it helps them to be more focused and goal-oriented, especially in changing times. However, about 21 per cent thought that engineering education in fact acts as a constraint in making the transition into management.
Interestingly, on this issue, about 43 per cent of the respondents remained neutral and only 36 per cent of the respondents disagreed, stating that engineering education is not a constraint at the workplace. Therefore, it can be concluded that the perceptions of engineers about their education vary according to factors such as the nature of their job, the employing industry and other factors. The differences and their statistical significance are discussed in later sections (refer to paras 5.10 and 5.11).

5.5.3 Non-technical content of undergraduate curriculum

On the issue of increasing the non-technical content of undergraduate courses, about 56 per cent of the respondents believed that such content prepares engineers better for a career in management. It is important to note that the average age of respondents was 40 years and that these professionals would have been studying for their engineering degrees in the early 1980s. Subsequent to that period, as discussed in the literature review section (refer to para 4.4.4), the non-technical content of the undergraduate engineering curriculum has risen to between six and ten per cent in many of the universities in Australia.

It is argued in the literature review that engineers don't realize the importance of non-technical subjects until they start practising. The literature points out that engineering students generally prefer specialist technical subjects to non-technical subjects, which they perceive as neither relevant nor useful for their engineering careers. This survey confirms that engineers generally neglect non-technical subjects while studying engineering. About 65 per cent of the respondents considered that they did not realize the importance of these non-technical subjects while they were at engineering school.

Although this aspect has been established in the survey, a review of the qualitative comments reveals other factors that are responsible for engineers' general lack of interest in non-technical subjects. According to the survey, this apparent disinterest can be attributed to the general weaknesses in multidisciplinary teaching in
universities and the processes adopted in teaching these non-technical subjects. With cooperation between faculties usually being low, there is also no proper understanding and appreciation of issues affecting other faculties. For example, it is argued in the literature that faculties of commerce and business do not have an appreciation and understanding of technological/engineering issues, while faculties of engineering do not seem to acknowledge the human side of technology and its role in the broader business context. Without such understanding by and between faculties and academics, engineering students tend to dismiss non-technical subjects as impractical and subjective.

Even if they are exposed to some hours of class contact in subjects such as sociology, psychology, economics and business management, engineering students cannot see any meaningful connection between these subjects and their engineering education, the survey pointed out. In the academic environment, the longstanding prejudices of educators and academic politics make understanding even more difficult. Though it seems to be improving, interdisciplinary cooperation between the various faculties is a low priority for many academics. This is especially so in an environment of budget cuts, where faculties are competing for student numbers to retain and improve their funding.

The survey therefore concludes that an increase in the non-technical content of their undergraduate curriculum may in itself not achieve the desired outcome of improved ’soft’ skills among engineers. It is essential to create an awareness of their importance among engineering students and to encourage an interest in those subjects by modifying the educational processes.

5.5.4 Accentuation of professional mentality

About 50 per cent of the respondents believed that the very nature of the engineering curriculum created the inadequacies in ‘soft’ skills. Similarly, half the respondents
indicated that it underdevelops managerial skills among engineers and further accentuates the ‘professional mentality’ as against broader development. The majority of respondents expressed the belief that a heavy emphasis on quantitative issues made engineers inadequate in soft skills.

It was acknowledged by the respondents that a good academic performance in engineering school does not lead to a successful practice. About 34 per cent disagreed with the statement that good practising engineers have a good academic performance at university/college, and about 26 per cent remained neutral. However, about 40 per cent of the respondents believed that academic performance leads to successful practice at the workplace, thus endorsing the engineering education.

Though positive assertions are not overwhelmingly high on these aspects, it can be safely concluded that engineering education accentuates analytical skills at the expense of ‘soft’ skills. These findings confirm the earlier studies in the USA and reinforce the importance of the relationship between educational processes adopted in teaching and learning, and the outcomes in terms of skills acquired by students. Once again, it is to be noted that the lack of a dominant pattern on this issue can be explained by the differences between engineers regarding discipline, nature of job, qualifications, training and other variables (refer appendix 5.10 and 5.11).

5.5.5 Process of engineering education

An overwhelming percentage of engineers (about 81 per cent) felt that the engineering curriculum gave less emphasis to the development of communications skills. About 70 per cent observed that the emphasis on group work in the form of assignments, projects or exercises was considerably less in engineering courses than in other courses.
On the process of teaching and learning, the majority of the respondents preferred a change in strategy. For example, about 65 per cent preferred an increase in group assignments in order to develop the teamworking and communication skills that are essential for success in the modern workplace. Similarly, about 58 per cent stressed the need to place engineering students in work assignments to help them develop these ‘soft’ skills. While about 48 per cent of the respondents called for multidisciplinary teaching, about 76 per cent agreed that an increase in group seminars and/or presentations would help engineers refine their communication skills.

Thus a significant percentage of respondents preferred a change in the process of teaching and learning in undergraduate courses, and not just an increase in the management content, as advocated in the past.

This finding has significant implications not only for the teaching of the non-technical content of the undergraduate curriculum, but also for the teaching and learning process adopted, even in technical subjects. The survey stressed the need for an increase in the number of group assignments, oral presentations and seminars, including for technical subjects. Several engineers made comments about the process of education in engineering schools and expressed disappointment with the emphasis placed on the overall development of individuals in the engineering course, when compared with other undergraduate courses. For example, many of them indicated that they only carried out one or two group projects and no more than one oral presentation/seminar throughout their four-year engineering course. Although this low number is apparently improving, the heavy emphasis on the technical content and its ever-increasing growth do not allow enough flexibility for academics to modify their teaching and learning strategies.

Thus it is clear from this study that the focus must be on the process of teaching and learning rather than simply on content in undergraduate engineering courses.
5.5.6 Heavy workload

Another issue this survey brings up is the heavy workload in engineering courses. It is generally perceived that the workload in undergraduate engineering course is generally higher than a comparative course in science, commerce or business. As it is, engineering courses in Australia are one year longer than other undergraduate degree courses, such as commerce, science or humanities, generally are. In addition, the number of contact hours per semester is also considerably higher in engineering than in other courses, thereby limiting the time available for students to develop other skills or spend extra time on projects or assignments. Normally, a typical engineering course has 25 contact hours per week, as against about 12 to 16 hours for a business/commerce course.

Confirming these figures and community perceptions, the survey revealed that an overwhelming 83 per cent of respondents felt that the workload is heavier than in comparable undergraduate courses. On the effect of such a heavy workload, the majority of engineers believed that it inhibits the development of ‘soft’ skills. The study thus concludes that the heavy workload in the engineering curriculum has a significant effect on the overall development of engineers.

5.5.7 Engineering recruits

Engineering is not an attractive option for high school leavers, as the benefits in terms of status and compensation are not considered commensurate with the effort required to obtain the necessary qualifications. The perception of a high workload in engineering school and the comparatively low compensation appears to be affecting the recruitment of high school leavers into engineering courses. For example, as pointed out in the literature review, recruits into engineering in Australia have
relatively low tertiary entrance scores when compared with those entering other professions such as accounting, law and commerce/business.

About 44 per cent of the engineers surveyed were of the opinion that engineering recruits generally lacked ‘soft’ skills. The survey, while acknowledging the accentuation of these inadequacies by engineering education, raises other factors, such as the status and importance attached in high school to subjects such as mathematics and physical sciences that are traditionally considered prerequisites to engineering. It is beyond the scope of this research to discuss the influence of the quality of engineering recruits on engineering education and subsequent professional formation.

5.5.8 Differences between various groups

On certain issues, the attitude towards engineering education is well spread on the continuum, and is influenced by variables such as job nature, employing industry and discipline (refer to paras 5.10 and 5.11 for details).

5.6 Organizational support

5.6.1 Introduction

A summary of the overall responses concerning organizational support are given in appendix XIII.3. The following discussion presents the attitude of engineers towards various issues.

5.6.2 Utilisation of engineers

The study reveals that the skills and knowledge of engineers are relatively underutilised. About 42 per cent of the respondents indicated that engineers are underutilised in their organization. This finding confirms past research in Australia
and highlights the perception of employers. The study notes that engineers are employed as providers of simple technical services and are perceived to be unsuitable to take on broader management responsibilities.

5.6.3 Incidence of dual-ladder approach

The survey observed that only 23 per cent of organizations have some form of dual-ladder approach for managing the careers of engineers. However, a significant majority (72 per cent) of the respondents believed that the technical ladder is less rewarding than the managerial ladder. Interestingly, a large proportion of engineers were of the opinion that the separate technical ladder was predominantly used to accommodate those engineers who were unsuccessful in their attempts to move into managerial. Thus it can be implied that engineers generally associate managerial progression with status and prestige within the organization and do not view the technical ladder as an effective alternative. This research concurs with the conclusions drawn from overseas research on the ineffectiveness of having a separate technical career path, and highlights the non-existence to a large extent, and the ineffectiveness, of the dual-ladder approach in Australian organizations.

5.6.4 Support provided to engineers in transition

The study found that only 36 per cent of organizations prepared engineers for future management roles. While 56 per cent of the respondents indicated that their organizations encouraged them to acquire postgraduate management qualifications, another 32 per cent had a different point of view. Only 24 per cent of the respondents indicated that their organizations provided the necessary training to make the transition, and it appeared that the responsibility of acquiring management skills was left completely to the individual engineer. Overall, the survey concluded that the support that organizations provided to engineers to make the transition into
management was insignificant, and that the responsibility, by and large, was left to the individual.

Although it may not be an appropriate indicator of their future performance in managerial roles, many organizations base their assessment of whether or not an engineer is suitable for promotion into management on that engineer’s present technical performance. About 50 per cent of the respondents in the survey stated that their organizations consider technical performance as the basis for promoting engineers into management positions.

The likelihood of engineers performing successfully in managerial roles is linked to their generally successful performance in any of the roles given them, including technical roles. Confirming this perception, 56 per cent of the respondents thought that success in technical roles increased the probability of success in management roles. The study notes that the probability of success in managerial roles increases with success in technical roles.

5.7 Attitude towards status of engineers

A summary of the engineers’ responses on the questions relating to their status is presented in appendix XIII.4. It is argued in the literature that self-image of status and the status bestowed by others such as the general public and top management coincide in the case of engineers. The survey revealed that a majority (about 56–68 per cent) of engineers ranked their profession much lower than that of accountants, economists and marketing professionals within an organization.

When considering salary as an indication of status in an industrial society, about 61 per cent of engineers surveyed believed that their compensation was not relative to their contribution to society. Though there are no accurate ways of measuring the contribution made by any profession to society, it is particularly difficult in the case of
engineers, as their contribution tends to get mixed up with that of technology in general. However, the salary levels of engineers seem to compare well with those of other professions in Australia (as pointed out in the literature review section). In spite of that, it appears that engineers perceived a low status for themselves.

The reason for the relatively lower entrance score required to be accepted for undergraduate engineering courses in Australia is attributed to its status. According to the study, 72 per cent of respondents believed that the low status of the profession contributed to the low preference high school leavers gave it. Thus this survey suggests a link between the status of the engineering profession and the low interest that high school leavers show in studying engineering.

Though the finding is not significant, about 38 per cent of respondents felt that their senior management did not consider them suitable for senior management positions, while about 37 per cent had the opposite view. Similarly, on the issue of status within the organization, engineers felt that they had less influence than other occupations such as accountancy, marketing and economists. For example, about 61 per cent believed they had less influence than accountants in organizational decision-making, while 48 per cent thought they had less influence than marketing professionals. About 52 per cent believed they had less influence than the economists in their organizations.

In general, the survey revealed that engineers’ perception of their status within an organization is influenced to some extent by the nature of their job nature, with ‘managerial’ engineers perceiving a higher status than the technical engineers.

Pointing out the importance of status in a successful transition, the majority (68 per cent) of respondents believed that the higher the status of engineers in organizations, the greater the probability of their success in their transition into management roles.

Thus, analysis suggests that this low self-image, together with the perception of top management, perpetuates the low status of engineers in organizations. It appears that
engineers are treated at best as trusted workers with a little more additional prestige and privilege compared with other technical and non-technical employees. This perception of an engineer’s inability to reach top management positions plays a significant role in diminishing the importance of the engineer in the organization.

5.8 Strategies for managing transitions

5.8.1 Introduction

Various strategies are employed for managing the transition into management both at the individual and the organizational level. Responses on the various strategies commonly employed were collected from engineers and the results are summarised in appendix XIII.5.

5.8.2 Postgraduate management education

On the subject of postgraduate management qualifications, about 67 per cent of the respondents thought that acquiring tertiary qualification in management helped engineers manage transition better. In support of this statement, about 31 per cent of the respondents indicated that studying for an MBA is an important strategy. About 24 per cent of engineers surveyed indicated that they had either acquired or were in the process of acquiring a tertiary qualification in management. In fact, about eight per cent of the respondents (60 engineers) had already acquired or were in the process of acquiring an MBA. Similarly, about 13 per cent of the respondents had acquired a Graduate Diploma in management. The study observes that engineers, fairly convinced of the importance of tertiary qualifications in management, are increasingly pursuing this path to help them in making the transition.
5.8.3 Changes in engineering education

The study reveals that a majority of engineers supported changes in undergraduate engineering education. Importantly, most respondents felt that a change in the process of engineering education is more important than the mere content. The literature points out that engineers in general lack communication and team-working skills and feel inadequate at the workplace in technical roles as well as in managerial roles. Hitherto, most past studies have concentrated on increasing the management content from four per cent to 10 per cent or 15 per cent in order to develop the ‘soft’ skills, with relatively little attention paid to the educational processes.

Reflecting concerns about process, about 76 per cent of respondents suggested that the number of seminar/presentations in undergraduate courses must be increased in order to improve the communication skills of engineers. Similarly, about 74 per cent of respondents stressed the need for increasing the number of group assignments or projects in undergraduate courses, for improving opportunities for group working and improving the group skills of engineers. Another 58 per cent of respondents supported the introduction of multidisciplinary teaching or cross-faculty teaching.

Only 42 per cent of respondents suggested an increase in the management content of undergraduate engineering courses, while about 45 per cent of respondents strongly rejected this strategy and another 13 per cent remained neutral. As argued in the literature review, the management content has already been increased in universities to the required level of 10 per cent, with no apparent impact on the performance of engineers at the workplace. This finding thus supports the shift in focus to the process rather than just on the content of engineering education.

It is argued that the workload in engineering courses is very heavy and highly focused on the engineering content. Mirroring their concerns about the engineering content, a majority (72 per cent) of respondents felt that it should be reduced. With the ever-
increasing expansion of knowledge, it is almost impossible to include all the latest developments in engineering in the four-year curriculum and, at the same time, provide a broad basic knowledge of engineering. Therefore, by reducing this engineering content to certain core issues, some time may be freed up for engineering students to concentrate on developing other broader professional skills. In any case, it is generally believed that the technical knowledge gained at university would become obsolete within five years, considering the knowledge and technology gap that exists between industry and academic institutions. It can therefore be argued that the general core of engineering principles should feature more strongly in the curriculum rather than the latest developments.

This study concludes that placing emphasis on the process of teaching and learning in the undergraduate curriculum by increasing the opportunities for seminars and group working is far more important than increasing the non-technical content; such an emphasis would encourage the development of ‘soft’ skills among engineering graduates.

5.8.4 Organizational support systems and policies

The role that organizations play in terms of appropriate support systems and policies to assist the transition is well-known in the literature. Regarding statements on the support that organizations could be expected to provide, a significant majority of the respondents indicated that providing support to those who return to technical roles, and rewarding and encouraging superiors to provide assistance and guidance, were the most preferred strategies.

The study identifies the need to support engineers who return to technical fields after unsuccessfully attempting management roles. An overwhelming majority (82 per cent) of the engineers believed that this kind of support is essential. Such overwhelming support for this strategy is understandable, given the perception of the engineers
themselves and of senior management that returning to the technical field is a career failure.

Organizations must realize that not every engineer or, for that matter, any specialist, is cut out for management. Organizations must take a certain risk-taking attitude and try engineers out in managerial roles, with no stigma attached to those who return to the technical field. The perception that a separate technical ladder helps unsuccessful engineer—managers also seems to reinforce this.

About 80 per cent of the respondents believed that rewarding superiors who provided assistance to new engineer—managers is an important strategy. Though not significant, about 51 per cent of them suggested providing opportunities for aspirants to take on small managerial assignments on a trial basis.

A majority of engineers (about 72 per cent) indicated that the basis for promoting engineers into managerial roles must be their management potential and orientation rather than their current technical performance. It is important to realize that not every engineer will want to be, or will be, an effective engineer—manager. It is important to differentiate between those engineers who have the potential and motivation to succeed in managerial roles and those who want to make the transition to achieve higher compensation and status within the organization.

On training, about 78 per cent suggested short training courses on specific areas/skills, while 74 per cent preferred specially designed training programs to assist the transition. Off-the-job training has been a traditional tool in providing management skills to engineers. Though training is necessary, as discussed in the previous section (para 5.4.9), its timing is critical. The survey noted that the training in managerial skills given at the beginning of an engineering career is more effective and useful than training given just before the move into management.
5.8.5 Experiential learning

Experiential learning strategies are by far the most frequently used strategies in managing the transition, whether they are supported by organizations or not. The literature review suggested that managing transition is the responsibility of not only the individuals but also their organizations. The survey found strong support for strategies such as job rotation, discussions with peers, and delegation and guidance from superiors, which confirmed the findings of overseas research by Hill and Badawy, as reported in the literature review section.

For example, 79 per cent of the respondents suggested special projects/assignments that were managerial in nature, 65 per cent supported job rotation, and 68 per cent recommended that superiors delegate some managerial tasks. Similarly, 64 per cent of the engineers suggested direct promotion to management roles, thereby allowing the manager to learn on the job by experience.

Learning through daily interaction with superiors and colleagues is another aspect of the experiential learning strategy recommended in the literature. About 67 per cent of the respondents considered that feedback through constructive criticism was a useful strategy. The survey observed that only about 46 per cent suggested seeking advice and help from a superior, while about 62 per cent supported learning through discussions with colleagues. The relatively weak support given to the concept of seeking advice from a superior is worth noting; this may be due to the traditional beliefs of engineers about hierarchical structure and their general perceptions about authority and power. The literature review also supports the argument that engineers are, in general, hierarchically oriented. These perceptions, then, might have created a barrier between the superior and the engineers which discouraged the latter from seeking advice from the former. In addition, fear of having one’s weak points being revealed to one’s superior, who has the traditional role of performance appraisal, might act as a further deterrent.
5.8.6 **Individual development**

The importance of the personality of the individual and his/her motivation to acquire management skills is recognised in the literature. The literature review argued that individual personality plays an important role in managing transitions. Learning based on personal motivation and acquired through self-development is therefore an alternative strategy for the individual. In support of these assertions, the survey indicated that about 69 per cent of the respondents preferred learning by observing and experimenting, and reflecting on past experiences. Interestingly, only 42 per cent supported learning based on reading and interpretation of theoretical knowledge, which is purely an individual-based strategy.

5.9 **Factors influencing the transition - a conceptual model:**

Analysis of case study and survey data revealed the influence of several factors on the process of transition. These factors that are identified from the study are grouped into four categories, viz., individual factors, educational factors, organizational factors, and societal factors. A conceptual model depicting the relationship between these factors and the process of transition is developed and presented below.
In this model, factors that are individual based include personality, occupational orientation, and general attitude. Similarly factors that are specific to a particular organization include industry type, promotional policies, changing nature of work, de-engineering trend, dual ladders, and utilisation of engineers. Educational factors include process, content and workload in engineering education, postgraduate management education, quality of engineering recruits, and secondary and primary school education. Similarly there are some factors that are specific to a particular nation or society which include general status of engineering profession in that country, professional formation in that country, intensity of engineering and technology, general image of engineers in the society, proportion of public sector
engineers, value added by engineers to the society, occupational control and industrial relations system.

Anecdotal evidence from this research suggests that these individual, organizational and educational factors simultaneously influence the process of transition, and affect each other, within the overarching influence of societal factors. For example, the generally negative image of engineers in Australian society, reinforces the unsuitability of engineers for top management positions by both senior management or employers and the engineers themselves, which are specific to a particular organization. Similarly this negative image also influences the attractiveness of engineering education. Study found that the educational factors such as process, content and workloads in engineering education underdevelop soft skills among engineers and further accentuates narrow professional mentality as against broad development. Study revealed that the utilisation of engineers, which is specific to a particular organization, is influenced by the general image and societal status of engineers, and viewed by employers as simple providers of technical services.

Study points out that the transition is influenced by individual occupational proclivities (orientation towards a particular occupation). It provides anecdotal evidence to the argument that some engineers have better potential than others to succeed in managerial roles due to their individual personalities, social background and attitudes. The interacting influence of societal and individual factors on the process of transition is evident from this finding.

According to this study, higher the status of engineers within the organization, better the probability of success in managerial roles. A general belief that the lower tertiary entrance score required to study engineering at university is due to lower status of engineers in society, is strongly supported by this study. Study also found that the perception of engineers’ status held by senior management was high in the manufacturing and consultancy sectors when compared with the government sector.
Thus the organizational factor represented by the industry type, and the educational factor represented by lower tertiary entrance score, are observed to have influence on the status, a societal factor and on the transition.

On the issue of post-graduate management qualifications, study found that acquiring management qualifications helped engineers counter the general perception of their lack of managerial skills, but also enhanced their chances for promotion into management roles. Study emphasised the continuous life-long learning philosophy, well accepted by the profession in Australia. Study found that management qualification is one of the powerful predictor of engineers' attitude towards various issues relating to transition. By acquiring management qualifications, study asserts that it is possible to manage the transitions successfully and enhance the societal status of engineers in general. The study confirms the importance of postgraduate management education for engineers in improving their managerial performance, and generally supports the popular trend in Australia. Thus, the interacting influence of educational factor on the societal status of engineers, as well as on the transition is established in the study.

Though not well supported statistically because of the low sample of female engineers, this study confirms the influence of gender differences on the process of transition. The differences between various groups of engineers in terms of their predominant job nature, engineering discipline, type of employment sector, and management qualifications further highlight the interacting influence of the individual, educational, organizational and societal factors.

Understanding of the interacting influence of these factors, helps in redesigning the curriculum and teaching and learning strategies of undergraduate engineering education. This reengineering of the engineering education curriculum will focus on the process issues of teaching and learning and variations in the individual learning styles, and occupational proclivities of the engineering recruits. At the individual level,
engineering practitioners who are interested in making the transition, can go for postgraduate management education in engineering management and achieve career growth as well as the enhancement of their status in the society in general.

Engineering organisations can take an integrated approach to their engineering graduate training as well as management training for middle level engineers. This can be achieved by designing and providing support mechanisms for effective experiential learning as well as for effective management of the transitionary phases. Engineering organisations can design and implement appropriate human resource management policies that encourage management education for engineers for those interested in making the transition and support for those specialising in technical areas. This model, facilitates better development of organisational support mechanisms and management of experiential learning of the fresh engineering graduates by the engineering organisations.

Understanding the interacting influence of these factors helps professional institutions like Institution of Engineers Australia (IE Aust) and Association of Professional Engineers Scientists and Managers Australia (APESMA), in developing better links between the general public, engineering organisations and engineering schools. Well established communication and interacting links will enhance the public perception of the profession and the value added by professional engineers to the society.

5.10 Relationship between various variables

5.10.1 Introduction

In order to answer the second research question on the differences between various groups of engineers, an analysis of the relationships or associations between them was carried out. Identification of the relationships or associations between two subgroups
of engineers helps to predict other characteristics and the influence these variables have on various aspects of transition.

As explained in the methodology chapter (refer 3.5.7), the Chi-square test of independence with Pearson chi-square statistics was used in cross-tabulations, to test the hypotheses that the row and column variables are independent. Considering the possibility of type I and type II errors, as explained in the methodology section, a significance level of 0.01 for large samples and 0.05 for smaller samples was considered in this analysis, to reject the null hypothesis of no association.

Detailed information about the proportion of nominal variables such as discipline of engineering, nature of the job, age group, gender, management qualifications, experience, employing industry and number of employees supervised were given in appendix XII. A summary of the results of those tests are presented here.

5.10.2 Cross-tabulations—discipline by other nominal variables

In the cross-tabulations, the hypothesis that the engineering discipline and other nominal variables were independent was tested for significance using the Chi-square test. The analysis reveals that the hypotheses that the engineering discipline and the variables—country of qualification, age, employing industry and managerial experience—are independent is rejected. It means that the proportion of respondents in one engineering discipline (with reference to the above nominal variables) is significantly different from that in another discipline. The proportion of the respondents in different subgroups of the above variables indicates the extent of these differences (see appendix IX). A summary of the results is presented below.
Table 5.2: Summary of cross-tabulations between discipline and other nominal variables

<table>
<thead>
<tr>
<th>Discipline and other nominal variables</th>
<th>Pearson chi-square statistic</th>
<th>Significance level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discipline and job nature</td>
<td>1.425</td>
<td>0.839</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and gender</td>
<td>5.457</td>
<td>0.177</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and country of qualification</td>
<td>10.111</td>
<td>0.005</td>
<td>Yes</td>
</tr>
<tr>
<td>Discipline and employing industry</td>
<td>87.22</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Discipline and age group</td>
<td>15.60</td>
<td>0.0016</td>
<td>Yes</td>
</tr>
<tr>
<td>Discipline and mgmt. qualifications</td>
<td>5.52</td>
<td>0.238</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and technical experience</td>
<td>5.83</td>
<td>0.666</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and managerial experience</td>
<td>19.31</td>
<td>0.111</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and employees supervised</td>
<td>17.48</td>
<td>0.025</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and levels above</td>
<td>7.647</td>
<td>0.469</td>
<td>No</td>
</tr>
<tr>
<td>Discipline and levels below</td>
<td>16.84</td>
<td>0.032</td>
<td>No</td>
</tr>
</tbody>
</table>

5.10.3 Cross-tabulations—job nature by other nominal variables

The hypothesis that the job nature and other nominal variables are independent was tested for significance using the Chi-square test in cross-tabulations. The analysis reveals that the hypotheses that the nature of the job is independent of other nominal variables is rejected, except for engineering discipline and country of undergraduate qualification. An examination of the proportion of engineers, with reference to the job nature and the above variables, and discipline and other variables, reveals the relationships between them, as discussed in subsequent sections. A summary of the results is presented below.
Table 5.3: Summary of cross-tabulations between job nature and other nominal variables

| Job nature and other nominal variables | Pearson chi-square statistic | Significance level | Relation
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Job nature and engineering discipline</td>
<td>1.425</td>
<td>0.839</td>
<td>No</td>
</tr>
<tr>
<td>Job nature and gender</td>
<td>6.836</td>
<td>0.032</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and country of qualification</td>
<td>0.923</td>
<td>0.623</td>
<td>No</td>
</tr>
<tr>
<td>Job nature and employing industry</td>
<td>22.17</td>
<td>0.0011</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and age group</td>
<td>28.79</td>
<td>0.0003</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and management qualifications</td>
<td>16.21</td>
<td>0.0027</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and technical experience</td>
<td>70.78</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and managerial experience</td>
<td>283.66</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and employees supervised</td>
<td>85.07</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and levels above</td>
<td>36.50</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Job nature and levels below</td>
<td>39.03</td>
<td>0.000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

5.10.4 Gender

Though the subgroup of female engineers was small (16), analysis revealed that the distribution pattern of gender by job was not similar. For example, the nature of the jobs of a significant proportion of female engineers was predominantly managerial (50 per cent), whereas the proportion of male engineers who have jobs of a managerial nature is only 22 per cent (refer appendix XII.4). The distribution of gender by engineering discipline, however, is similar (refer appendix XII.5).

Overall analysis indicated that about 98 per cent of engineers are male, reflecting a generally low proportion of female engineers in the Australian engineering population. The total female membership of the IE Aust., from which the respondents were drawn, was only 2980 (about 4.8 per cent of total membership) (Engineers Australia, November 1995: 30).
5.10.5 **Country of qualification**

Analysis indicated that about 20 per cent of professional engineers have obtained their professional qualifications overseas (refer appendices XII.6 and XII.7). It can be seen that these overseas-qualified engineers are spread equally among the various categories of job nature. However, the picture changes if the data is analysed by branch of engineering. The number of electrical/electronics engineers in the overseas-qualified category is significantly higher than the number of civil or mechanical engineers in that category, reflecting a higher level of skilled migration.

5.10.6 **Type of Employing industry**

It could be expected that enterprise-specific knowledge, organizational culture and the management systems specific to a particular industry would have an influence on the professional formation of engineers. Data about the employing industry was collected in four broad categories—manufacturing, government, consultancy and other services sectors. Overall, about 35 per cent of respondents worked in the manufacturing sector, another 33 per cent in consultancy organization, 23 per cent in government and the remaining nine per cent in service organizations (refer to appendices XII.8 and XII.9).

As indicated in tables 5.2 and 5.3 above, among the four industry groups, there were significant differences in the distribution pattern for each of the civil, mechanical and electrical/electronics groups; and for each of the categories for nature of job, ie, technical, managerial or an equal mix of technical and managerial. For example, about 30 per cent of the engineers working in consultancy had a predominantly technical job, while in manufacturing, only 16 per cent had a technical job. Similarly, a higher proportion of technical engineers were found in the consultancy sector, as expected, and a higher proportion of ‘managerial’ engineers in the manufacturing sector. Most civil engineers were in the government and consultancy sectors, while most
Mechanical engineers were in manufacturing. This reflected the trend expected for engineering employment in Australia.

5.10.7 Age groups

It is argued in the literature that engineers progress into managerial roles with age and enterprise experience. An analysis of age and nature of the job revealed that the managerial content of engineers' work increases with age. For example, only 12 per cent of respondents in the age group 'up to 30 years' were in managerial jobs, whereas about 24 per cent aged over 40 were in management (refer to appendices XII.10 and XII.11). The proportion of engineers whose jobs are technical decreased with their age. Therefore, it can be concluded that the number of engineers moving into management roles in Australia increases with their age, confirming similar trends in the USA and the UK.

5.10.8 Management qualifications

Acquiring management qualifications is by far the most popular strategy employed by individual engineers in Australia who wish to obtain management skills. In confirmation of this, the survey revealed that about 24 per cent of respondents had acquired or were in the process of acquiring postgraduate management qualifications, and another 10 per cent were acquiring qualifications in arts or the social sciences. About 64 per cent of engineers had no management-related qualifications (refer to appendices XII.12 and XII.13).

As indicated in tables 5.2 and 5.3 above, among the three groups of management qualifications variables, there were significant differences in the distribution pattern for each of the job nature categories. However, there were no differences by discipline in engineers' propensity to acquire management qualifications.
A closer analysis of this data by job nature revealed that about a third of the professional engineers whose jobs were predominantly managerial had management qualifications, while only about a quarter of those who had an equal mix of both technical and managerial work had studied management in their postgraduate courses. As expected, the study indicates that about 76 per cent of technical engineers did not perceive any need for management qualifications. The study concludes that 'managerial' engineers (engineer-managers) have a greater propensity to acquire management qualifications than have technical engineers, and that engineers perceive the need for such qualifications as the managerial content of their jobs increases.

Though the differences between the three disciplines of engineering under study are not statistically significant (as indicated in table 5.2), the study reveals that about 20 per cent of civil engineers have postgraduate qualifications, while about 30 per cent of electrical/electronics engineers have similar qualifications. It is important to note this difference in the context of previous research findings, wherein it was argued that electrical/electronics engineers in general do not perceive the need for management education, as their work extensively involves technical work when compared with other disciplines. For example, Williams (1988) observed that the electrical/electronics/electronic engineers were relatively less enthusiastic about management education in engineering than were mechanical or civil engineers.

Therefore, the Mann-Whitney test for two independent samples was carried out. It indicated that the distributions between electrical/electronics and civil engineering disciplines was not same. Test results indicated that the hypothesis that they are similar was rejected at 0.05 significance level. Although not conclusive, it appeared that electrical/electronics engineers have a much greater propensity to acquire management qualifications than the other two disciplines. This research finding, although not conclusive, contradicts the Williams' findings, and reflects the changing perception engineers have about management education.
This change in the perception of electrical/electronics engineers appears to have come about as result of deregulation and competition in the telecommunications sector in Australia. Deregulation and competition resulted in the elimination of middle management positions and an expansion of engineers' roles into such non-technical areas as customer relations, management of technology, business planning, management of technical staff and management of change. It can be argued that these changes acted as catalysts in reshaping the perception of electrical/electronics engineers on the need for management skills. Importantly, this finding indicates that there are some differences between electrical/electronics engineers and civil/mechanical engineers.

5.10.9 Technical experience

Respondents were asked to indicate the years of technical experience they had accumulated. The survey revealed an average technical experience of 14 years. Analysis revealed (refer to tables 5.2 and 5.3) significant differences in the distribution pattern of technical experience for each of the job nature categories, whereas no differences were noted when analysed by discipline of engineering.

The average number of years of technical experience by job nature for technical, managerial and 'both equal' categories of engineers were 18.1, 11.7 and 15.8 respectively, with standard deviations of 8.8, 6.5 and 7.7 respectively. From the cross-tabulations analysis (as given in table 5.2) and the average data, there appeared to be a difference in the technical experience profile of engineers by their job nature (refer to appendix XII.14).

The average number of years of technical experience of civil, mechanical and electrical/electronics engineers were 15.3, 15.8, and 14.9 respectively, with standard deviations of 8.0, 8.4, and 7.1 respectively (refer to appendix XII.15). The cross-
tabulations and the average data indicated no apparent differences in the technical experience profile of engineers in the different disciplines.

It can be observed from the survey data that more than 92 per cent of respondents in the survey had experience exceeding five years, with about 22 per cent having more than 20 years of technical experience. This result was expected, as the survey was carried out among members of the Institution of Engineers Australia, who should have experience before being graded corporate members of the institution.

The literature review indicated that managerial work increased with experience. It was clear from the survey analysis (refer appendix XII) that engineers move into management positions after acquiring some experience in technical positions. For example, 96 per cent of technical engineers had more than five years' technical experience, while 83 per cent of the engineer-managers had more than five years' technical experience. While about 70 per cent of technical engineers had over 10 years' experience in the technical area, only 50 per cent of engineer-managers could be placed in that category. This analysis implies that there are two clearly separate career paths for engineers in Australia, one moving into the technical area and the other moving into management after the acquisition of some technical experience.

5.10.10 Managerial experience

The survey revealed that the average managerial experience of the respondents was 7.5 years. Cross-tabulations analysis and the data (refer to tables 5.2 and 5.3) revealed significant differences in the distribution pattern of managerial experience for each of the job nature categories. However, no such differences were found to be significant when analysed by their discipline of engineering.

Analysis indicated that the average managerial experience of engineers in the technical, managerial and 'both equal' categories was 2.8, 13.1 and 8.8 years, and their
standard deviations were 4.97, 7.82, and 6.75 respectively. As was expected, ‘managerial’ engineers had the greatest and technical engineers had the least managerial experience, with the ‘both equal’ category falling somewhere between the two. About 20 per cent of the ‘technical’ engineers had more than five years’ managerial experience, while more than 80 per cent of the ‘managerial’ engineers had more than 5 years’ managerial experience (refer to appendix XII.16)

The average managerial experience of civil, mechanical and electrical/electronics engineers were 7.3, 9.4, and 8.5 years respectively, with standard deviations of 7.1, 8.0, and 7.1 respectively, indicating the wide spread of the distribution. From this data, as well as from the cross-tabulations analysis, no significant differences in the managerial experience pattern between the three disciplines of engineering could be observed.

5.10.11 Number of employees supervised

It is argued in the literature that engineering work usually involves the supervision of resources including people, and that supervisory responsibilities come early in the engineer’s career. The survey revealed that about 80 per cent of engineers are involved in the supervision of people. An analysis of the data on the number of employees supervised by job nature revealed significant differences between the various job nature categories, whereas no such differences were found to be significant when analysed by engineering discipline (refer to table 5.2 and 5.3).

The average number of employees supervised by technical engineers, ‘managerial’ engineers and ‘both equal’ engineers was 1.95, 4.6, and 4.5 respectively, with standard deviations of 2.48, 3.44, and 3.68 respectively. Similarly, the average number of employees supervised by civil, mechanical and electrical/electronics engineers was 3.96, 3.83 and 4.42 respectively, with the electrical/electronics engineers supervising slightly more staff than the civil engineers. Although this difference was seen in the
data, it was not found to be statistically significant. Details of the analysis are given in appendices XII.18 and XII.19.

The study observes that about 41 per cent of technical engineers have no responsibility for supervising the work of other employees. However, about 94 per cent of ‘managerial’ engineers have the responsibility of supervising the work of others. While about 60 per cent of the ‘managerial’ engineers have the responsibility of supervising more than five employees, only 14 per cent of the technical engineers had that responsibility.

Although the number of employees supervised by an engineer is an indication of the degree of responsibility, it does not necessarily reflect the level the respondent has reached in the organization’s hierarchy. In the managerial category of engineer, it is possible that engineers have reached a relatively high level within the organization and therefore have a number of middle managers/engineer–managers reporting to them. It is therefore not possible to draw any conclusions about a respondent’s current degree of responsibility without knowing the levels below and above the respondent. A further analysis of these variables has been carried out to explain the responsibility factor.

5.10.12 Level respondents occupy in the organizational hierarchy

One variable that determines the extent and degree of engineers’ responsibilities is the number of levels below and above their position in the organizational hierarchy. Analysis of the survey data revealed that the average number of levels above a respondent is two (standard deviation is 1.54) and the number of levels below a respondent is three (standard deviation is 2.424). Thus the average respondent is a typical middle-level engineer.
Analysis of the data on the number of levels below and above the respondent revealed significant differences between various job nature categories, whereas no such differences were found to be significant when analysed by engineering discipline (refer to tables 5.2 and 5.3). For example, about 18 per cent of technical engineers did not have any levels below them, while only about five per cent of the ‘managerial’ engineers did not have a level below them.

Similarly, about eight per cent of technical engineers had five or more levels below them, whereas about 20 per cent of ‘managerial’ engineers fell into that category, with a third category between them (about 16 per cent). The average number of levels below for technical, managerial, and ‘both equal’ categories of engineers were 2.1, 3.6 and 2.9 respectively. Similarly the average number of levels above the technical, managerial and ‘both equal’ categories were 3, 1.9 and 2.2 respectively (refer appendices XII.20 and XII.22 for details).

The data indicated that ‘managerial’ engineers occupied relatively higher positions within an organization when compared with the other two categories. Also, the traditional career progression from technical to managerial roles also seems to be operating in Australian organizations. Therefore, it can be concluded from this analysis of engineers in Australia that the typical career path for most of them involves a move from a technical role to a managerial role as their experience increases.

The average number of levels below the respondents for civil, mechanical and electrical/electronics engineers were observed to be 3.2, 2.7 and 2.8 respectively, with standard deviations of 2.56, 2.31 and 2.01 respectively. Similarly, the average number of levels above the respondents in those categories was 2.0, 1.97 and 2.1 respectively. These average figures and an analysis of the data are presented in appendices XII.21 and XII.23. About 20 per cent of civil engineers had more than four levels below them, whereas in other disciplines it was only 12 per cent. Although the differences do not
appear to be much, it is clear that civil engineers are at a higher level relatively in their organizations than are mechanical or electrical/electronics engineers.

The difference in the number of levels below the respondents—a high number for civil engineers and a low number for electrical/electronics engineers—may be attributed to the type of organization in which they normally worked. For example, a majority of civil engineers work in the government/public sector where there is a tendency towards many hierarchical levels within a bureaucratic structure. In contrast, a significant majority of mechanical engineers tend to work in private enterprise, where the number of levels within the organizational structure could be relatively low. According to the study, about 60 per cent of civil engineers work in the government sector, whereas only about 25 per cent of mechanical engineers and 12 per cent of electrical/electronics engineers work in that sector.

5.10.13 Engineers—a non-homogenous group

The above analysis, with the help of the cross-tabulations procedure, reveals that engineers are not a homogenous group and differ according to the nature of their job, their discipline, their management qualifications, employing industry and their age. Of all the variables, job nature is observed to be a critical factor in differentiating between the engineers in the various groups. It could be expected that their attitudes on various factors such as managerial transitions, engineering education, status and organizational support would also differ.

Considering the differences in the specific skills required in various enterprises, due to variations in the technological, structural and cultural environments, differences between the various engineering disciplines and the different types of work carried out by engineers of specific disciplines within the same enterprise, it could be expected that studies focusing on these differences would provide more insight into the transitional process. With such a wide diversity in engineering, it is no longer valid
to treat engineers as a single homogeneous group and draw conclusions from that. The following discussion highlights the differences in attitude towards transition between the various subgroups or categories of engineer.

5.11 Discriminant analysis

Discriminant analysis has been carried out to discover whether the variables mentioned above have any predictor value in terms of engineer’s attitude towards transition as explained in the methodology chapter (refer para 3.5.7.4). The results of the discriminant analysis are presented below, indicating the percentage of cases correctly classified and other statistical values such as eigen value, Wilks lambda and significance levels.

The percentage of cases classified correctly is one indicator of the effectiveness of the discriminant function. Also, small values of Wilks lambda are associated with functions that have much variability between groups and little variability within groups. Similarly, large eigen values are associated with ‘good’ discriminant functions. In addition, if the observed significance levels are less than 0.01, it rejects the null hypothesis that population means of the above categories are equal. If all the three conditions are satisfied, then we can say that it is unlikely that the engineers belonging to each of the above categorical variables have the same means on the discriminant function. As seen in the table below, all the three conditions are not completely satisfied for most of the factors except job nature. For example, in case of engineers classified according to the possession of management qualifications, the percentage of cases classified correctly is high (79.81%), the Wilks lambda value is neither high nor low (0.608), and the eigen value is low (0.412), and the significance level is less (less than 0.000). If management qualifications have a good discriminant function, the eigen value should be high (more than 0.7), Wilks lambda value should be low (less than 0.30), percentage of cases classified correctly high (more than 0.80) and significance level low (less than 0.005).
Table 5.4: Summary of the results of discriminant analysis
(all the variables considered as independent variables)

<table>
<thead>
<tr>
<th>Discriminant variable</th>
<th>% classified correctly</th>
<th>Eigen value</th>
<th>Wilks lambda</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job nature (technical vs. managerial)</td>
<td>90.91%</td>
<td>1.462</td>
<td>0.406</td>
<td>0.000</td>
</tr>
<tr>
<td>Branch of engineering</td>
<td>58.99%</td>
<td>0.245</td>
<td>0.694</td>
<td>0.000</td>
</tr>
<tr>
<td>Age of the respondents</td>
<td>54.94%</td>
<td>0.156</td>
<td>0.743</td>
<td>0.024*</td>
</tr>
<tr>
<td>Management qualifications (yes vs. no qualifications)</td>
<td>79.81%</td>
<td>0.412</td>
<td>0.608</td>
<td>0.000</td>
</tr>
<tr>
<td>Employing industry group (manfg., consultancy and govt.)</td>
<td>65.36%</td>
<td>0.502</td>
<td>0.531</td>
<td>0.000</td>
</tr>
<tr>
<td>Gender (male vs. female)</td>
<td>98.44%</td>
<td>0.267</td>
<td>0.789</td>
<td>0.000</td>
</tr>
<tr>
<td>Levels above (No levels and at least one level above)</td>
<td>84.34%</td>
<td>0.172</td>
<td>0.853</td>
<td>0.026*</td>
</tr>
<tr>
<td>Levels below (No levels and at least one)</td>
<td>90.23%</td>
<td>0.105</td>
<td>0.905</td>
<td>0.840*</td>
</tr>
<tr>
<td>Number supervised by engineer (none vs. more than zero)</td>
<td>80.65%</td>
<td>0.179</td>
<td>0.847</td>
<td>0.013*</td>
</tr>
<tr>
<td>Local vs. overseas-qualified</td>
<td>81.35%</td>
<td>0.234</td>
<td>0.810*</td>
<td>0.005*</td>
</tr>
</tbody>
</table>

* As the observed significance levels are higher than 0.01, the null hypothesis that the population means of the categories are equal is not rejected.

Therefore, considering all the four aspects of discriminant analysis—large eigen value, small Wilks lambda, correct classification of cases, and the low significance level in the above analysis—it can be stated that the job nature, and the employing industry are the most significant predictors of the attitude of engineers towards transition, with management qualifications as the next important factor. In connection with other variables such as age, levels above, number supervised, branch of engineering, and locally or overseas-qualified, though the significance level is less than 0.01, the eigen values are not large enough and the Wilks lambda is not big enough to consider them as significant predictors. However, the percentage of cases correctly classified are considerable for all the independent variables except branch of engineering and age.
Therefore, further statistical analyses, testing the differences in the responses of various categories of engineers, was carried out to explain the phenomenon.

5.12 Analysis of differences between various subgroups of engineers

5.12.1 Introduction

In order to answer the second research question, it was necessary to analyse and test the differences between the responses of the various subgroups of engineers to various statements. Since the number of variables was very large, it was necessary to reduce them to fewer factors. A statistical technique called factor analysis was used and, as explained in the methodology section (refer para 3.5.7.2), a large set of variables were reduced to a smaller set of underlying factors by examining the correlations and interdependence of several items in the questionnaire. Using the summated score of various factors, the differences in their means were tested using t-tests between various subgroups of engineers.

5.12.2 Factor analysis

Based on the literature review and the case study findings, five broad issues concerning transition, such as general attitude, engineering education, organizational support, status of engineers and strategies for managing it, were identified and questionnaire items designed. A summary of the factor analysis results carried out using SPSS software was presented (see the following table) with details about the examinations of correlations between variables, the test of sphericity, significance levels, and sampling adequacy measure, percentage of residuals, and cumulative percentage of the variance accounted by the factors identified from the analysis.
Table 5.5: Summary of factor analysis results for various dimensions

<table>
<thead>
<tr>
<th>Result of the factor analysis</th>
<th>General attitude</th>
<th>Engg. educatn.</th>
<th>Orgn. support</th>
<th>Status</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin measure of sampling adequacy</td>
<td>0.644</td>
<td>0.645</td>
<td>0.723</td>
<td>0.676</td>
<td>0.675</td>
</tr>
<tr>
<td>Bartlett test of sphericity</td>
<td>9169</td>
<td>6668</td>
<td>2995</td>
<td>3494</td>
<td>9857</td>
</tr>
<tr>
<td>Significance</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of variables</td>
<td>34</td>
<td>16</td>
<td>6</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td>Number of factors</td>
<td>18</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Cumulative percentage of variance attributable to the number of factors identified</td>
<td>76%</td>
<td>84.4%</td>
<td>95.9%</td>
<td>91%</td>
<td>66%</td>
</tr>
<tr>
<td>Percentage of residuals greater than 0.05 in absolute value</td>
<td>16%</td>
<td>15%</td>
<td>5%</td>
<td>14%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Considering the interpretability of the factors, and the grouping of the variables from the rotated factor matrix, the variables were grouped into several factors. Appendix XV summarises the factor analyses carried out on several variables falling under each dimension influencing the transition. Summated scales were constructed for each of the factors by adding the individual raw scores on each of the selected variables to obtain the scale score.

5.12.3 Differences between means of various subgroups of engineers using t-tests

Two tailed t-tests for two independent samples were employed to analyse the differences in attitudes of various subgroups by testing the hypothesis that the means of those subgroups are the same. The null hypothesis in these tests was that there is no difference between these two subgroups' scores. Details of the t-test results between the various subgroups of engineers are presented in appendices XVI and XVII. A discussion of the significance of those differences is presented in the following sections.
5.13 Job nature—technical vs. managerial

5.13.1 Introduction

Analysis revealed that job nature is by far the most important variable in differentiating between engineers. In particular, the study observes that there are significant differences between technical engineers and ‘managerial’ engineers in their attitudes towards several aspects concerning transition. Considering the fact that the majority of engineers move into managerial positions from technical roles, these differences signify the impact of experience on their attitudes towards general issues in transition, engineering education, status, organizational support and strategies for managing transition. A comparison of the responses of these two groups of engineers, technical and managerial, is presented below.

5.13.2 Comparison of responses

Placing degree of support into four categories, a comparison of the support expressed in the survey responses by technical engineers and ‘managerial’ engineers was made, and is presented below. The degrees of support were classified as follows: very strong support (indicates that more than 70 per cent agreed); strong support (indicates that 50–70 per cent agreed); weak support (30–50 per cent agreed); no support (less than 30 per cent agreed). The following table indicates the degree of support expressed by the technical engineers and managerial engineers to various statements in the questionnaire.
Table 5.6: Summary of differences between technical and ‘managerial’ engineers

<table>
<thead>
<tr>
<th>Factor/proposition related to transition</th>
<th>Support by Technical engineers</th>
<th>Support by Managerial engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft skills are necessary for engineers at all responsibility levels.</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Engineers’ career advancement is limited more by the lack of soft skills.</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Training in soft skills is necessary at the beginning of an engineering career rather than just before moving into management positions.</td>
<td>Strong</td>
<td>No</td>
</tr>
<tr>
<td>Move into management is a natural career progression.</td>
<td>Very strong</td>
<td>No</td>
</tr>
<tr>
<td>Move into management positions opens up new leadership opportunities.</td>
<td>Very strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Engineers moving into management positions have better compensation than those remaining in technical positions.</td>
<td>Very strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Engineers believe that there is no significant change after transition, as management is an integral part of engineering work.</td>
<td>Very strong</td>
<td>No support</td>
</tr>
<tr>
<td>Engineers move into management for higher pay and perks</td>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>Engineers move into management attracted by the higher pay and prestige rather than their aptitude for managerial work.</td>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>Only way to progress in engineering career is to become a manager.</td>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>People management is the most challenging and difficult aspect of transition.</td>
<td>Very strong</td>
<td>Weak</td>
</tr>
<tr>
<td>By becoming a manager, engineers lose engineering identity.</td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td>Technical competence will be undervalued if engineers move into managerial roles.</td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td>Move from specialist to generalist roles is inevitable, consistent with organizational changes.</td>
<td>Strong</td>
<td>No support</td>
</tr>
<tr>
<td>A separate technical career path is necessary for engineers.</td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td>Engineers prefer to remain as technical specialists rather than move into management positions.</td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td>Engineers dislike the move away from technical matters in their new roles</td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td><strong>Engineers do not perceive any achievement in doing business-related functions.</strong></td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td><strong>Increase in non-technical content in undergraduate engineering curriculum.</strong></td>
<td>Weak</td>
<td>No support</td>
</tr>
<tr>
<td><strong>Nature of present engineering education curriculum creates inadequacies in soft skills.</strong></td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Present engineering education curriculum lacks focus on process-related issues.</strong></td>
<td>Very strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Organizations provide support for making transition into managerial roles.</strong></td>
<td>Weak</td>
<td>No support</td>
</tr>
<tr>
<td><strong>Organizations encourage engineers to acquire management qualifications.</strong></td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Organizations provide necessary training for engineers for making this transition.</strong></td>
<td>Very strong</td>
<td>No support</td>
</tr>
<tr>
<td><strong>Engineers’ skills are underutilised in organizations.</strong></td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td><strong>Technical performance plays an important role in engineers’ promotion into managerial roles.</strong></td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Top management perceives engineers as incapable of holding senior management positions.</strong></td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td><strong>When compared with other professionals in marketing, economics and accounting, engineers’ status is lower.</strong></td>
<td>No support</td>
<td>Strong</td>
</tr>
<tr>
<td><strong>The higher the status of professional engineers within the organization, the greater the probability of success in transition.</strong></td>
<td>Very strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Acquiring postgraduate management qualification (like an MBA) is an important strategy to prepare for the transition.</strong></td>
<td>Very strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Reduction of technical content and increase of non-technical content in undergraduate engineering education curriculum.</strong></td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td><strong>Changing the process of teaching and learning in undergraduate engineering education curriculum.</strong></td>
<td>Strong</td>
<td>Very strong</td>
</tr>
</tbody>
</table>

5.1.3.3 Overall comparison

The study concludes that transition is continuous and that the increasing managerial content of engineers’ jobs makes a critical contribution in providing them with the necessary experience and skills. An overall comparison of the responses revealed that engineers whose job nature was predominantly managerial (‘managerial’ engineers) had a more positive attitude to managerial work, better accepted the change in
engineers' role and gave greater recognition to the need for 'soft' skills than did technical engineers. 'Managerial' engineers were also more critical of the engineering curriculum for its lack of focus on process-related issues and strongly supported a shift towards process of teaching and learning strategies when compared with technical engineers.

On the issue of organizational support, the study concludes that 'managerial' engineers use their own initiative to prepare themselves for management, without any organizational support. The study also found that 'managerial' engineers enjoy a higher status in organizations than do technical engineers. While most of the technical engineers perceived their status to be low (from their individual point of view as well as from that of senior management), 'managerial' engineers viewed their status as relatively high and comfortable. The study found that from an individual perspective the acquisition of a postgraduate management qualification was an important strategy in managing transition.

5.14 Differences within engineering disciplines

5.14.1 Introduction

Though the discriminant analysis and cross-tabulations carried out with branch of engineering as the independent variable do not conclusively indicate that there are significant differences between civil, mechanical and electrical engineers, an attempt was made to test the differences between these groups of engineers statistically and to analyse the implications to better understand the transition. The results of the t-tests are given in appendix XVI. The following sections discuss the significant differences between engineers categorised by discipline.

5.14.2 Civil vs. mechanical engineers

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Analysis of the t-tests indicated that, except for a few, there were no significant differences between civil and mechanical engineers on various aspects (refer appendix XVI.1). For example, on the issue of the problems posed by transition, mechanical engineers tended to view transition as more problematic and challenging due to widespread inadequacies in people-management skills than did civil engineers. Compared with mechanical engineers, more civil engineers perceived transition as involving loss of engineering identity; they also seemed to believe that their technical competence was undervalued if they moved into management. Thus, civil engineers, more than mechanical engineers, are apprehensive about the transition. One of the reasons for this could be the type of industry in which most civil engineers are employed; an analysis of the responses indicated that a majority of civil engineers (about 40 per cent) worked in the public sector, as compared with mechanical engineers (about 16 per cent).

On the issue of de-engineering, civil engineers believed that it has a significant effect and that engineering qualifications should be mandatory for managerial positions in engineering-based organizations. For example, about 72 per cent of civil engineers thought that engineering qualifications should be made compulsory for senior management positions, whereas only 18 per cent of mechanical engineers felt the same way.

This difference in attitude between civil and mechanical engineers towards de-engineering and its effects is significant. The large number of civil engineers working in the public sector, and their perceptions of the effects of de-engineering in the public sector, appear to have influenced their attitude towards the transition. Consequently, unlike mechanical engineers, they feel strongly about the transition and the effect it has on engineering identity.

The study indicates that a separate technical ladder exists in most organizations where civil engineers are employed, whereas mechanical engineers did not report the same
incidence of a separate technical ladder. It can therefore be concluded that, in spite of the de-engineering trend in the public sector, provision for separate technical ladders had been made, especially in civil engineering-dominated organizations. However, in manufacturing, no such support was available, making it all the more critical for mechanical engineers to compete and move into a management career path.

5.14.3 Civil vs. electrical engineers

As can be observed in appendix XVI.2, some significant differences between civil and electrical engineers were noted. For example, on the issue of the move from specialist to generalist roles, electrical engineers subscribed to this view more than did civil engineers. In fact, it is argued that specialist roles are in general large and are more focused in electrical engineering rather than in mechanical and/or civil engineering. With the deregulation of the telecommunications and power industries, there is considerable pressure on electrical engineers to change. From this study, it appears that electrical engineers responded well to the pressure and accepted the inevitability of this general move towards generalist roles, when compared with civil engineers.

The previous section also pointed out that civil engineers are less convinced about the need for this inevitable move than are mechanical engineers. Thus it is fair to state that civil engineers, when compared with other disciplines, have neither embraced current organizational change nor become convinced of its inevitability.

In support of this finding, on the issue of emphasis on the process of teaching and learning in undergraduate engineering education curriculum, there appears to be a significant difference between civil and electrical engineers. According to this study, a significant proportion of electrical engineers noticed that the emphasis on the communications and group working in their undergraduate courses was considerably less. Similarly, they thought that the academics in engineering colleges placed heavy emphasis on content-related issues and relatively ignored process-related issues in the
engineering education curriculum. On the other hand, civil engineers, though not happy with the engineering education curriculum, were less emphatic about the process-related issues.

Although it is not possible to conclude from this study that civil engineers emphasised on process issues than do electrical engineers, the study indicates that electrical engineers have recognised process as an important issue in teaching and learning in engineering education. This observation fits well with the generally progressive profile of electrical engineers, when compared with civil engineers, regarding their acceptance and preparation for organizational changes.

It appears from the study that most organizations employing civil engineers had a separate technical career ladder, when compared with organizations employing electrical engineers. Similar observations have also been made in the previous section when comparing civil engineers with electrical engineers. It is therefore fair to state that the existence of separate technical career ladders for civil engineers, in a way, does not force them to compete for managerial positions, a situation which differs from that of electrical engineers.

Analysis reveals that only an insignificant fraction of electrical engineers stated that a separate technical ladder for career growth existed. In the absence of such an alternative to fall back on and thereby continue in their careers, electrical engineers are forced to be proactive and prepare themselves for management positions. By embracing the organizational changes and by acquiring management qualifications, electrical engineers have prepared themselves better for managerial progression when compared with civil and mechanical engineers. The study observes that this has been achieved despite relatively less organizational support.

Consistent with the above argument, the study notes that electrical engineers differ significantly from civil engineers on the issue of strategies for managing transition.
They are observed to differ in their preference for postgraduate management education. It appears that electrical engineers prefer to prepare themselves for transition.

Rather than depending upon the organization to provide support by way of training, rewards and experiential learning, the study indicates that electrical engineers concentrate on the individual strategy of managing the transition. Conversely, civil engineers appear to prefer to seek stronger and more effective organizational support by way of training and better management of experiential learning within the organization. This finding once again confirms the general trend of electrical engineers being more proactive in dealing with the issues of transition.

5.14.4 Mechanical vs. electrical engineers

As can be seen from appendix XVI.3, there are no significant differences between these two groups on the overall indices except for the general attitude towards transition. However, a closer examination of the factors under each dimension reveals significant differences between some of them, where the significance level is less than 0.05 in the t-test results (refer appendix XVI.3).

There appears to be a significant difference between their general attitude towards transition. The study observes that electrical engineers are more positive than are mechanical engineers. The mean for the four factors identified under this is greater for electrical engineers than for mechanical engineers. The study notes that, when compared with mechanical engineers, electrical engineers are more inclined to consider transition a natural career progression and to consider technical job knowledge an important factor in managerial performance. They are also observed to be convinced of the inevitable change in the engineers’ roles from specialist to generalist functions and embrace the situation—more so than the other groups of engineers. On other aspects of transition, such as status and organizational support,
there appear to be no significant differences between mechanical engineers and electrical engineers.

On the issue of strategies for managing transition, differences were observed between mechanical and electrical engineers in their preferences for experiential learning and organizational support strategies, with electrical engineers less dependent upon organizations. The attitudes of mechanical engineers and civil engineers on these issues, however, appear to be similar.

The above discussion reveals that electrical engineers are significantly different in their attitude towards transition when compared with civil and mechanical engineers. Of the three groups, it appears that electrical engineers are the most proactive, with mechanical engineers coming next. This study refutes the strategy of combining engineers into a single group and drawing conclusions on that basis; instead, it proves there are significant differences between the three disciplines.

5.15 Management qualifications—engineers with/without them

The discriminant analysis carried out with management qualifications as the independent variable indicated that it is one of the most powerful predictors of an engineer's attitude towards transition and related issues. In view of this, an attempt was made to compare the engineers with management qualifications with those with no management qualifications, and to statistically analyse the implications of the findings. A summary of the t-test results indicating the significance of the difference in the means between these two subgroups of engineers is given in appendix XVII.1.

The study reveals that the differences between these two subgroups of engineers are significant—differences in attitude towards transition, their opinions about engineering education, and the strategies to be adopted for managing the transition. It could be expected that the engineers who had studied management would be able to
understand and appreciate the issues involved in management and the benefits they could personally gain from management. Therefore, it is not surprising that a majority of the management-qualified engineers were significantly different in outlook from the technical engineers, who did not see management qualifications as a way of achieving career progression and success.

A closer examination of the factors underlying each dimension reveals that management-qualified engineers had a more positive orientation towards the transition into management roles than did those without management qualifications. For example, on the issue of 'soft' skills, management-qualified engineers emphasised the need for 'soft' skills at all levels of responsibility and for all types of engineers including specialists. As expected, management-qualified engineers were more likely to consider management to be an integral part of engineering work and to view the transition as a natural career progression, in comparison with the other group. On the issue of their movement into managerial positions, they are more attracted by the opportunities and the status associated with that than the pay and perks, when compared with the other group.

On the issue of technical work, management-qualified engineers are less emphatic than the other group, who strongly contended that the move into management was not because of dissatisfaction with technical work. Though not conclusive, it implies that engineer-managers are less enthusiastic about engineering work than they are about managerial work.

For example, the study observes that engineers with no management qualifications derive higher satisfaction from technical work than they do from business-related non-technical functions, whereas it is different for management-qualified engineers. Similarly, engineers with no management qualifications would prefer engineering as a career much more strongly than those with management qualifications.
The overall index on engineering education also points out the significance of the differences in attitude towards the engineering curriculum. Importantly, after experiencing a teaching and learning processes in a non-technical or non-engineering educational environment, management-qualified engineers have recognised the importance of educational issues better than those with no management qualifications. Management-qualified engineers, as might be expected, believe more strongly than the other group that engineering education is heavy on content. Consequent to their experiences in management education, they are more likely to seek changes in process-related issues, such as an increase in the number of group assignments and opportunities for improving communications through seminars etc., than are the other engineers.

The study indicates that there are no significant differences on the issue of organizational support, as it is more employment-related than the attitude and desire for postgraduate management education. Similarly, on status, there are no significant differences on the overall index. However, it is important to note that the management-qualified engineers believe more strongly than the other group about the status gained by moving into management positions. The study reveals that management-qualified engineers place more emphasis on the relationship between the status of engineers in organizations and the probability of success than do engineers with no management qualifications.

On the issue of strategies for managing these transitions, differences were observed between these groups of engineers on several individual factors and on the overall index. As would be expected, engineers with management qualifications are more inclined towards postgraduate management education as a critical strategy than are the other group. Similarly, they are also more emphatic about the changes in the educational processes in undergraduate engineering curriculum.
However, on the issue of organizational support, the study reveals that engineers with management qualifications are less dependent on the organization than are those with no management qualifications. It is clear that the former group has chosen to pursue an individual strategy of managing their transition, without being overly dependent upon the organization. Conversely, engineers with no management qualifications placed more importance on organizational support than on an individual-based strategy such as postgraduate management education.

The above analysis strongly indicates that management qualifications at the postgraduate level have a significant influence on the attitude towards transition and general managerial work. It also reveals that the educational processes during postgraduate management courses influence thinking on the engineering curriculum, with a majority of engineers advocating changes in the processes and a reduction in the engineering content.

Importantly, these management-qualified engineers have taken a proactive approach in dealing the problems of transition and have the initiative for managing their transition. This analysis supports the view that the general status of engineers within the organization and within society in general can be enhanced by managing these transitions successfully. The study confirms the importance of postgraduate management education for engineers in improving their managerial performance, and generally supports the popular trend in Australia.

5.16 Type of employing industry

The type of industry in which engineers work is an important factor that shapes their attitudes. The literature suggests that engineers are more likely to be ‘organization people’ who place organizational interest above individual professional interest. Therefore, it is expected that the type of industry in which engineers work plays an important role in their transitions. For the purpose of analysis, industries are grouped
into four basic categories: manufacturing, government sector, technical consultancy and others.

Discriminant analysis between the first three groups indicates that the industry group is a good predictor of the engineers' attitudes towards various dimensions of transition. The analysis revealed, as indicated in table 5.5, that about 65 per cent of the cases are correctly classified using discriminant analysis. Two function discriminant analysis, with the employing industry group as the independent variable between any two categories, also proves that it is an important predictor of engineers' attitudes. As indicated in table 5.5, a considerable percentage of cases are correctly classified at a significance level less than 0.05 (actual value is 0.000).

In order to better explain the differences between these groups, t-tests were carried out to see the significance of differences in attitude scores on various factors under each dimension, between manufacturing engineers and government engineers, manufacturing engineers and technical consultancy engineers, and government engineers and technical consultancy engineers. A summary of the results is at appendix XVII.2

Analysis revealed significant differences between these groups in their attitude towards organizational support. In general, differences on the dimension of engineering education and managing strategies were not found to be significant.

On the general attitude of the different groups of engineers towards transition, the study observes that government engineers and technical consultancy engineers are more concerned about losing their engineering identity by accepting a change in management roles than are those working in the manufacturing industry. This is reflected by the significance of the t-test result (with significance levels less than 0.05 in both cases). However, the difference between the government engineers and the consultancy engineers was not found to be significant on this dimension. Similarly,
they also agree that technical competence is undervalued if engineers accept change into management positions. On the other hand, manufacturing engineers, in line with contemporary organizational changes and restructuring, do not believe that their engineering identity is lost because of transition.

In fact, in the manufacturing industry, supervising human resources is an important element in an engineer's role right from the first level and this attitude could therefore be expected. Also, the literature suggests that the de-engineering trend is primarily confined to the government sector, where engineers have historically tried to maintain a separate technical career ladders to counter it. No such protection or alternative career route is available in the manufacturing sector, according to the literature.

Therefore, it can be stated that the differences between these groups of engineers can be attributed more to the differing nature of their work environment, with engineers in manufacturing less concerned about losing their engineering identity and those in the government and consultancy sectors generally more concerned about it. Also, the integration of engineers into the management structure is more prevalent in the manufacturing sector, by virtue of the significance of manufacturing and related functions, than in the government and consultancy areas. Thus, on the issue of general attitudes towards transition, those of engineers working in the government and consultancy areas are similar, while the attitudes of engineers in manufacturing are different.

The type and the extent of support that engineers receive from their organizations in making these transitions is an important factor, and could be expected to depend upon the type of organization. For example, on the issue of utilisation of engineers, the study reveals that government engineers are underutilised when compared with engineers in the manufacturing and consultancy sectors (t-test result significance 0.000). In fact, the study indicates that the extent of underutilization is reported to be higher in the government sector than in manufacturing and consultancy sectors. It
could be expected that underutilization is low in consultancy, where engineers are predominantly using their engineering skills, unlike the other two sectors, where managerial skills are an essential requirement.

Importantly, on the issue of the support provided by organizations in making these transitions, the study observes that manufacturing organizations are more supportive than the government or consultancy sectors. Either through encouraging engineers to acquire management qualifications or by providing the necessary training for making the transition, manufacturing organizations are more supportive of engineers’ efforts than are government organizations.

With the consultancy sector primarily focusing on technical issues, a lack of support for engineers to acquire managerial skills could be expected. Recent restructuring by several Australian manufacturing organizations in order to compete in international markets by way of multiskilling and changes in management styles and structures, and the general pressure for the private sector to lift its performance, might have created a supportive environment for engineers to make these transitions.

Also, traditionally, many of the senior management positions in the manufacturing sector are generally occupied by engineers by virtue of their familiarity with the product and the manufacturing processes and the general career growth patterns. Moreover, survey data reveal that about 50 per cent of the ‘managerial’ engineers are working in the manufacturing sector, while only 28 per cent of them are in the government sector.

Although most engineers from all groups reported that no separate, technical career ladder was provided for engineers, in relative terms, the incidence is expected to be high in the government sector. More engineers from the government and consultancy sectors reported a separate technical career ladder than did those from the manufacturing sector. By virtue of their numbers in the government sector, and with
the support of professional associations such as IE Aust. and APESMA, engineers in the government sector ensured a separate, technical career ladder, despite its limitations.

However, this arrangement is neither practical nor feasible for engineers in the manufacturing sector, since their numbers and opportunities are more limited. Unless they move into managerial positions, their opportunities for growth are fairly limited both within the organization and outside it. Also, unless it is a large organization employing a considerable number of engineers, it is not practical to provide a separate career ladder. Therefore, separate technical career ladders are reported less in the manufacturing sector.

Government engineers (when compared with manufacturing engineers) indicated strongly that the basis for promotion to management positions should be technical performance. By placing less emphasis on technical performance, manufacturing engineers highlighted the importance of considering management potential when promoting engineers into management positions.

Perception of status is another dimension that is significantly different between government engineers and manufacturing engineers. Manufacturing engineers reported a higher status accorded to them by their senior management, compared with government engineers. However, organizational status, when compared with that of marketing professionals, economists and accountants, was reported higher by the government engineers. On the other hand, government engineers have a lower perception of their own status in society than do manufacturing engineers.

On the general orientation of engineers, government engineers reported a higher technical orientation and a preference to remain in specialist roles when compared with engineers in manufacturing. Manufacturing engineers indicated a greater preference to choose engineering as a career, if they had to make the choice again, than
did government engineers, who were less enthusiastic. However, there are no significant differences between manufacturing and consultancy engineers.

In summary, the study observes that government engineers are more technically oriented, less inclined to change, perceive less status in organizations and society in general and feel a general loss of engineering identity in managerial roles than do engineers in the manufacturing sector, while engineers in the consultancy sector falling somewhere between the two. On the organizational front, it appears that manufacturing organizations are more supportive of the managerial transitions of engineers than the government sector organizations are, and that engineers’ skills are most underutilised in the government sector than in the manufacturing and consultancy sectors. This analysis points out that organizational support and status are the two independent variables that are influenced by the type of employing industry, and that the engineers’ perceptions are dependent upon their organizational work environment.

5.17 Gender differences

Although the differences in their attitudes are still debatable, there was anecdotal evidence to suggest that the increase in the number of women engineers will, in a way, balance the situation, apart from ensuring gender equity. It is argued that women have a greater concern for the humanistic aspects of the profession than men (Florman 1986). For example, it was found in an American study that women engineers felt more strongly than men that a more ‘humanistic’ education with emphasis on people and ‘soft’ skills was essential for engineers (Weil 1987). Considering this, the differences in attitude towards various aspects of transition are analysed for their significance. Although the sample size of women engineers was not great, due to the generally low number of women engineers in Australia, this analysis provides some anecdotal evidence. A summary of the t-test results is presented in appendix XVII.3.
Analysis revealed that women engineers have a more positive general attitude towards transition than do male engineers. For example, significant differences were observed on factors such as dissatisfaction with technical work being the reason for transition, people management being the main problem in transition, and on the inevitability of the move into generalist roles. Although engineers generally consider people management as the most challenging and difficult aspect of transition, women engineers tend to endorse this aspect more strongly than male engineers. Similarly, on the issue of inevitability of changes in the engineers’ roles as generalists, women engineers have a better score. Dissatisfaction with technical work was not considered an important reason by engineers in general. However, the study indicates that, in relative terms, male engineers tend to support it more strongly than the women engineers, indicating that dissatisfaction with technical work is an important factor.

There were significant differences on the engineering education dimension. For example, women engineers felt more strongly than the male engineers that the very nature of engineering education, with its heavy emphasis on quantitative issues, creates inadequacies in ‘soft’ skills among engineers. Women engineers placed more importance on the issue of ‘process’ in engineering education, than male engineers. Importantly, while male engineers’ score on the issue of increasing business management content in undergraduate engineering curriculum was higher, women engineers appeared not so enthusiastic about this. Instead, they focused more strongly on the emphasis given to the process of teaching and learning as opposed to the content of the engineering education curriculum. This in a way confirms other studies in the USA, which suggested that women engineers place more emphasis on ‘soft’ skills and people-related issues in engineering education do than male engineers.
5.18 Conclusion

This chapter has provided a detailed analysis of the survey data and findings of the study. It has provided answers to the research questions and sub-questions, based on a comprehensive analysis of the data and evidence. This study demonstrates that engineering education, general attitude of engineers, status, organizational support and managing strategies are important dimensions in the transition to management. It proved how influential factors such as the nature of the job, employing industry, management qualifications and the discipline of engineering can be in the successful management of transition. Importantly, it concludes that the transition into management roles is a continuous process for engineers. Recognising engineering education as an important dimension, this research provides, for the first time, conclusive evidence that a shift is needed in the undergraduate curriculum towards process-related issues. The next chapter presents a summary of the important conclusions reached as a result of this research study, highlighting the contribution made by this research, its implications and further research that could be undertaken.
CHAPTER 6

CONCLUSIONS
CONCLUSIONS

6.1 Introduction

This chapter summarises the findings on each research question or proposition. It explains these findings within the context of this thesis and earlier research reviewed in chapter 2. Based on the discussion of the findings from the research questions, the implications for further research are then explored and the significant contribution made by this thesis to the body of knowledge in the area is summarised. The issue of further research to extend this work in terms of topics and methodologies is then addressed. Finally, the theoretical and practical implications of this research are discussed and issues of policy and practice highlighted.

6.2 Summary of findings and conclusions

This study is by far the most comprehensive study of engineers' attitudes towards the transition into management roles in Australia and makes a significant contribution to the body of knowledge on engineers, engineering education and the management of engineers. This research concludes that the transition into management roles is continuous and is influenced by the increasingly managerial content of the job and the acquisition of management qualifications and training. A conceptual model depicting the influence of several individual, educational, organizational and societal factors on the process of transition, and their relationships, is one of the major outcomes of this study.

One of the most important findings of this research is the diversity within the engineering profession. Past research considered engineers a homogenous group and generalised the findings accordingly (Badawy, 1983; Williams 1988; APESA et al, 1992 and others). This research, however, delineates some of the significant differences between the various subgroups of engineers, and concludes that their perceptions of transition are significantly influenced by the nature of their jobs, the
type of employing industry, their management qualifications and their discipline of engineering.

Importantly, this study raises the issue of the process of engineering education, probably the first time in Australia, in a continuous search for a better engineering education that can contribute to the overall development of engineers. This study argues that increasing the non-technical content in the already crowded undergraduate engineering curriculum is not effective, and instead contends that a change in the focus, from simply increasing the non-technical content to a more effective process of teaching and learning, is critical, and is needed now. This finding is supported by the overwhelming support by the respondents for a change in the process of teaching and learning.

Confirming the previous research in the USA and the UK (Barclay 1986; Rynes 1987 and others), this research finds that engineers are ‘pulled’ by attractions such as status and the higher pay associated with management, rather than being ‘pushed’ because of dissatisfaction with engineering work. Importantly, people management is perceived as the most challenging and difficult aspect of transition by all engineers, irrespective of age, amount of experience, nature of job and discipline of engineering. The study highlights the importance of early training in imparting managerial skills to engineers early in their careers, rather than just before they move into management.

The study confirms the importance of postgraduate management education for engineers in improving their managerial performance as well as their organizational status, and generally supports the popular trend in Australia and overseas (Whalley 1986; Williams 1988; APESA 1994 and others). Apart from postgraduate management education, experiential learning is by far the most frequently used strategy in Australia, as a strategy to manage these transitions. This study strongly emphasises experiential learning strategies such as job rotation, discussions with peers, and delegation and guidance from superiors, confirming overseas research findings (APESA et al 1992; Hill 1992; Callan 1995 and others).
This research finds that, in general, status, as perceived by the engineer within the organization, is relatively low. This low self-image, together with the fact that senior management appears to hold a similar perception, perpetuates the low status of engineers in organizations. The study, however, concludes that the acquisition of management qualifications, a job that is predominantly managerial and employment in the manufacturing industry have a positive influence on the perception of status. The study concludes that the probability of success in managerial positions increases with the higher status within an organization.

This research finds that the support Australian organizations give their engineers in making the transition is insignificant, and that the responsibility is left entirely to the individual. Confirming overseas research on dual ladders (Badawy, 1983; Northrup & Malin 1984; McCormick 1995 and others) the study finds that technical ladders are less rewarding than managerial ladders, and are found to be ineffective.

One of the most important findings was the difference between electrical engineers and the other groups. According to the study, electrical engineers are more proactive than civil engineers, with mechanical engineers falling somewhere between the two. By embracing organizational changes, and by acquiring management qualifications, electrical engineers have prepared themselves better for managerial progression, when compared with civil and mechanical engineers in Australia. They achieve this despite relatively sparse organizational support. Rather than depending upon the organization to support them by way of training, rewards and experiential learning, the study found that electrical engineers concentrated on managing the transition themselves.

The study observes that engineers employed in the government sector are more technically oriented, are less inclined to change, perceive themselves as having less status in organizations and in society in general, and feel there is a general loss of engineering identity in managerial roles, than do those working in the
manufacturing sector, with consultancy engineers falling somewhere in between the two. On the organizational front, the study observes that manufacturing organizations are more supportive of the managerial transitions of engineers than the government sector is, and that engineers’ skills are most underutilised in the government sector.

Considering the anecdotal evidence from case study, and observations from survey analysis, this study visualises a conceptual model integrating the influence of various factors on the process of transition and the interrelationships between them. Within the overall influence of societal factors which are specific to a particular nation, each of the individual, educational and organizational factors simultaneously affect the transition from engineer to engineer-manager roles, while influencing other factors.

6.3 Implications

These research findings have significant implications for policy and practice in the area of engineering education, organizational policies on career development and training, and the management of engineers.

6.3.1 Non-homogeneity of engineers:

The study concludes that engineers are not homogenous in their general attitude towards the various factors influencing transition. In particular, it observes that having a job which is predominantly managerial in nature, the acquisition of management qualifications, employment in the manufacturing sector and belonging to the electrical engineering discipline influenced engineers’ attitudes significantly. Therefore it is necessary to develop strategies for managing them separately.
6.3.2 Redesigning of engineering education curriculum:

To change the focus towards process-related issues in the engineering curriculum, from the traditional content-based curriculum, is a challenging task for universities and engineering schools. Considering the limited flexibility available in the undergraduate curriculum, and the need to provide management skills to practising engineers, postgraduate courses in engineering management that are specifically designed for engineers are essential. Introducing innovative techniques in teaching and learning technical as well as non-technical subjects, emphasising teamwork, communication and other generic competencies, is a challenge to both universities and academic staff. Designing of double-degrees, postgraduate courses in engineering management, cross-faculty teaching, an increased number of seminars and group projects, effective management of the industry-experience component of the curriculum, and inclusion of experiential learning projects in courses are some of the strategies universities may have to seriously examine.

Academic staff should ensure that students see a meaningful connection between technical subjects and non-technical subjects in the engineering curriculum, and convince them of the importance and usefulness of these subjects in the overall context, as well as strive to make learning effective. A simple increase in the percentage of non-technical content would not add value to a student's learning. Given the slow response rate of academic institutions in translating industrial requirements into the academic curriculum, it may be naive to assume that changes in the engineering education will be easy. Changes to reposition the engineering profession to meet the challenges of the twenty-first century require a significant shift in academic thinking and traditional teaching and learning processes in universities.
6.3.3 Quality of engineering recruits:

The quality of recruits to the engineering profession is another issue. High school leavers hold negative views of the profession, perceiving high workloads at university, a long course of study, low compensation packages that are not commensurate with the effort required at university, and a relatively low status in society. A survey last year, however, noted that the salary levels of fresh engineering graduates compared well with those of other professions and were just below those of dentists and medical practitioners (Engineering News, April 1996). Although salary is only one measure of status, salary levels do appear to be competitive. In spite of this, the perception of their low status persists among engineers; senior management share this perception, thus reinforcing views that engineers are unsuitable for top management positions. A self-fulfilling prophecy therefore seems to be operating in Australia, similar to the situation in the UK. All these factors therefore present the engineering schools in Australia with the challenge to attract some of the brighter students away from the traditional faculties such as medicine, law and commerce, which currently attract the best talent among high school leavers,

6.3.4 Organisational support and experiential learning:

Organizational support for engineers in making the transition into management roles is found to be negligible, and confirms recent findings in Australia. Although much invaluable learning takes place on the job, through experience, not much emphasis has been placed in managing it effectively. Organizations must devise ways and means of doing this in order to take advantage of the potential for learning.
6.3.5 Status of the profession and importance to maths and science subjects:

This study, while acknowledging that engineering education currently accentuates inadequacies, raises other factors, such as the status of the profession in society as characterised by salary levels and the importance attached to subjects such as mathematics and science that have traditionally been considered prerequisites for the study of engineering. It would be interesting to study what influence the quality of engineering recruits has on engineering education, and the recruits’ subsequent professional formation.

6.3.6 Individual personality and occupational orientation:

The importance of individual personality and the personal motivation to acquire management skills and to succeed in management cannot be emphasised enough. Individual personality plays a crucial role in the transition. There are strong indications from both the case study and the survey that individual personality greatly influences the achievement of a successful role transition. Detailed longitudinal studies on the transition of engineers are needed in order to delineate the influence individual personality has on success or failure.

Despite sharing fairly common backgrounds in terms of educational qualifications, age and professional experiences, the engineers differed significantly in their perceptions of transition. These differences were found to depend upon the individual and his/her own occupational orientation. Although it is beyond the scope of this research, it is possible to predict occupational proclivities during the early stages of an engineering education; to do so would avoid the enormous cost of promoting into management those engineers who have neither the interest in it nor the potential for it.
6.4 Further research

This research points the way for further research on engineers—on engineering education in particular, and on the professional formation and career development of engineers in general.

6.4.1 Comparison of engineers with accountants:

The literature makes the point that other specialists such as accountants also face similar problems, difficulties and challenges as engineers in their transition into management roles. However, there seems to be no empirical evidence to support or this finding. Though some anecdotal evidence is available from some isolated case studies, no such study has been undertaken in Australia. With accountancy considered to be a major profession in Australia, and with the general perception of accountants being similar to that of engineers, a comparative study of engineers and accountants would better explain the phenomenon and help to identify some common factors.

6.4.2 Evaluation of relationships:

The conceptual model detailing the factors and their relationship with the process of transition may have to be tested for empirical evidence. Studies to investigate the differences in the influence of societal factors, which are specific to a particular nation, on the transition are important to understand the relationships better. A study investigating the influence of individual factors, organizational factors, and educational factors on each other and on the process of transition, is necessary to explain the phenomenon better.
6.4.3 Effectiveness of process in engineering education:

While the research establishes that a focus on process issues is important to make engineering education effective, it is beyond the scope of this study to evaluate its effectiveness in the classroom. It would be necessary to carry out a longitudinal study of students on the effectiveness of learning in engineering schools, taking into consideration the effects of their individual learning styles, the teaching styles of the academic staff, and limitations in terms of the content, capabilities and resources in engineering schools in Australia.

6.4.4 Occupational orientation of engineering recruits:

It has been established in the literature that occupational proclivity can be established in the early stages of education and can assist in the selection of a career. Apart from the study of engineering students in the USA undertaken by Rynes (1987), no similar study has been undertaken, certainly not in Australia. Through an understanding of the occupational orientation of engineers, which would indicate whether or not they are likely to succeed in management, it would be possible to avoid the enormous cost of promoting into management those engineers who have neither the interest nor the aptitude for it.

6.4.5 Influence of individual personality on transition:

Individual personality and the possession of management qualifications are observed to have a significant influence on whether a transition succeeds or fails. Although some anecdotal evidence is available from case study (Seethamraju 1996), no scientific analysis of the influence of these factors has been undertaken. It would be necessary to carry out a longitudinal study to measure the influence of individual personality and its relationship with successful transitions. Similarly, a longitudinal study would be necessary to analyse the influence of management qualifications on the managerial performances of engineers, by comparing their performances before and after the acquisition of the qualifications. The findings of
such a study would provide invaluable information on the strengths and weaknesses of the management education provided to engineers, and would also highlight the influence of individual personality.

6.4.6 Reasons for differences among subgroups of engineers:

This study has established that there are significant differences between different subgroups of engineers in Australia: for example, electrical engineers and civil engineers; male engineers and female engineers; engineers employed in the manufacturing sector and those in the government sector. However, because of the research design and its scope, this study is unable to explain the reasons for such differences. Moreover, research questions based on ‘why?’ can be better understood by employing a qualitative research design. A qualitative research study to investigate the reasons for the differences that have been identified on various dimensions of transition would be necessary, both to understand the phenomenon better and to develop some policy initiatives at both the educational level and the organizational level.

6.5 Concluding remarks

This research identifies and conceptualises the interacting influence of several factors, on each other, and in turn on the process of transition of engineers into engineer-manager roles. This study emphasises that the processes of teaching and learning in engineering education are becoming more important than simply increasing the managerial content of the undergraduate engineering curriculum, although it recognises that the exponential growth of engineering knowledge poses difficulties. Importantly, this study highlights the differences that exist within engineering profession, differences that relate to branch of engineering, employing industry, gender and management qualifications. Although they are well-recognised as being important factors in learning, no support systems are in place in organizations to assist engineers manage the experience of transition effectively. This study strongly recommends an effective system of managing organizational
experience in order to reap the benefits of the most widely employed strategy of learning.

Given the importance of engineers and management in industrial society, it is important to understand the process of engineers' transitions into management roles. Whether they are successful or not, it is clear that a large number of engineers are moving into management positions and that their numbers are set to increase along with the growing influence of technology and information technology in the management of business. This study has taken a further step in exploring the phenomenon in the Australian context and provides a framework for further research.
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Appendix I

DEFINITIONS OF THE TERMS USED IN THIS RESEARCH

Several terms are used in this research study. An explanation of those meanings in the context used in this study on the "transition of engineers in Australia" is given below, in alphabetical order.

Business education, business management education or management education

Business management education is acquiring knowledge and skills in order to manage an organisation's resources (people, money, equipment, information, etc.) so that optimum outcomes are achieved, primarily by undertaking formal courses of study at tertiary institutions (McLaughlin 1990)

Such courses are undertaken at an educational institution, and include business subjects such as management, accounting and marketing. The courses lead to a formal qualification in business, such as a certificate, diploma or degree. These courses do not include in-company training, management training or development courses which result in a certificate of attendance only. These terms do not include education acquired informally through the experience of working in a business organisation or by reading books.

De-engineering

The term 'de-engineering', as defined by Lloyd (1991), is the managerial approach whereby engineers are replaced in the management and leadership of professional engineering functions by non-engineers. De-engineering does not relate to those general management roles that do not require engineering qualifications.

It is a trend, particularly in Australian public sector organisations, where senior management, in an attempt to achieve increased efficiencies and effectiveness, dispense with the hitherto-required occupation-specific qualifications for senior managers. The term does not refer to any negative strategy of closing options for engineers; it simply refers to the removal of the exclusive right of professional engineers to occupy senior management positions in engineering-based public sector organisations.

Engineer

The word 'engineer' means 'professional engineer' as stated in the Professional Engineers Award in 1961 established by the Australian Conciliation and Arbitration Commission. According to this award, a 'professional engineer' is a person who is employed to carry out duties, the adequate discharge of any portion of which requires the possession of a qualification recognised by IE Aust. for graduate membership.
This definition, for legal purposes, leaves the interpretation to the professional body of the engineers, Institution of Engineers, Australia (IE Aust.) from time to time.

**Engineering work**

The Association for Professional Engineers, Scientists and Managers (APESMA), an association of engineers, scientists and managers, that represents professional engineers and scientists in the Commonwealth Industrial Relations Commission in Australia, defines professional engineering work as that: ‘...which involves professional engineering knowledge and judgment in the development, application and management of engineering technology and the economic utilisation of resources. Professional engineering knowledge includes the knowledge of techniques and principles in the areas of mathematics, science, technology and management obtained during the acquisition of professional engineering qualifications and relevant experience (APESA 1990: 5).

APESA was established in 1945 and was formerly known as APEA. Scientists were included in the association in 1993; in 1995, it also included managers and was renamed the Association for Professional Engineers, Scientists and Managers, Australia (APESMA).

**Engineering**

Engineering is the profession in which knowledge of mathematics, science and technology are combined with the principles of management and applied in the practical application and management of technology and associated human, physical and financial resources for the creation and operation of products, processes and systems, and community works and services, in the fulfilment of commercial and social needs (Lloyd 1988: 9).

**Experiential learning**

Experiential learning is the term used in this thesis to describe the learning process through on-the-job experience. It is a learning where individuals learn by doing, as opposed to being instructed or reading about particular topics (McLaughlin 1990). Taken from the educational theories, it is defined as ‘A process through which managers learn, that explicitly provides opportunities for individuals to integrate cognitive, emotional and behavioural learning—by doing something; reflecting on and assessing what they have done; and drawing conclusions and expressing opinions about what they will do in the future, how and why’ (Mullen 1992). According to Kolb, it is a four-stage cycle involving four adaptive learning modes: concrete experience, reflective observation, abstract conceptualisation and active experimentation (Kolb 1984). While all the four stages are steps in a continuous process, people usually have a preferred learning style. Therefore, individuals tend to
be better at, or more comfortable with, one or two stages of the process than with others.

**Generalist engineers**

The term ‘generalist’ engineer refers to an engineer who undertakes marketing, project management, customer relations, financial accounting and human resource management activities, in addition to his/her specialist technical functions. The term specifically refers to an engineering specialist who performs business-oriented non-engineering functions such as customer relations, marketing and accounting in addition to technical functions.

**Interpersonal skills**

The ability to communicate well with people and achieve good social relations in the workplace. It relates to the exchange of information between two people or within a group (Robin 1995).

**Learning style**

If learning is to be effective, how it is offered must consider the styles and requirements of the individuals who are being taught. In this context, what causes individuals to react differently to a given learning experience, based on differences in the ways in which they approach learning, is termed ‘learning style’ (White 1992). A ‘learning style inventory’ or questionnaire is a self-descriptive, self-administered instrument that assesses an individual’s orientation towards learning, in terms of Kolb’s four stages of learning in his experiential learning cycle. It measures the relative emphasis the respondent attaches to each of the learning modes.

**Manager**

A manager is ‘...an individual who achieves results with and through others’ (Schermherhorn, J.R. Jr. 1996). Managers are responsible for the control or direction of people, a section, a department, or an organisation. Management is ‘The process of planning, organising, leading, and controlling the use of resources to accomplish performance goals.’ (Schermherhorn, J.R. Jr. 1996).

**Management training**

Management training provides specific skills and skills, or develops attitudes, of direct use to a manager in his/her current or future job (Eastburn 1987). It is expected to be more narrow and specific than education. The methods employed in management training, whether provided in-company or externally, normally include lectures, programmed instruction, case studies, seminars, group discussions, syndicates, role playing, business games and simulations.
Management skills or managerial skills

The aptitudes, abilities and qualities of a manager, for which a certain level of proficiency can be developed and maintained through practice or training. Management skills specifically refer to 'The functional skills such as marketing, accounting and operations; general management skills such as communication, teamwork, leadership, motivational, and interpersonal skills; and conceptual skills such as planning, organising, budgeting and time management skills.' (Yau and Sculli 1990).

'Soft' skills

The term 'soft' skills refers to non-technical skills such as communication skills, interpersonal skills and business management skills (Williams 1988). Contrasting them with the 'hard' technical or professional skills, the term 'soft' is used to denote the skills related to human relations and social issues.

Specialist engineers

The term 'specialist engineer' refers to an engineer who has worked for a considerable period of time in a special technical field of engineering in functions such as design, research and development. In these areas, engineers work as individual contributors. The term here refers to engineers who work in these specialised areas as individual contributors and are generally not responsible for the work of others.

Status

The word 'status' has two levels of meaning depending upon the context: one refers to status in society in general and the other refers to the organisational status of engineers in comparison with that of other professions. The status of engineers in society, as defined by Glover and Kelly (1987) refers to lifestyle and patterns of consumption, and is generally conferred in ways which legitimise existing differences in power and wealth.

On the other hand, the organisational status is a term used to reflect the perceptions held by senior management, and by others in the organisation, of the abilities of engineers to hold senior management and leadership positions in relation to other professionals such as accountants, economists, human resources practitioners and marketing specialists. The term also refers to the power and influence engineers have as a professional group in the organisational decision-making process.

Transition
The word 'transition' refers to the change in the work role of engineers from engineering to that of the engineer-manager, and/or a change from the role of specialist to that of generalist. This term is used here to describe this change as a continuous process with no definite beginning and ending (Hill 1992). The emphasis in this study is on the process rather than definite outcomes.
Appendix II

POPULATION OF ENGINEERS IN AUSTRALIA

1. Population of engineers

Engineering is the second-largest professional occupation in Australia after teaching. The number of engineers per head of population or ‘engineering density’ is considered to be a primary relative measure of the state of engineering development (Rice & Lloyd 1991), and is used as a basic measure for international comparisons. It is recognised that engineers are required for the operation and maintenance of manufacturing facilities, utilities and infrastructure, and the demand for them is proportionate to the population. In industrialised societies, the demand for engineers is expected to increase as the demands of the continuous growth and development of these facilities and infrastructure increase in line with population growth.

According to Rice and Lloyd (1991), there are about 92,000 professional engineers of working age in Australia, about 1.1 per cent of the labour force (Rice & Lloyd 1990). However, an estimated 85 per cent or 78,000 engineers are employed directly or indirectly on engineering work including engineering management, according to the population analysis by Rice and Lloyd (1990).

From just over 1000 engineers in the year 1900, the professional engineering population is likely to reach approximately 100,000 by the year 2000, and 120,000 by the year 2010 (Rice & Lloyd 1991). In spite of such apparently large numbers, it is considered that the number of engineers per capita in Australia is relatively low when compared with other industrialised countries (EPAC 1988).

Several studies have pointed out the low engineering intensity of Australia (IE Aust. 1972; Clarke & Krbavac 1982; Endersbee 1985; Edelstein 1987; Lloyd 1988; Williams 1988; Mathews 1989; Rice & Lloyd 1990; Lloyd 1991a; Rice & Lloyd 1991). For example, it has been noted that there are 30 graduate engineers per 100,000 population in Australia, while there are 82 in Japan, 73 in Canada, 63 in the UK, and 50 in the USA (Williams 1988). This low density of engineering population has an effect on the recognition of the value added by engineers and the general perception of their contribution to society (CTSC 1991).

2. Diversity of engineering discipline

Within the term ‘engineer’, there is a great variety of individual roles and specialisations, and it is important to understand these diversities within the engineering discipline. Engineers differ by specialty, such as civil, mechanical, electrical, electronic, chemical, production, industrial, aeronautical, mining, petroleum, agricultural, environmental, nuclear, bio-medical and a few others. With the growth and expansion of technology and its increasing interface with other disciplines, many
Other specialisations are increasingly offered by the universities. However, the majority of engineers in Australia are in the civil, mechanical, and electrical and electronics engineering disciplines (Clarke & Krbavac 1982; Rice & Lloyd 1990: vii). The composition of engineers in the various disciplines in Australia and its changing pattern, as estimated by Rice and Lloyd (1990), is given below.

Table 1: Disciplines, engineers in Australia

<table>
<thead>
<tr>
<th>Discipline/specialisation</th>
<th>Year 1955</th>
<th>Year 1990</th>
<th>Year 2020</th>
</tr>
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<tbody>
<tr>
<td>Civil engineering</td>
<td>35%</td>
<td>26%</td>
<td>20%</td>
</tr>
<tr>
<td>Mechanical engineering</td>
<td>30%</td>
<td>26%</td>
<td>20%</td>
</tr>
<tr>
<td>Electrical and electronics</td>
<td>30%</td>
<td>33%</td>
<td>40%</td>
</tr>
<tr>
<td>engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>5%</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
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</tbody>
</table>

A survey by labour market consultants, John Ray & Associates, in Australia, observed that in 1992, there were 84,500 employed engineers in the profession, of whom some 71,800 were in the civil, mechanical or electrical/electronics fields (The Weekend Australian, August 28–29 1993: p. 40). That means that these three fields or disciplines comprise about 85 per cent of the engineering population. The report estimated that about 31 per cent of working engineers are employed in manufacturing. The report noted that about 83 per cent of engineers have tertiary qualifications such as a degree, diploma or certificate (The Weekend Australian, August 28–29 1993: p. 40).

Another dimension to this diversity of engineering population comes from migration. It is estimated that about 21 per cent of engineers in Australia are migrants who have acquired their engineering qualifications overseas (Rice & Lloyd 1990). Although they are still in a minority, the proportion of women in engineering is increasing, which may reflect the initiatives taken by the profession and the government in reducing gender differences (Byrne 1985; Carter & Kirkup 1990). However, the number of female engineers is very low in Australia. The Institution of Engineers Australia has about 62,000 engineers on its register; about 4.8 per cent or 3000 of them are women (Engineers Australia, November 1995: 30).

Regarding the distribution by employment sector, it is estimated that about 40 per cent are working in the public sector and the remainder in the private sector (Rice & Lloyd 1990). With the increasing trend towards privatisation and commercialisation of various public sector organisations at both federal and state government levels, and through economic rationalisation policies, the proportion of engineers working in the public sector is likely to fall in the future.
Engineers are also categorised by the type of activity, technical or managerial, in which they are mainly engaged. For example, the job nature of research, design and development, and consulting appears to be predominantly technical, while jobs in production/manufacturing, sales, purchasing, supervisory/management fields have a mainly managerial content. The approximate proportions of engineers performing different functions, as established in an Association of Professional Engineers Australia survey in 1988/89, was as follows.

Table 2: Distribution of engineers in Australia by function

<table>
<thead>
<tr>
<th>Function</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management/administration</td>
<td>34%</td>
</tr>
<tr>
<td>Design</td>
<td>16%</td>
</tr>
<tr>
<td>Research &amp; development</td>
<td>10%</td>
</tr>
<tr>
<td>Production &amp; maintenance</td>
<td>9%</td>
</tr>
<tr>
<td>Construction supervision</td>
<td>10%</td>
</tr>
<tr>
<td>Marketing</td>
<td>3%</td>
</tr>
<tr>
<td>Teaching</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>16%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Though in many studies engineers have been considered a cohesive group, there is a diversity of engineering opinion on various issues (Bell & Bordin 1964; Wearne et al. 1984; Whalley 1986; Glover & Kelly 1987; Williams 1988; Bella 1990; APESA et al. 1992). In view of this diversity and also because it constitutes about 85% of the total engineering population, this study is confined to investigating the differences between and within the disciplines of civil, mechanical and electrical/electronic engineering. In view of the diversity in engineering work, it may be necessary to study the differences between various groups, as discussed above.

2.2.5 Limited literature on engineers

While undertaking a review of the literature on engineers, its limited nature in general and particularly with regard to Australia must be borne in mind. As observed by Lloyd, "Engineers tend not to write about the social aspects of their occupation." (Lloyd 1988: 2). The literature on engineers and their work has been largely created by non-engineers in Britain and the USA (Buchanan 1989; Glover & Kelly 1987; and Lloyd 1988). The involvement of groups in engineering work, the continuous
undertaking of projects one after the another without taking the time to write the history of any of them, and the commercial and policy constraints on publications within an organisation are some of the reasons for this tendency, as Lloyd pointed out. In view of limited past research on engineers in Australia, this review is extensively based on overseas research, particularly that done in the USA and the UK.
THE CHANGING ROLES OF ENGINEERS
AN HISTORICAL ANALYSIS

1. Introduction

This appendix discusses the evolution of engineering as a profession and gives an historical background to the study of engineers based on the literature. It argues that the role of engineers is changing continuously, influenced by different management paradigms. Starting from scientific management to the present ‘Japanese’ management approaches such as JIT and quality management, it reviews the engineers’ role in chronological order and argues that engineers played an important role in the introduction and diffusion of these management paradigms in industrial organisations.

2. Engineering—an ancient profession

Engineering is an ancient profession, though it was not known and referred to an engineering. The word ‘engineering’ is notionally about 2000 years old (Warren Centre 1988: 18). Though there are certain engineering monuments such as the pyramids in Egypt, the cathedrals of Europe and the Great Wall of China, engineering involvement was not clearly documented in history (Hill 1984). In the eighteenth century and earlier, engineer meant a military engineer, whose skills were required for designing fortresses and preparing ordnance.

Napoleon, a great patron of the sciences, greatly influenced the development of engineering by establishing special schools to educate sufficient numbers of military engineers for his needs. These schools have since become the exclusive grandes ecoles of France which now produce the polytechnicians, the country’s intellectual elite (Gerstl & Hutton 1966: 2). In France, military engineers like Vaughan, Belidor and Coulomb, under the rule of King Louis XIV, were concerned about the economic utilisation of labour and are known to have conducted physiological studies on the exertion of labour in the early eighteenth century (Merkle 1980: 89).

The history of engineering in Australia is limited to the period of 200 years since European settlement. Before the gold rushes of the 1850s there were practically no engineering works in Australia. In view of this lack of engineering in Australia prior to the 1850s, the historical beginnings and development of engineering have to be traced to the UK and the USA (Lloyd 1988: 1). The social literature on engineering and engineers has been created largely in those countries.

In history, there were a few individuals who foresaw the future role of engineers and engineering and discussed their importance in society. Saint-Simon (1760–1825), was probably the first person championing the cause of industrialism and engineers (Glover & Kelly 1987). He saw the future as an age of the machine and of peace and
progress. His ideas were later called the ‘religion of engineers’ (Hayek 1955). Simon was of the opinion that the future would belong to a democratic, one-class society consisting of ‘les industriels’, all those involved in production.

August Comte (1798–1857) saw the role of engineer as being crucial in the analysis of social dynamics (cited in Glover & Kelly 1987). He believed that the understanding of human societies would increase through the discovery and application of scientific laws. He argued that the military, a predominantly political organisation in a religion-based society, would be replaced by industrial organisations in the scientific and positivist society. He predicted that engineers, people at the heart of the industrial complex, would be important politically in the new social order.

Herbert Spencer (1820–1903), who coined the term ‘survival of the fittest’, had great faith in industrial progress and industrial societies. Like Saint-Simon, Comte, Marx and others, Spencer regarded the ‘captains of industry’ as the power-holders of the future (Glover & Kelly 1987: 19). The place of engineers in history has been neglected by historians, who have tended to largely disregard the technology that has been associated with virtually every important historical change and which critically impinges upon every person in his/her day-to-day life (Smith 1970: 493).

This neglect was partly related to the fact that some natural scientists have, in some countries, claimed at least some of the glory of modern engineering’s achievements for themselves (Fores 1977; Klemm 1959). Rae, an American historian, observed that far more has been written about the history of engineering than about engineers, and much more about those who promoted engineering works than about those who actually designed and built them (Rae 1975: 404).

Most of the literature written about the inventions and lives of famous engineers predates the twentieth century. Samuel Smiles wrote several books on the lives of various engineers, such as The Life of George Stephenson (1857), Lives of the Engineers (1862), Lives of Boulton and Watt (1865), Men of Invention and Industry (1884), James Nasmyth (1885) (cited in Buchanan 1989). In his book on the history of British engineering, Buchanan (1989) pointed out that the achievements of engineers in later periods were primarily in managerial organisation and entrepreneurship, and they had less opportunity for innovation than had their predecessors. This he concluded was the reason why engineering biography and history was confined to the pre-1860 period (Buchanan 1989: 19).

3. Evolution of the engineer’s role in the nineteenth century

The literature suggests that the role of engineers has been changing continuously, along with the changing paradigms of management in industrial organisations. In the nineteenth century, manufacturing industry was in its infancy and was generally managed by engineer–entrepreneurs. Though the main task of the early factory owner was the coordination of resources such as materials, machines and people,
management was not at that time recognised as an important element in the success or failure of an organisation.

In fact, engineering and accountancy were the only professions that were based in industry in the early nineteenth century (Urwick 1953). As would be expected, many of the early writers on management were trained in or influenced by these professions (Tillett et al. 1970). Though management problems were as old as the first factories in the late eighteenth century, the earliest publications in which management situations were analysed appeared at the end of the nineteenth century in the UK (Tillett et al. 1970).

It is argued that the engineering profession actually initiated the development of basic management concepts. Several engineer entrepreneurs in the nineteenth century made improvements to work organisation through specialised machinery and interchangeable components in industries such as textiles, steel and glass manufacturing (Nelson 1980: 5), and through the advanced division of labour with conveyerised operations in slaughterhouses in the UK and the USA (Edwards 1979: 115). There is evidence to suggest that some form of management of production and distribution existed in the early nineteenth century in UK enterprises run by engineer-entrepreneurs.

Certain innovative ideas such as personnel management, production planning concepts, shop order controlling, piece-rate wages and time wage sheets were conceived and implemented by entrepreneurs like Robert Owen and James Watt in the early nineteenth century (Urwick & Brech 1946). In 1795, Boulton, in partnership with James Watt, the inventor of the steam engine, built his own factory known as the Soho Foundry in Birmingham, England, for the manufacture of steam engines. Some of the scientific management principles were practised at the Boulton and Watt foundry in the year 1805, well before the advent of Taylorism.

These aspects of management were first described in a book entitled Commercial Organisation of Factories by Slater Lewis, an engineer himself, in 1896. The scientific works design, subdivision and specialisation of labour conforming with the increased use of machinery, more accurate methods of wages payment and the system of cost and production accounting, were evident at the Soho Foundry during the period 1790–1805, well before the Industrial Revolution (Urwick 1946: 37).

In 1887, a book entitled Factory Accounting, written by Garcke and Fells, an engineer and accountant respectively, presented the principles of factory accounts for the first time (Urwick 1943: 22). In fact, Slater Lewis, an engineer, was one of the first people in the world to write a book on management; The Commercial Organisation of Factories written in 1896 in London was based on his experience of running industry (Urwick 1943).

With discussions on organisation structure, detailed job descriptions, procedures for manufacturing accounts, concern for employees’ morale and comfort, employment
4. Evolution of the engineer’s role in the twentieth century

It was the engineering profession in the USA that actually laid the foundations of scientific management concepts. A group of engineers there, during the early twentieth century, attempted to apply the intellectual concepts of science and mathematics to the questions of business management. As pointed out by Urwick, “This group of engineers, with the support of the then Society of Mechanical Engineers, USA, were the first men in the world to approach this wider problem of managing an industry.” (Urwick 1953: 376).

The American Society of Mechanical Engineers provided a ready platform for the discussion of management concepts. F. W. Taylor, H. L. Gantt, F. B. Gilbreth, Lillian Gilbreth, H. R. Towne, C. T. Porter, Henry Metcalfe and Harrington Emerson were some of the pioneering engineers who contributed to the development of scientific management in particular and industrial management in general (Hoxie 1915).

In fact, the American engineering profession was already concerned with the problems of management, well before the advent of Taylorism, and was very well-predisposed to welcome further developments. In 1886, H. R. Towne, an industrialist, before the advent of Taylorism, while addressing the American Society of Mechanical Engineers, stated that, “The true function of an engineer is, or should be, not only to determine how physical problems may be solved, but also how they may be solved most economically.” (Towne 1886).

Henry Fayol from France was another engineer was concerned with efficiency at the level of the organisation. Fayol asserted that managerial ability could be acquired like technical ability, first in educational institutions, later in the workshop. He stated that an exclusively technical education fails to answer the general needs of even the industrial undertakings, and advocated management training in engineering work. He also observed that a person who was superior in orderliness, organisation, authority and bearing would be selected for promotion from “...workman to foreman, or from foreman to superintendent, or from engineer to manager”, along with their basic technical ability (Fayol 1949).

Thinking far ahead of his times, Fayol asserted that the attitude of workers could be changed for the better (or worse) through able (or misguided) management (Fayol 1949: 103). Although it is obvious now, Fayol stated that managerial ability was fundamental and important for a manager compared with specialised ability, whether in technical, commercial or financial area.

While Taylor was concerned about the efficiency at the detailed level of the operations and tasks, at the operator level, Fayol was focusing on overall control of the firm, at
organisational level. Henry Fayol's work is thus complementary to that of Taylor. This difference in their approach to management was not merely a reflection of their different careers, but was a reflection of the political and social history of the two nations (Cuthbert 1970: 121).

Noble (1977) commenting on the history of corporate capitalism in America, concluded that "Modern management was not simply the creation of engineers, it was the product of engineers functioning as managers." (p. 263). Noble explained that the shift of focus on the part of engineers from the engineering of things to the engineering of people during the early nineteenth century (1900 to 1920) involved two complementary phases. He stated that "The first social engineering was the conscious attempt to exercise managerial prerogatives through the medium of the workplace, through organisation of the work activity of labor. The second human engineering was the movement to control the human element of production at the individual and group level through the study and manipulation of human behaviour." (Noble 1977: 264).

The role of engineers in industrial enterprises thus changed in the early 1900s from that of a pure technical professional to scientific manager, with the advent of scientific management. The 'social engineering' phase, as pointed out by Noble (1977) began in the last decade of the nineteenth century in the form of 'scientific management' or Taylorism in the USA.

Merkle (1980), analysing the scientific management movement, commented that Taylorism reflected the transfer of power in the production process from craftsmen to engineers in the form of management control over workers and owners, in order to save the then industrial system from growing social and productive dysfunctions (Merkle 1980: 12). The impact of Taylorism on organisations was significant in the USA, the UK and, to some extent, in Russia, France and Germany, and it is still termed the engineering style of management (Nadworny 1955).

Commenting on the identity of engineer in America, Layton pointed out that "The engineer came to be self-identified as the agent of technological change, and hence as a vital force for human progress and enlightenment...as a logical thinker free of bias and thus suited for the role of social leader ad arbiter between classes, with a special social responsibility to protect progress and to insure that technological change led to human benefit." (Layton 1971: 57). The scientific management movement and its revisionism confirmed the "Victorian faith in science as the material embodiment of irresistible human progress, and the emergence of engineers as a profession indispensable to technically advanced society." (Rose 1975).

Several labour process theorists commented the role of engineers in the scientific management movement. Braverman commented that scientific management had become the "...fundamental bedrock of all work design and the practitioners of 'human relations' and 'industrial psychology' are the maintenance crew for the human machinery..." (Braverman 1974: 87). Burawoy (1978) and Edwards (1979)
argued that the impact of scientific management on American industry was overestimated by Braverman and was only implemented in 50 per cent of enterprises in the USA in the 1950s. Similarly Stark argued that the scientific management movement should be seen "...as the articulation of an engineer's ideology rather than as simply a development of capitalist management thought." (Stark 1980: 102–103).

After the death of Taylor, the emergence of the scientific management movement recognised the role of trade unions and, in collaboration with the corporate reformers again led by engineer–managers in the USA, implemented the 'human engineering' phase (Noble 1977: 265). Integrating the methods of physical and social sciences, and shifting the emphasis to the 'engineering' part of the 'human engineering', they created a new science of 'personnel management' (Noble 1977: 265). He observed in his historical study, that the "...scientific management led by engineers provided the first engineering insight into the problems, the possibilities, and the methodology of 'advanced management' procedures to the trade unions in the USA, and exerted a direct influence on the evolution of American trade union policies." (Nadworny 1955: 154).

The highly differentiated British craft engineering organisations were unable to take control of the scientific management movement in Britain, and left it to industrial psychologists and management consultants such as Urwick. In fact, it is argued that it was appropriated by the then nascent indigenous management movement in Britain which was generalist in inclination (Armstrong 1991 and 1992). As British engineers were too specialised within particular industries and craft forms, Taylorism in the UK was implemented by non-engineers in the non-engineering, non-craft controlled sectors such as the food, drink and tobacco industries (Littler 1982; Rowlinson 1988).

It has been argued that while Taylorism exerted a worldwide impact at the turn of the century, Fordism, in many ways the inheritor of Tayloristic thinking, was diffused by production engineers to European societies from the 1920s onwards (Smith & Meiksins 1995). Throughout the nineteenth century, engineers devoted their attention primarily to the introduction of profit-making and labour-saving machinery, equipment and tools.

Against this background, engineers adopted the behaviourist approach proposed by Mayo and other industrial psychologists and sociologists to solve 'human factor' problems (Ottaway 1977). This again called for a change in their roles and expanded the scope of their roles in industrial organisations. This expansion of engineers' role in organisations in the name of improving efficiency and productivity was not without criticism.

For example, Noble (1977) criticised it on the grounds that engineers adopted the findings simply because they enabled them to manipulate people without appeal to reason, ignoring the consciousness of workers. He argued that this expansion of engineer's role simply focused upon the unconscious, irrational underpinnings of
human behaviour (Noble 1977: 298). The scientific management movement was led by engineers even after the death of Taylor and, despite some changes, became synonymous with the management style of engineers (Drury 1915).

The development of socio-technical systems in the 1940s influenced the role of engineers as technical specialists (Cherns 1973; Cherns 1987). While in classical Taylorism, industrial engineers ruled, within Fordism, one set of engineers designed technology without taking into consideration those who operated it, while other engineers patrolled the line (Armstrong 1989). The increasing complexity of technology and industry continued this transition of the engineer into a socio-technical system designer and manager by the middle of the twentieth century (Warring 1991). At the end of the nineteenth century, under the pressure of increased competition, engineers expanded their focus by including the workplace and the work activity of labour. It was necessary to design industrial systems considering the requirements, expectations and aspirations of employees, under the title 'humanisation of the workplace' (Cherns 1976a).

This approach involved consideration of human expectations, requirements and aspirations at the workplace in the design and operation of industrial systems. In fact, engineers were considered to be an important agency through which the innovative Swedish approach to work redesign has been promoted. In the radical job redesign 'movement' in Sweden, especially in Volvo, engineers played a crucial role in designing and developing socio-technical systems (Berggren 1992: 14).

Thus the engineers' role became expanded to include the design of work organisation and methods. Though this change was not as pronounced as the previous one as a scientific manager, certain parts of its philosophy were accepted in different parts of the world by the middle of the twentieth century (Warring 1991). In his report on engineering education in the USA, William Wickenden, while mentioning the expanding scope of the engineer's work and training, stated that "The rise of the engineer as an organizer and manager has been a natural evolution covering the last half century." (p. 1056). He argued for the need "...to bring together the mechanical, physiological, and psychological factors in human work within the bounds of a predictable science." (p. 1059) (Wickenden 1929).

However, in Australia, local industry significantly lagged behind its American and other Western counterparts. During the post-war period, multinational companies and management consultants, some of whom were engineers, significantly contributed to the dissemination of scientific management principles in Australian industry. It has been argued that those management consultants comprising mainly engineers were, more than any other factor, responsible for the introduction of the new management practices into Australian industry (Wright 1989).

In the absence of clear empirical studies on work practices at that time, contradicting arguments have been made about historical analyses in Australia. For example, Nyland
(1989) argued that scientific management was central to the design of work organisation, and extended beyond the workplace encompassing the more general concepts of management rationalisation and state economic planning (Nyland 1989).

On the other hand, Wright argued that the impact of scientific management in Australia was overstated (Wright 1993) and was limited by factors such as strong unionism; general disillusionment among employers and workers with the incentive systems; changes in employee attitudes towards increases in work intensity and inhumane working conditions; and the impact of increasing mechanisation on standards and incentive schemes (Wright 1989).

He argued that scientific management techniques had a short life and faced a variety of limiting factors and attained long term impact in a minority of industries. With the general decline of these industrial engineering techniques, the importance of engineers had been relegated to the background, especially in the automobile industry, textiles, electrical appliance manufacture, and other manufacturing industries, he stated.

Thus, Taylorism, reflecting the self-interest of engineers in turn-of-the-century Western firms, could be considered an engineering ideology (Meikins 1984). Similarly, according to Smith and Meikins, the emphasis on developing scientific identity for the engineer by moving away from typical production function to the research and development functions was also an engineering ideology designed to promote the status of the profession in the USA (Smith & Meikins 1995).

Australia has imported the British work practices such as craft unions, professional institutes and apprenticeship training for engineers. Thus it would be expected that these work practices could not produce local solutions to problems that are not detachable from the contextual issues, and hence are different for different countries such as Australia and Canada where the British craft form of organisation has been implemented. In those circumstances, the engineering profession as an occupational group is squeezed between the competing forces of labour and capital in the production process (Smith & Meikins 1995: 424)

5. Diversity between different countries

Though engineers are often responsible for putting into practice new ideas which are diffused from one society to the next or from one industry to the next, they act in ways specific to their national experience (Smith & Meikins 1995). Evidence suggests that there is substantial diversity between different countries in the organisation of engineering, the degree of responsibility taken by engineers and the relationships they develop towards various other groups within their organisation.

Meikins and Smith (1992) identified four major approaches to the configuration of engineers from a historical survey of six advanced capitalist societies—the UK, France, Germany, Japan, Sweden and the United States. They the ‘craft’ organisation,
the ‘managerial’ organisation, the ‘estate’ organisation and the ‘company’ organisation.

According to Meiksins and Smith (1992), under the ‘craft’ form of organisation, engineers are produced through apprenticeships which emphasise practical, on-the-job training, and are excluded from management, the typical British system. The ‘managerial’ form of organisation incorporates managerial practices in the training of engineers through their formal education, as is done in the USA.

The ‘estate’ form of organisation creates a stratified hierarchy of technical labour within the middle level of the firm, in between those representing capital and labour on two extremes, a model found in Germany, Sweden and France (Meiksins & Smith 1992). The ‘company’ form of organisation is where the engineer is integrated into the firm, with generalist formal qualifications supplemented by enterprise-specific on-the-job training in a single firm, a form unique to the Japanese model.

Summarising the contemporary role of engineers in industrial organisations, Lloyd stated that “Engineers accepted the power structures of business, espoused loyalty to employer, hostility to organized labour, and independence of business from government, tenets of individualism and entrepreneurship and urged for better management and improved efficiency.” (Lloyd 1988: 37). The study shows that the social organisation of engineering in Australia was a very late development in comparison with that in Britain and the United States, where it was well-developed during nineteenth century.

However, Lloyd observed that in neither country has industrial relations emerged as a factor in the control of the identity of the occupation, as in Australia. He concluded that “Occupational control for the engineering profession in Australia is different from that in Britain and North America, and that, in contrast, with those countries, occupational identity has been strongly reinforced in Australia through industrial relations.” (Lloyd 1988: i).

The engineering profession in Britain and in the United States was fragmented on the basis of disciplines. But in Australia, all the engineering disciplines came together within the Institution of Engineers, Australia, in 1919. The small number in the profession compared to the numbers in the UK and the USA could be one reason why discipline-specific associations did not survive in Australia, Lloyd observed (Lloyd 1991). The scale of the occupation is much smaller, too, in Australia, with 25 times more engineers in the United States and five times more in Britain (Lloyd 1988).

Unlike in the USA, there is no statutory registration of professional engineers in Australia. However, from 1920, the Institution of Engineers, Australia, gained influence and power over engineering through influence and persuasion (Lloyd 1988: 271). He observed that the present complementary role exercised by the Institution of Engineers, Australia, and the Association of Professional Engineers, Scientists and
Managers, Australia (APESMA) in occupational control and identity might be seriously challenge in the future from the social and environmental trends such as shift of engineering employment from the public to the private sector, the challenge to engineering leadership in the public sector through de-engineering, and the growing indifference among engineers to the professional organisation (Lloyd 1988: 274). Thus, the unique conditions of the engineering profession in Australia do not allow blind comparisons with the the UK and USA models, and call for separate investigations.

6. Evolution of the engineer's role—contemporary changes

Rapid advances in information technology, increasing globalisation of markets and other social and organisational changes accelerated the changes in organisations and further influenced the engineer's role. In the 1980s and 1990s, the changes in organisations through the introduction of various approaches such as quality circles, Just-In-Time management, semi-autonomous work groups, Total Quality Management and World Class Manufacturing, under the banner of ‘Japanisation' further influenced the role of engineers (White 1990; SME 1989).

These approaches involve new methods of work organisation and management which include broad philosophies such as workplace democracy, continuous improvement and employee empowerment, and radical re-engineering of the processes. In addition, the intensity of international competition by the removal of tariff barriers, the change from a resource-based economy to a technology-based economy and increasing globalisation of markets forced Australian organisations to improve efficiencies through restructuring, de-layering and more flexible and democratic workplaces (Endersbee 1985; TASC 1990; Kramar 1990).

For example, it has been observed that specialist functional structures such as design, production, maintenance, distribution and sales have been abolished and ‘integrated professional groups' created to facilitate closer integration between those structures in the majority of companies in all the industrialised nations (Smith, Child & Rowlinson 1990). There is already a tendency in many international companies to outsource many technical functions to specialist subcontractors, themselves composed of integrated and not functional specialist teams (Smith 1990; Whittington 1990).

Commenting on the similar changes in the UK, Hawkins and Barclay (1990a) stated that there is an imperative need for engineers to “...change from the 'old order' with the focus on production-oriented, efficiency-based, authoritarian, stable and functionally based structures and processes to the 'new order' emphasising market-oriented, entrepreneurial, co-operative, inter-disciplinary and changing structures and processes.” (Hawkins & Barclay 1990a: 48).

It has been argued that engineers are involved in the development of many of the contemporary ideas associated with ‘Japanese management'. The ideas about new,
flatter and more flexible organisational forms have emerged from engineer-dominated companies, such as computer firms, with their strong patterns of engineering occupational culture (Kunda 1992). Moreover, engineers are often directly responsible for the introduction and interpretation of new managerial approaches in actual production settings, and have taken the role of mediator in organisational learning (Coles 1989).

The techniques pioneered by Japanese engineers—just-in-time (JIT), quality control (QC), zero defect, total quality management (TQM) —may be considered to be an outcome of the influence of Taylorism and Western management in Japan (Morikawa 1991). Sharply contrasting with engineers in the Western countries, Japanese engineers work together with the blue collar workers. Morikawa noted that engineers who work exclusively in the office or in R & D are not 'by definition' considered to be engineers in Japan (Morikawa 1991: 136). Japanese engineers are perceived to be central to the development of contemporary production techniques in Japan and their diffusion (Cusumana 1985; Cole 1989; Warner 1992).

Discussing the changing importance of engineers with reference to organisational change cycles, Rae observed that:

"After an industry has survived the perils of childhood and begun to grow, the problems of finance, organisation, marketing and, in recent times especially, industrial relations, are likely to overshadow technological matters and bring to the fore executives whose training and aptitudes lie in these areas. When a level of stability has been reached so that even a minor technical improvement can mean a major competitive advantage, however, then the importance of engineer rises again." (Rae 1957: 24).

Engineers have a unique role when compared with other occupations in industrial organisations. In the introduction of new products, processes and new equipment or new methods, engineers find themselves a target of change and are required to adapt to the new work environment continuously as the technology progresses (Glover 1992). On the other hand, engineers themselves are originators of such change by improving technology, processes, products and methods (Krick 1967). Thus they are considered as targets as well as originators of change in organisations. At times, as middle-level managers and line supervisors, they are also responsible for the implementation of organisational changes (Waldersee & Blackstock 1993; IE Aust. 1993a).

Thus it can be argued that engineers perform the role of change managers in some industrial organisations. In fact, the attitudinal criticism of engineers as being authoritative and unconcerned about people is mainly due to the role some engineers have played as middle managers in implementing the painful and often difficult structural reforms in Australian industrial organisations, a survey conducted by the Institution of Engineers, Australia, observed (IE Aust. 1993).
Engineers’ roles are also ambivalent. In supervising or in designing supervisory/control systems, engineers carry out the function of capital, but in coordinating and designing, they also perform the labour (Whalley 1986). In view of their unique role and the ambivalence of their positions in industrial organisations, they are likely to be the most affected by organisational change processes. Thus engineers are neither an extension of labour nor an arm of management, and play a semi-independent role influenced by their national diversity.

This, together with the present structural and cultural changes in industrial organisations in the attempt to become internationally competitive, and the rapid growth of information technology, accelerated the change processes as never before (White 1990). These changes necessitated the further redefining and adjusting of engineers’ role in industrial enterprises (Tegart 1989; TASC 1991).

However, a study in Australia has observed that engineers as a group are not able to respond to the changing circumstances due to their poor status in the community, the negative perception of the employers about the value of investment in technology, the poor perception of employers of the ability of engineers and their contribution, and the perspectives that guide the career paths and education of engineers (TASC 1991). The study suggested that further research work on engineers in Australia could make a valuable contribution by developing a well-informed assessment of their changing roles and identifying the implications of these trends for career development, education and training.

7. Changing roles of engineers—a summary

It is clear from the above discussion that engineers have unique multiple roles in industrial organisations as technical specialists, designers, developers and managers of system and system changes. Engineers have been changing and adapting their roles throughout the nineteenth and twentieth centuries in line with the changes in management paradigms. Engineers are under increasing pressure to redefine their roles and re-equip themselves to meet adequately the forthcoming challenges of the next century. As recommended by TASC (1991), further investigation on engineers is necessary, "...in order to provide a basis for analysing the development of engineers and the detailed assessment of the changing roles of engineers." (TASC 1991: 56). With the boundaries between technical roles and managerial roles becoming increasingly blurred in modern industrial organisations in 1990s, the changing role of engineers has considerable influence on their transition into management roles.
Appendix IV

QUEENSLAND TRANSPORT
THE CASE STUDY ORGANISATION

1. Introduction

This appendix provides background information on Queensland Transport, Queensland, Australia, the organisation that was chosen to carry out the case study component of this study. It details the role and organisational climate, the role of engineers in this organisation, concept of transition in the organisational context, the respondents investigated, and the dimensions of the study.

2. Organisation

Queensland Department of Transport is an important infrastructure manager supporting road, rail, and shipping services in Queensland, Australia. It is responsible for providing safe, efficient and cost-effective transport throughout Australia’s second largest state, Queensland. Within an area of 1.7 million square kilometres, Queensland Transport manages about 35,000 km of major traffic-carrying and linking roads in the state. It employs 3069 public servants and 2882 wages employees (1992–93), with an estimated expenditure for 1991–92 of $1166 million which includes commonwealth funding of $265 million (PSMC 1992). It has a roads asset base of approximately $20,000 million (QT 1993d).

In particular, it is responsible for the infrastructure development and maintenance of roads and other transport services throughout the state. In addition to infrastructure support, the department undertakes licensing and registration of a wide variety of vehicle types in 15 districts in Queensland. It has 15 district offices under five regional offices in Queensland and eight head office divisions.

The change initiatives and the restructuring of the public sector in Queensland can be attributed to the change of government in 1989. A blueprint for public sector change in Queensland, entitled Making Government Work, was issued in August 1989 by the Queensland Government. Consequent to the policy changes, a restructuring took place, culminating in the reduction of the number of departments from 27 to 18 (PSMC 1990). The amalgamation of the Department of Main Roads, the Department of Transport and parts of the Department of Harbours and Marines took place consequent to government policy initiatives. To complete the process of restructuring, the Public Sector Management Commission was formed with a view to review the purpose, structure, functions and management of all Queensland public sector organisations (PSMC 1990).

In the year 1991–92, PSMC carried out a review of its purpose, structure, functions and management processes. An efficiency and effectiveness audit was carried out including the review of management structures, the adequacy of devolution of responsibility,
appropriateness of information systems and staffing levels, staff training and professional development and career path planning (PSMC 1992). While commenting that the organisation had been operating effectively and efficiently, the review team made several recommendations in the areas of program management, human resource development, asset management, interdepartmental liaison, and information systems and services. Some of the particular recommendations made by the PSMC included: “Review of the current region and district organisational structures, commercialisation of various workshops, transport technology services and district operations including pricing policy and systems; devolution of responsibility for operational management of human resources to line management; implementation of quality management practices in Transport Technology division; and development of schemes for the professional development of engineers.” (PSMC 1992).

3. Change initiatives: road reform, commercialisation and workplace reform

Against a background of general micro-economic reform across various sectors in Australia, and in response to the PSMC review, an initiative termed 'Road Reform' was taken by the Queensland Government. The road reform project was initiated by Queensland Transport in 1992 as an integral part of micro-economic reform of Australia’s overall transport network in general and in the roads sector in particular (QT 1993a). It is an initiative by the Queensland Government with an aim to “...achieve best value for the roads’ dollar by doing the highest priority works in the most economical way, with at least 20 percent productivity improvement.” (QT 1993a). The aim was to achieve improvements in the efficiencies and effectiveness of the roads sector in Queensland. This was about giving priority to the most important road projects in the most efficient way through better procedures, improved work practices, training and better management information systems, commercialisation and with a strategic focus (QT 1993b). According to the policy document released by the department, the road reform initiatives included:

“Packaging of construction and maintenance works into larger jobs to achieve greater economies of scale, creating a competitive environment in which Queensland Transport, local authorities and private contractors will demonstrate best value for money; introducing agree price performance contracts and productivity improvement targets (particularly where local government employment is a major factor in community viability); introducing design/construct and design/construct/maintain contracts; undertaking projects involving private and public sectors on a co-operative basis; allocating scarce resources to areas of greatest need in order to promote economic and regional development; identifying and implementing performance indicators to measure and compare; and revising tendering arrangements so that quality standards and past performance, not only price, are considered.”

(Queensland Transport 1993b)
Consistent with the policy reform of the state government on competition, in line with the Hilmer reforms on competition at the national level, the financing, construction and operation of infrastructure in Queensland was opened to competitive private sector bidding. According to the Queensland Transport policy document, road reform was expected to deliver several benefits, including:

More strategic approach to management of the road system;
An environment where public and private sector compete for all work in fair an open competition; More roadworks for the road user’s tax dollar;
Greater predictability of road funding; Achievement of national and international best practice in the delivery of road programs; More innovative and efficient approaches to project delivery; Improved use of technology;
Increases emphasis on greater professionalism within Queensland Transport achieved through training and better management information systems;
Improved job skills and skills recognition for road industry workers;
Improved work practices and flexibility in the workplace.

(Queensland Transport 1993d)

Implementation of the concept of ‘district business model’ was an important component of the road reform at the district office level. Fundamental principles in this district business model involved commercialisation, open competition, accountability and transparency (separation of owner and doer roles within the district unit) (QT 1993d). Essentially, these districts were expected to operate as independent business units and compete for works with local governments and private contractors for funding from state and federal governments for various infrastructure projects.

Commercialisation was another reform initiative taken by the Department with the aim of achieving increased efficiency and international competitiveness. Commercialisation, according to the policy document, was the ‘common thread’ that linked many of the other changes such as road reform, workplace reform and regionalisation that were taking place throughout the Department. The main aim of commercialisation, according to the Department, was “...to provide the people of Queensland with transport management services that represent best value for money.” (QT 1993d). Implementation of commercialisation is a key element which underpins road reform.

According to the Department, implementation of commercialisation was expected to help the organisation to be:

“...able to operate as a business, be able to prove competitiveness and value for money; be more accountable for performance; enhance transparency of the decision-making processes of the organisation; ensure customers receive the products and services they need, reduce red tape and bureaucracy; fund business units with income derived from customers; give staff control over commercial decisions for which they are accountable; respond quickly because decisions are
made as close as possible to the customer; and have a strong, viable working environment providing opportunities for learning and personal growth"  
(Quéensland Transport 1993d).

In order to achieve gradual change, the Department proposed commercialisation in three levels as described below:

"Level 1 - This level is about developing a customer-supplier relationship. It requires Business Units to match their products and services with the needs of customers and to identify and communicate the costs of providing them.

Level 2 - At this level, more formal business arrangements between customers and the Business Unit will be established. Customers will provide the income for Business Units. All units will move to Level 2, with movement to Level 3 at the discretion of the Director-General.

Level 3 - At this level, customers have greater discretion over the use of goods and services from the Business Unit, however the Unit has greater control over its inputs. Business Units will compete with other providers"  
(Quéensland Transport 1993d)

While the road reform program was concentrating on the district offices in the roads program delivery, commercialisation was intended to make the organisation commercial and enter open competition within a two-year framework. As indicated above, three stages of commercialisation were envisaged by the Department. While stage I and II were expected to be preparation and rehearsal for the commercialisation, stage III was complete commercialisation. The essence of the concept of commercialisation was that each business unit within Queensland Transport would be free to select its services from open competition; similarly, each business unit would be competing with the private sector in offering its services to other units within the organisation and to external clients. The necessary financial accounting process was in place to manage financial transactions between project teams, business units and divisions.

Transport Technology Division (TTD) was the first division to undertake commercialisation in Queensland Transport. This division offers specialist transport infrastructure services, business services (fleet management, purchasing and supply), design, bridges, traffic engineering, road transport, pavement design, passenger transport, environmental engineering and safety management services to various district offices and other departments within Queensland Transport. This division comprises eight business units that are expected to operate independently and are headed by a business managers (engineers turned business managers).

In each business unit, a team of specialists are assembled depending upon their expertise and skills for each project and, under the leadership of the team leader, it is responsible for the marketing and delivery of the project, from the conceptual stage, to customer
relations and quality assurance. In the process, the specialist engineers who are working as project leader and members are expected to perform marketing, customer service, financial accounting and human resources functions along with their specialist technical functions. The necessary accounting and information systems were being developed so that an individual specialist members could work simultaneously in various project teams and their contributions costed proportionately. This change in the work roles of engineers from 'specialists' to 'generalists' is another dimension of this transition that is under study.

In each business unit, a team of specialists are assembled depending upon their expertise and skills for each project and, under the leadership of the team leader, it is responsible for the marketing and delivery of the project, from the conceptual stage to customer relations and quality assurance. In the process, the specialist engineers who are working as project leader and members are expected to perform marketing, customer service, financial accounting and human resources functions along with their specialist technical functions. The necessary accounting and information systems were being developed so that individual specialist members could work simultaneously in various project teams and their contributions costed proportionately. This change in the work roles of engineers from 'specialists' to 'generalists' is another dimension of this transition that is under study.

The third level of reform program is workplace reform. The purpose of this program is to achieve improved work practices which contribute to increased efficiency in roadworks delivery, and to provide commensurate benefits to employees. The values this reform process is planning to foster in Queensland Transport include a participatory work culture, best practice/continuous improvement, flexible work practices, training and development, skills recognition, reward for performance and productivity and mobility. Though this reform is in its infant stage at the time of study, and is influenced by unions, government policies on industrial relations and enterprise bargaining principles, etc., it is expected to affect the way districts are managed and thus could have an impact on the district manager’s role.

These reform programs—road reform, commercialisation and workplace reform—are expected to result in significant structural and cultural changes within the organisation. Importantly, these reforms are expected to force the organisation to change its historically supply-driven approach to roads infrastructure programs and relate them to needs and outcomes. With engineers playing key roles at different responsibility levels, this reform process is expected to have a significant impact on those roles. As pointed out by several information brochures and discussion notes issued by the Department, district managers are the key figures who have a considerable responsibility to implement these reforms at the district level. Also, the district engineer’s role has changed and became more managerial as the organisation changed. From the simple delivery of a roads construction program, seen from an engineering point of view, the district manager’s role increasingly became managerial, involving design, evaluation of tenders, liaison with local governments and other clients, management of human
resources, both technical and non-technical support staff, and other related administrative functions.

In implementing commercialisation practices, the engineers responsible for delivering technology-based services to internal and external clients are identified as the key staff. It has been well-recognised that these changes involve the way employees think and work in the organisation, calling for a major shift in the traditional public sector view. Traditional systems, structures and processes are reviewed and modified to suit the changed environment, to enable the shift from operating under the normal Public Service structure to being organised into business units. These changes are expected to have a significant effect on the role of engineers in the organisation.

4. Role of engineers in Queensland Transport

Traditionally, engineers were a significant workforce in the former Main Roads Department. With about 320 professional engineers working there, it was one of the few government sectors that had a high concentration of professional engineers working at different levels. At the first level, engineers were involved in the first line supervision of construction or maintenance contracts and/or designing of works. At the district manager's level, they were responsible for the road network planning, maintenance, human resource management, customer relations, liaison with local government and other stakeholders, and general administration of the district office. Before the amalgamation, they were called 'district engineers' and responsible for the maintenance and construction of roads. After amalgamation, these district offices are headed by the 'district managers' who have the additional responsibility of other transport services along with the roads infrastructure. In line with the policies of government, these positions are open to any experienced person, not necessarily professional engineers. In spite of that, at present all the district managers and the regional directors positions are occupied by professional engineers, who came from the former Main Roads Department.

In addition, Transport Technology Division (TTD) was another department which had a significant number of specialist engineers providing technical specialist services to the district offices and other units in the department. This division offers specialist transport infrastructure services, business services (fleet management, purchasing and supply), designs, bridges, traffic engineering, road transport, pavement design, passenger transport, environmental engineering and safety management services to various district offices and other departments within Queensland Transport.

5. Transition concept in case study organisation

The sample selected for the study of transition are taken from two functions. The first group of engineers were district managers and regional directors, who are professional engineers working as managers. The predominant job nature of these positions is managerial. Queensland Department of Transport has 15 district offices and five regional offices throughout Queensland, with the head office situated in Brisbane. The second
group were senior engineers working in Transport Technology Division (TTD), responsible for the delivery of specialist technical services to district offices and various other divisions within Queensland Transport. The predominant job nature of these second group of engineers is technical.

With the amalgamation in 1989, the district engineers, the heads at each of the district offices of the then Main Roads Division, were put in charge of the amalgamated district offices and were made responsible for the program delivery in the areas of roads infrastructure and transport services. This resulted in the broadening of the engineers’ role and since then they have been called district managers. Prior to amalgamation, these district managers were called district engineers in the Main Roads Department, with a heavy emphasis on the technical aspects of their work. Though there was some degree of administrative work involved as a district engineer, it was less than that in the present district manager position.

In the present district manager position, engineers are responsible for the roads program in which technical emphasis was predominant, whereas in the transport services the emphasis is on customer relations. Basically, this is the first level of management position in the organisation with full responsibility for program delivery, human resources, finances and customer relations, and with practically no technical content.

Their roles are considered to be changed further with the introduction of road reform, through the implementation of the concept of the ‘district business model’. In addition, the implementation of commercialisation has affected the focus of the district manager’s role significantly towards customer relations and effective management of the programs in the district.

The implementation of road reform, commercialisation and workplace reform have further expanded the managerial content in the district manager’s role. Here, the concept of transition is not considered to be an event with a definite start and end, rather as a process. Under the process, the role of professional engineers is continuously changing in line with the organisational changes. The objective of selecting them as a sample here is to understand the transition the engineers have undergone or are undergoing in their present managerial positions. To tap into and understand the experiences the engineers have in making the transition is the main focus of this study.

The second group of engineers considered for study were senior engineers working in Transport Technology Division (TTD). Here, as result of commercialisation and other reform processes underway in the department, the role of ‘specialist’ engineers has changed and has become a ‘generalist’ role that normally includes customer relations, marketing and finance functions, in addition to specialist technical functions. The predominant job nature of these ‘generalist’ engineers is technical.

Transport Technology Division (TTD) offers specialist transport infrastructure services, business services (fleet management, purchasing and supply), designs, bridges, traffic
engineering, road transport, pavement design, passenger transport, environmental engineering and safety management services to various district offices and other departments within Queensland Transport. The TTD division comprises eight business units: pavements, design and survey, bridges, marine technology, materials and geotechnical services, environmental services, traffic and safety.

Under commercialised environment, each business unit in TTD is expected to operate independently and is headed by a business leader/manager. Within the business units, the concept of project teams is employed, whereby a team of specialists are chosen, depending upon their expertise and skills; a specialist can be a member simultaneously of various project teams. His/her time is divided between these different project teams and costs are apportioned accordingly for billing purposes. The project team is headed by a specialist with no relation to his/her present ranking.

Each project maintains its own accounts and prepares profit and loss statements for each project. In these teams, ‘generalist’ engineers work as leaders and/or members, depending upon their expertise in the particular technical field. The term ‘generalist’ engineers denotes engineers who perform marketing, customer relations, financial accounting and human resources management activities, in addition to their specialist technical functions. Under the leadership of the team leader, the business unit is responsible for the marketing and delivery of the project, from the conceptual stage to customer relations and quality assurance. In the process, the specialist engineers who are working as project leaders and members are expected to perform marketing, customer service, financial accounting and human resources functions along with their specialist technical functions. It is expected that an individual specialist member can work simultaneously in various project teams. The necessary accounting and information systems were being developed in order to cost their contribution to each project proportionately.

6. Specific issues investigated in case study organisation

The objective of this study was to investigate the changes in the roles of engineers from the engineers’ perspective. The specific questions the researcher wanted to answer through this case study were:

1. What are the perceptions of engineers of their jobs in the changed conditions such as difficulties, challenges, rewards, best parts and the worst parts, strengths and weaknesses in terms of skills and attitudes?

2. What are the reasons, motivation and challenges in becoming a manager?

3. What type of organisational support do engineers receive during this transition?

4. What is their perception of the change management within the organisation?
5. What is the influence of engineers as a professional group on this transition?

6. What is the impact of the de-engineering process in their organisation?

7. How important is individual personality in succeeding in these new roles?

8. What are the perceptions of engineers on their status within the organisation?

9. How good and useful was their engineering education and what are their views on improvements?

10. What are their impressions about their career development?

With the above questions as background, semi-structured questionnaires were used by the researcher for interviewing district managers/regional directors and senior engineers in the Transport Technology Division.
Appendix V

THE CASE STUDY PROTOCOL

1. Overview of case study project

This case study investigates the process of work role transition of professional engineers in Queensland Transport, a Queensland State department responsible for the infrastructure development and maintenance of roads and other transport services. The change in the role of engineers is a result of significant structural and cultural changes in Queensland Transport under the broad ‘reform’ agenda. The reform programs include road reform, commercialisation and workplace reform’ as defined by Queensland Transport and explained below.

2. Concepts of road reform and commercialisation within Queensland Transport

Road reform is an integral part of overall micro-economic reform in Australia. It is an initiative of the Queensland Government to improve the efficiency and effectiveness of the roads sector in Queensland. Road reform (RR) aims to ensure best value for the roads’ dollar; it is about giving priority to the most important road projects and doing those projects in the most efficient way through better procedures, improved work practices, training and better management information systems, and commercialisation, and with a strategic focus. Implementation of the concept of district business model is an important component of the road reform at the district office level. The fundamental principles in this district business model involve commercialisation, open competition, accountability and transparency (separation of owner and doer roles within the district unit). Essentially, these districts are expected to operate as independent business units and compete for work with local governments and private contractors for funding from state and federal governments for various infrastructure projects.

Another change program is commercialisation to support the road reform program. While the road reform program was concentrating on the district offices in the roads program delivery, commercialisation was intended to make the organisation commercial and enter into open competition within a two-year framework. There are three stages of commercialisation: stage I, stage II and stage III. While stages I and II are preparation and rehearsal for commercialisation, stage III, which was supposed to start from July 1994, is complete commercialisation. The essence of this concept of commercialisation is that each business unit within Queensland Transport would be free to select its services from open competition; similarly, each business unit would be competing with private sector in offering its services to other units within the organisation and to external clients. The necessary financial accounting process was in place to manage the financial transactions between project teams, business units and divisions.

The third level of reform program was workplace reform. The purpose of this program was to achieve improved work practices which contribute to increased efficiency in
roadworks delivery and provide commensurate benefits to employees. The values this 
reform process was hoped to foster in Queensland Transport included a participative 
work culture, best practice/continuous improvement, flexible work practices, training 
and development, skills recognition, reward for performance and productivity and 
mobility. Though this reform is in its infancy, it was expected to influence the way the 
district is managed and thus could have an impact on the district manager’s role.

3. Engineers' role transition: meaning and concept

3.1 Transition concept

There are two types of role transition investigated in this case study research. The first 
one is the transition of engineers in the Transport Technology Division and other 
technology oriented divisions, where ‘specialist’ engineers move into ‘generalist’ roles. 
This change is the result of commercialisation reform in this organisation. Another type 
of transition is the transition of engineers into management roles at the district offices. 
The then Main Roads Department and the Transport Department were amalgamated in 
1987. The district engineers of the Main Roads Department were put in charge of the 
integrated district offices and termed ‘district managers’. The implementation of road 
reform and commercialisation and, to some extent, workplace reform has further 
increased their managerial content and changed their roles. This is the second type of 
transition this study is interested in. In this study, the transition is not considered to be 
an event with a definite start and end, rather it is a process. Hence, the study is 
investigating the contemporary change processes experienced by engineers, as a result of 
several reform programs under way in Queensland Transport.

3.2 Transition of specialist to generalist role

Transport Technology Division was the first such division that initiated this reform in the 
organisation. The study concentrated on senior engineers working in this division at 
different levels. Transport Technology Division (TTD) offers specialist transport 
infrastructure services to district offices, business services (fleet management, purchase 
and supply), road transport, passenger transport and safety divisions. This TTD division 
comprises seven business units; each unit is expected to operate independently and is 
headed by a business leader/manager. Within the business units, the concept of project 
teams is employed whereby a team of specialists are chosen, depending upon their 
expertise and skills for each project; one specialist can be a member simultaneously of 
various project teams. His/her time is divided between the different project teams and 
costs are apportioned accordingly for billing purposes. The project team is headed by a 
specialist with no relation to his/her present ranking. The team under the leadership of 
the team leader is responsible for the marketing and delivery of the project from the 
conceptual stage to the customer relations, and to quality assurance. Each project 
maintains its own accounts and prepares profit and loss statements for each project. In 
these teams, ‘generalist’ engineers work as leaders and/or members. The term 
‘generalist’ engineers denote engineers who perform marketing, customer relations,
financial accounting and human resources management activities, in addition to their
specialist technical functions. The change in the work roles of engineers in this division
into ‘generalist’ engineers is considered as one type of transition.

3.3 Transition into management roles

Queensland Department of Transport has 15 district offices and five regional offices
throughout Queensland, with the head office in Brisbane. In 1987, the then Department
of Main Roads and the Department of Transport Services were amalgamated after a
change of government, as a part of the then government’s move to restructure the public
sector. As a result, the district engineers, the heads at each of the district offices of the
then Main Roads division, were put in charge of the amalgamated district offices and
were made responsible for the program delivery in the areas of roads infrastructure and
transport services. This resulted in the broadening of the engineers’ role and since then,
they were termed ‘district managers’. Prior to amalgamation, these district managers
were called ‘district engineers’ in the Main Roads Department, with a heavy emphasis on
the technical aspects of the work. Though there was some degree of administrative work
involved as a district engineer, it was less when compared with the present district
manager position. In the present district manager position, engineers are responsible for
the roads program in which the technical emphasis was predominant, whereas in the
transport services the emphasis is on customer relations. Basically, this is the first level
of management in the organisation, with full responsibility for program delivery, human
resources, finances and customer relations, and with practically no technical content.
Their roles are considered to be changed further with the introduction of road reform,
through the implementation of the concept of district business model. In addition, the
implementation of commercialisation has affected the focus of the district manager’s role
significantly towards customer relations and effective management of the programs in
the district. Thus, the role of district manager has changed further with the additional
responsibilities of marketing and customer relations. Thus this is the second type of
transition that involves change from district engineer to district manager and further
change in their work role with increased managerial content as a result of the
implementation of reform programs.

4. Objectives and scope of the study

The literature identifies several factors that influence this transition in the engineer’s
role. Apart from the individual personality that is considered to be important in this,
there are other factors such as status of engineers within the organisation as perceived by
the engineers themselves, and by their subordinates; engineering education, both the
content and the learning styles; training and development programs in the organisation,
both their content and timing; earlier work experiences; their career aspirations and
opportunities within the organisation; and the de-engineering trend in public sector
organisations as a part of a broader strategy to make the public sector efficient.
The expected outcomes of this research study are several strategies to successfully manage the transition, from the individual perspective and from the organisational perspective. These findings are expected to have implications for the development of training strategies, career planning and development and engineering education in general. This study focuses primarily on the role of engineers in this change process and does not address other issues such as the impact of this change on employees, change management strategies and their effectiveness, success or failure of those changes, problems in implementation and various models used in this process.

The objective of this study was to investigate these changes in the roles of engineers. The specific questions the researcher would like to answer through this case study are:

1. What are the perceptions of engineers of their jobs in the changed conditions such as difficulties, challenges, rewards, best parts and the worst parts, strengths and weaknesses in terms of skills and attitudes?

2. What are the reasons, motivation and challenges in becoming a manager?

3. What type of organisational support engineers receive during this transition?

4. What is their perception of the change management within the organisation?

5. What is influence of engineers as a group on this transition?

6. What is the impact of the de-engineering process in their organisation?

7. How important is individual personality in succeeding in these new roles?

8. What are the perceptions of engineers on their status within the organisation?

9. How good and useful was their engineering education and what are their views on improvements?

10. What are their impressions about their career development?

With the above questions as background semi-structured questionnaires were used by the researcher for interviewing district managers and engineers.

5. Background and procedures for the field study

5.1 Initial contact and permission to study

Queensland Transport initially approached the Dean of the Faculty of Business in June 1993 and explained the change process of road reform that was under way at that time. In view of its uniqueness, involving significant changes both at the macro levels and at
micro levels the way the organisation was functioning, the project manager of the road reform project sought the involvement of the researchers from QUT. This information was passed on to the heads of school to seek researchers. Subsequently, Mr Ravi Seethamraju (author) from the School of Management, Human Resources and Industrial Relations, and Mr Bob Thompson from the School of Communications and Organisational Studies volunteered to participate in the research. Accordingly, preliminary discussions were held with Mr John White, the project manager, in July 1993. After that, the road reform team, along with the project manager, explained the objectives, methodology and the expected outcomes of the road reform project. Later on in October and November 1993, discussions were held with the individual team members to understand the contextual and conceptual issues in road reform. The aims of those discussions were to identify the possible research areas and focus for the QUT researchers. Based on their invitation, the researchers attended a workshop on road reform at Koolamarra (Bribie Island) in September 1993.

Later on, this researcher approached the project manager in January 1994 to discuss the possibility of concentrating on the changes in the engineers' work roles in Queensland Transport. A background paper was prepared and submitted to the project manager, explaining the objectives of the study, the methods to be followed in data collection and the sample size for interviews. In January 1994, formal permission was given by the project manager to undertake a study and Ms Gloria Simpson, Executive Officer, Road Reform, was nominated as the point of contact for arranging interviews and to furnish any other data.

5.2 Preparation for data collection

Three types of research methods were used in this research. They were personal interviews, documents analysis and a questionnaire survey. However, on a few occasions, the researcher had the opportunity to be a non-participant observer during one workshop and at another review meeting. In the first phase, the researcher collected the published material such as addresses by the Director-general, Executive Director and Director, working papers, memos, circulars, and publicity materials to understand the background. It was agreed to mail the subsequent material to the researcher on a routine basis till the project was completed. The researcher carried the material back to his office for perusal. At times, the individual information given by the interviewees was taken back to the QUT office and relevant material was copied, and returned to the interviewee.

It was proposed to conduct interviews with the district managers. District managers, all engineers-turned-managers, were identified as the key middle management group for the implementation of the road reform, commercialisation and the workplace reform at the district offices. Redefining the roles of district managers was one of the main aspects in the overall restructuring of the district offices, to make them efficient and effective. It was agreed to interview the majority of the district managers (from a total of 15) either at their district offices or at the head office, during their one of the regular visits to the
Brisbane offices. Accordingly, interviews were arranged by Ms Gloria Simpson with eight district managers at the head office from February 1994 to June 1994. In June and July 1994, interviews were scheduled with the three out of the five regional directors, who were also engineers. The regional directors are responsible for three to four district offices and district managers report to them. The researcher was asked to visit the Warwick and Toowoomba Offices to interview the district managers at their offices and the regional director in July 1994. It was agreed by the project manager to reimburse the travel expenses incurred by the researcher upon the submission of receipts. A letter to that effect was given to the researcher by the project manager.

In the second phase, the researcher proposed data collection through personal interviews simultaneously from senior engineers in the Transport Technology Division. The purpose of these interviews was to collect data regarding the change of engineers' roles from specialist to generalist, as defined earlier. The work roles of engineers was changing as a result of commercialisation in that division, as explained in previous paragraphs. The executive officer contacted the Director-Transport technology division and explained the researcher's study. She sought appointments from the director, four group managers, and five other business unit leaders who were all engineers during the months of April to July 1994. A separate questionnaire was used for studying the role of engineers in this division. Background information about the commercialisation concepts and the approach adopted by the division was furnished to the researcher based on request through the executive officer.

A third research method of questionnaire survey is proposed to elicit information from the rank and file engineers in the organisation. It is estimated that there are about 250 engineers working at different capacities in the Department. It was proposed to conduct this survey to test some of the hypotheses generated based on personal interviews and also to provide the extent of such opinions and perceptions of engineers at lower level. Importantly, it is expected to indicate the relationships between such opinions and the age, responsibility level and general educational factors within Queensland Transport. It was proposed to conduct this survey sometime during September and October, 1994.

5.3 Interview procedure

A questionnaire used by Hill (1992) in investigating the transition of specialists into managers was taken as a basis and modified to suit the local conditions. Copies of the two questionnaires, one for interviewing district managers and another for senior engineers in Transport Technology division, were submitted to the project manager, before planning interview schedules. It was proposed by the researcher to record the interviews to enhance the accuracy of data collection after taking prior permission from the interviewee. The project manager agreed to this on principle and decided to leave it to the discretion of the individual interviewee to agree or not. The copies of interview questionnaires were sent to each of the district manager/regional director or engineers in Transport Technology Division prior to the interview by the Executive Officer, Road Reform. Confirmation of the date, time and the venue was sent to the researcher by the
executive officer, after consulting and taking a commitment from the individual respondents. In the case of the district managers, the availability of their time during their short visits to the head office was a problem and interviews had to be scheduled during their visits. This extended the timeframe to six months. The interviews were conducted from March 1994 to July 1994. Thus 10 district managers and three regional directors were interviewed on the transition of engineers into management roles, and nine senior engineers including the director were interviewed on the transition of engineers from specialist role to generalist role.

A copy of the questionnaire was sent to each interviewee prior to the interview. They were asked to furnish certain background information regarding their educational qualifications, experience particulars, and training programs attended, prior to the interview. However, some provided a written response and others preferred to explain orally during the interview. Each interviewee was told beforehand about the background of the researcher, the background to the selection of this case study and respondents, the objectives of the study, and the information the researcher was seeking. The type of transition the researcher was investigating in the case of district managers and in the case of engineers in Transport Technology Division was clarified. The researcher explicitly indicated to each of the respondents that the answers to the questions were voluntary and the interviewee was free not to respond to any of the questions. They were also informed that the answers would be kept completely confidential and would not be seen by anybody other than the researcher. A guarantee was given that no individual would be identified in the final analysis or their identity otherwise disclosed. The researcher indicated that a transcript of the interview would be sent to the individual to confirm his/her views and to make any modifications if necessary to the responses given during interview. It was also agreed by the researcher to switch off the tape recorder whenever the respondent did not want comments to be recorded. All the above information was in written form and was read and explained to each of the interviewees by the researcher before commencing the interview. The interviews closed with the researcher thanking the individuals for their time and effort. Later on, it was agreed to send the transcripts to individuals for their comments and confirmation.
Appendix VI

Semi-Structured Questionnaire
Interview of District Managers in Case Study Organisation

Introduction

I am doing a study of the transition of engineers into management roles. I am conducting the case study component of my research, in the context of road reform, an initiative by Queensland Transport for effecting a significant structural and cultural change. The main objectives of this research are to analyse the changing roles of engineers and to identify the implications of these trends for engineering education, training and career development. The aim of this part of study is to collect district managers’ views, they being engineers, on this topic in order to improve the experiences of those going through the transition.

Answers to all questions are voluntary and they will be kept completely confidential. Information that might identify you will be seen only by me. No individual will be identified in the final analysis or otherwise disclosed.

I would like to get your perceptions of (1) the transition from a district engineer role (before the road reform process) into the district manager’s job; 2) the status of engineers; 3) the present engineering education, content and learning styles; and 4) Career planning and progress.

Thank you for your assistance.

Ravi Seethamraju  
School of Management - QUT, GPO Box 2434, Brisbane, Qld - 4001  
Tel. (07) 864 1324  Fax. (07) 864 1500

Background information

Please furnish the following information in writing before the interview

1. Personal details: Name, Age, Gender, type of engineer, Current position and number of years in the current position (district engineer/manager).

2. List of post-school qualifications obtained: year of passing and name of course, university/institution and other courses currently studying.
3. Job history: Years of experience both within Queensland Transport and outside, job title, company, location, nature of tasks and responsibilities (briefly) and years/months.

4. Training courses attended while working in QT: Type, title of the program, year & month, duration and location of this training.

The District Manager's position

1. Briefly describe your current position and responsibilities.

2. What do the following groups expect from you on the job? a) your immediate superior, b) your subordinate engineers, c) your other subordinates, and d) your non-engineering colleagues.

3. How is (will) your performance on the job (be) measured or evaluated?

4. What are the major stresses and challenges you face on the job? What is the hardest part of your job?

5. What, if anything, you dislike about your job?

6. What rewards are associated with your job?

7. What do you like best about your job?

8. What do you think it takes to be effective or successful at your job?

9. What do you think are the critical differences between the top-performing district manager and the average or below-average district manager? What they do on the job and their skills, knowledge, attitudes and job experience?

10. Think about the skills and knowledge you need to be effective in this job. How did you acquire them? Do your technical (engineering) skills have any relevance to your present job? and are you concerned about it?

The transition

11. Why did you choose to become a district manager?

12. Do you think most engineers in the organisation would choose to go into management? Why?

13. What are the major stresses and challenges associated with the transition?
14. What do you find most demanding about making the transition? What is hardest for you to deal with in making the transition?

15. How are you coping with or managing these stresses, challenges, and demands?

16. What personal and organisational resources are you relying on?

17. What support are you getting from
   a) your superiors,
   b) RR team members,
   c) your subordinates, and
   d) other professionals from other functions like, human resources, industrial relations, corporate services etc.

18. What were your biggest mistakes thus far?

19. What resources do you wish had been available to you for making this transition?

20. What can the organisation do to make this transition relatively smooth and what is it doing now? and how is it doing?

21. What is the influence of your engineering education (both positive or negative) in making this transition easier or more difficult?

22. What do you think about the present organisational change process (Road Reform) in terms of its efficacy, its relevance, and its ability to sustain?

23. What do you think of the influence of the attitudes and value systems of engineers as a professional group on this transition?

24. What do you think of the de-engineering process in public sector organisations in Australia proceeding under deregulation of occupation-specific requirements in 'managerial' positions' (de-engineering is the managerial approach whereby engineers are replaced in the management and leadership of professional engineering functions by non-engineers)? How does it affect the engineers in QT in terms of their career growth, occupational identity, status within organisation, their job satisfaction and general morale.

25. What is the influence of individual engineer's personality characteristics apart from other factors on the successful transition or otherwise?

**Status of engineers**
26. What is the perception of top management and other non-engineering professionals in the organisation about the engineers' ability to hold leadership roles or top management positions in the organisation?

27. Give your personal ranking, and what you think is the ranking by the general public, of the following occupations (1, 2, 3 etc., with 1 being the highest in status).

   A. School teacher,       E. Social worker       I. Dentist
   B. Medical practitioner, F. Lawyer & Solicitors,    J. Accountants
   C. Professional engineers, G. University lecturers, K. Economists
   D. Research scientist    H. Small business person, L. Farmer

28. Why did you rank the engineer as you did? If you think the ranking should be higher, give your reasons.

**Engineering education**

29. How adequate is the current engineering education in Australia? What are its strengths and weaknesses? and how do you propose to overcome those weaknesses?

30. What do you think about the content and learning styles of engineering education in Australia? (for example, the percentage of time spent on different areas such as industrial management, industrial relations, human resource management, social sciences, fundamental sciences, basic engineering subjects and speciality engineering subjects; and learning styles such as participative group exercises/projects, learning through practical projects or by application of theoretical knowledge and direct classroom lecturing; and industrial work experience to be obtained before, during or after academic education)

**Your career**

31. How satisfied are you with your career so far? Is there anything that you have been especially pleased with or disappointed with in the way your career has turned out so far?

32. What do you hope to be doing five or ten years from now (technical versus managerial or design or construction or administration etc.). Would your answer be same if you could receive equal pay for doing technical work without going into management?

33. What do you think is the highest position you could ever expect to hold in future?
34. What sort of things/actions/qualities does it take to get on well in this organisation now, and in the past?

Conclusions

35. If you were me and doing a study of the transition of engineers into managerial roles, what questions would you be sure to ask an engineer-turned-manager?

36. Are there any questions you would like me to try to find answers to as I do this study?
Appendix VII

Semi-Structured Questionnaire
Interview of Senior Engineers, Transport Technology Division, in Case Study Organisation

Introduction

I am doing a research study on the transition of engineers' roles in organisations. The case study component of my research is being conducted in Queensland Transport where a significant structural and cultural change is taking place, in the context of road reform and other change agendas. The main objectives of this research are to analyse the changing roles of engineers and to identify the implications of these trends for engineering education, training and career development. The aim of this part of the study is to collect the views of engineers who are working in service departments on this topic in order to improve the experiences of those going through the transition.

Answers to all questions are voluntary and they will be kept completely confidential. Information that might identify you will be seen only by me. No individual will be identified in the final analysis or otherwise disclosed.

I would like to get your perceptions of (1) the transition from a traditional engineering role into the current role in the context of road reform, commercialisation and related change agenda in Queensland Transport; 2) the status of engineers; 3) the present engineering education, content and learning styles; and 4) Career planning and progress.

Thank you for your assistance.

Ravi Seethamraju
School of Management - QUT, GPO Box 2434, Brisbane, Qld - 4001
Tel. (07) 864 1324 Fax. (07) 864 1500

Background information

Please furnish the following information in writing before the interview

1. Personal details: Name, Age, Gender, type of engineer, current position and number of years in the current position.

2. List of post-school qualifications obtained: Year of passing and name of course, university/institution and other courses currently studying.
3. Job history: Years of experience both within the Queensland Transport and outside, job title, company, location, nature of tasks and responsibilities (briefly) and years/months.

4. Training courses attended while working in QT: Technical and non-technical, type, title of the program, year and month, duration and location of this training.

**Current position**

1. Briefly describe your current position and responsibilities.

2. How is (will) your performance on the job (be) measured or evaluated?

3. What are the major stresses you face on the job?

4. What, if anything, do you dislike about your job?

5. What rewards are associated with your job?

6. What do you like best about your job?

7. What is the hardest part of your job?

8. What do you think it takes to be effective or successful at your present job compared to the one before this change/transition?

9. What do you think are the critical differences between the top-performing engineer and the below-average engineer (poorly performing) under the present changed conditions in terms of their skills, knowledge, attitudes and job experience?

10. Think about the skills and knowledge you need to be effective on this job. How did you acquire them?

11. Do your technical (engineering) skills have any relevance to your present job? and are you concerned about it?

12. What additional skills do you think are required in your new role to succeed?

**The transition**

13. What is the hardest for you to deal with in making the transition?

14. What support are you getting from a) your superiors,
b) RR team members,
c) your subordinates, and
d) your colleagues
e) colleagues from other functions, like human resources, industrial relations, corporate services etc.

15. What resources do you wish had been available to you for making this transition?

16. What can the organisation do to make this transition relatively smooth and what is it doing now? and how is it doing?

17. What was the influence of your engineering education (both positive and negative) in making this transition easier or more difficult?

18. What do you think about the present organisational change process (Road Reform, Commercialisation and Workplace reform etc.) in terms of its efficacy, its relevance, and its ability to sustain?

19. What do you think of the influence of the attitudes and value systems of engineers as a professional group on this transition?

20. What do you think of the de-engineering process in public sector organisations in Australia? How does it affect the engineers in QT in terms of their career growth, occupational identity, status within organisation, their job satisfaction and general morale? (De-engineering is replacing engineers in the leadership and management of professional engineering functions by non-engineers)

21. What is the influence of the individual engineer’s personality characteristics, apart from other factors, on the successful transition or otherwise?

**Engineering education**

22. How adequate is the current engineering education in Australia, in terms of its strengths and weaknesses; relevance to industry; best things and worst things; degree of difficulty; adequacy of time; labs and other facilities etc.

23. What do you think about the content and learning styles of engineering education in Australia? (For example, the percentage of time spent on different areas such as industrial management, industrial relations, human resource management, social sciences, fundamental sciences, basic engineering subjects and speciality engineering subjects; and learning styles such as participative group exercises/projects, learning through practical projects or by application of theoretical knowledge and direct classroom lecturing; and industrial work experience to be obtained before, during or after academic education)
24. What is your assessment of the academic staff in your undergraduate course in terms of their knowledge of current technology, their competence in guiding your learning, their attitude, their ability to practical situations, and teaching?

25. What subjects/areas do you wish you had studied in your undergraduate course?

**Your career**

26. How satisfied are you with your career so far? Is there anything you have been especially pleased with or disappointed with in the way your career has turned out so far?

27. If you have to start all over again, would you choose the same profession, same organisation and same career path? Give your reasons for both negative and positive answers.

28. What do you hope to be doing five or ten years from now (sales, commercial, managerial, design, construction, research & development, administration etc.)? Would your answer be the same if you could receive equal pay for doing technical work, without going into management?

29. Is there a separate technical career path for engineers in Queensland Transport? If 'yes', how effective is it in terms of opportunities, number of levels, status, pay and perception of superiors about the technical career path/ladder. If 'no', do you think QT should have one? Justify your reasons and give your comments about its design and operation in Queensland Transport.

30. What do you think is the highest position you could ever expect to hold?

31. What sort of things/actions/qualities does it take to get on well in this organisation now, and in the past?

**Status of engineers**

32. What is the perception of top management and other non-engineering professionals in the organisation about engineers' ability to hold leadership roles or top management positions in the organisation?

33. Give your personal ranking, and the ranking of the general public, of the following occupations (1, 2, 3 etc., with 1 being the highest in status).

   A. School teacher,  E. Social worker  I. Dentist
   B. Medical practitioner,  F. Lawyer & Solicitors,  J. Accountants
   C. Professional engineers,  G. University lecturers,  K. Economists
   D. Research scientist  H. Small business person,  L. Farmer
34. Why did you rank the engineer as you did? If you think the rank should be higher, give your reasons.

Conclusions

35. If you were me and doing a study of the transition of engineers’ roles, what questions would you be sure to ask an engineer?

36. Are there any questions you would like me to try to find answers to as I do this study?
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### Appendix IX

**SUMMARY OF RESPONSES OF ENGINEERS IN CASE STUDY ORGANISATION ON DIFFERENT THEMES OF TRANSITION**

#### A. Management-oriented engineers

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<th>Theme/dimension</th>
<th>Agree</th>
<th>Disagree</th>
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<td><strong>Orientation</strong></td>
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<tr>
<td>Positive technical orientation</td>
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<td>8</td>
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<td>4</td>
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<td><strong>Attitude towards transition</strong></td>
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<td>Management an integral part of engineering work</td>
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<td>People management is the hardest part of transition</td>
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<td>Nature of work influences the success of transition</td>
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<td>Do not derive satisfaction in non-technical aspects of work</td>
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<td>Curriculum acts as a constraint in making transition</td>
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<td>Heavy workload inhibits development of ‘soft’ skills</td>
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<td>Teaching processes do not encourage ‘soft’ skills development</td>
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<td>Sacrificing technical content to include managerial content</td>
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<td>Ineffective dual-ladder approach</td>
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<td>Generally lack ‘soft’ skills</td>
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<td>Guidance/counselling from superior</td>
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<td>Individual reflection and self-development</td>
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<td>Training in ‘soft’ skills for all engineers</td>
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<td>Curriculum acts as a constraint in making transition</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Heavy workload inhibits development of ‘soft’ skills</td>
<td>8</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Teaching processes do not encourage ‘soft’ skills development</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Sacrificing technical content to include managerial content</td>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td><strong>Organisational systems and policies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ineffective dual-ladder approach</td>
<td>10</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td>Higher status for managers than for engineers</td>
<td>12</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td>Support to acquire management qualifications</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Managed learning on the job</td>
<td>1</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>De-engineering within the organisation</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Status</td>
<td>8</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>---</td>
<td>----</td>
<td>---</td>
</tr>
<tr>
<td>Status is relatively low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived by top management as incapable of management</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Individual personality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual determines success or failure in transition</td>
<td>7</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Nature of engineers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally lack 'soft' skills</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Suitable due to their analytical skills</td>
<td>10</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Strategies for managing transitions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussions with peers/subordinates</td>
<td>10</td>
<td>nil</td>
<td>2</td>
</tr>
<tr>
<td>Guidance/counselling from superior</td>
<td>8</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Individual reflection and self-development</td>
<td>7</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Training in 'soft' skills for all engineers</td>
<td>8</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Postgraduate management education</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Separate technical career path</td>
<td>12</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix X

QUESTIONNAIRE FOR THE SURVEY OF ENGINEERS ON THEIR
ATTITUDES TOWARDS TRANSITION INTO MANAGEMENT ROLES

Instructions for answering the questionnaire:

For each question please tick or circle the number or box which corresponds to the
category most appropriate to you, and where necessary supply details/ comments.
If you would like to make additional comments about the issues raised or any
other matters of concern to you, please feel free to use any space available or to
add an extra page.

1. Branch of engineering
   1□ Civil                2□ Mechanical            3□ Electrical/Electronics

2. Age
   1□ Upto 25 years       2 □ 26 to 30 years   3□ 31 to 35 years
   4□ 36 to 40 years      5□ 41 to 50 years   6□ Over 50 years

3. Gender
   1□ Male                2□ Female

4. Undergraduate (Bachelors degree) engineering qualification
   1□ Yes                 2□ No

5. Undergraduate engineering qualification obtained
   1□ Australia           2□ Overseas

6. Highest qualification in engineering
   1□ Graduate Diploma in..........  2□ Masters degree in......
   3□ PhD in..........................  4□ Others......................
   5□ Bachelors degree in engineering

7. Management-related qualifications (please tick the appropriate one and fill in the
details)
   1 □ Associate Diploma in ..........  2 □ Advanced Certificate in ........
   3 □ Graduate Certificate in ........  4 □ Graduate Diploma in ........
   5 □ Masters Degree in ............  6 □ MBA, ..........................
   7 □ PhD ............................  8 □ Others (please specify) ........
8. Years of experience in technical/managerial fields

1 □ Technical: ..........years (predominantly technical)
2 □ Managerial: ..........years (predominantly managerial)

9. Your experience (may be overlapping)

<table>
<thead>
<tr>
<th>Nature of experience</th>
<th>Years</th>
<th>Nature of exp.</th>
<th>years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 □ Commercial/purchasing</td>
<td>......</td>
<td>2 □ Construction/production</td>
<td>......</td>
</tr>
<tr>
<td>3 □ Designs &amp; development</td>
<td>......</td>
<td>4 □ Inspection/quality</td>
<td>......</td>
</tr>
<tr>
<td>5 □ Maintenance.</td>
<td>......</td>
<td>6 □ Management/admn</td>
<td>......</td>
</tr>
<tr>
<td>7 □ Marketing/sales</td>
<td>......</td>
<td>8 □ Other (please specify)</td>
<td>......</td>
</tr>
</tbody>
</table>

10. Type of organisation in which you presently work

1 □ Consultancy
2 □ Federal government
3 □ Laboratories/research
4 □ Local governments/council
5 □ Maintenance
6 □ Manufacturing
7 □ Teaching and/or training
8 □ Statutory authority
9 □ Others (please specify)....

11. Title of your present position

..........................................................

12. How many levels are there in your organisation

a. above your position....
   b. below your position....

13. Nature of your present job (predominantly) (please tick appropriate box)

1 □ Technical
2 □ Managerial or administrative
3 □ Managerial and technical equally

14. How many people directly report to you in your present job?
   (how many people are you directly supervising)

.................
DEFINITIONS OF SOME TERMS USED IN THIS QUESTIONNAIRE

1. **Generalist engineer**: An engineer who performs some of the business-oriented non-engineering functions such as marketing, customer relations, accounting and human resource management, in addition to technical specialist functions is termed a 'generalist' engineer.

2. **Status**: The term 'status' is used here to reflect the perceptions held by top management, and other non-engineers within the organisation, of the abilities of engineers to hold senior management and leadership positions as compared with other professions such as accountants, economists, lawyers, marketing professionals and HR professionals; also the power and influence they have, as a professional group, in the decision-making process within the organisation.

3. **Soft skills**: Skills such as communication skills, interpersonal skills and business management skills are termed 'soft' skills.

4. **Transition**: The term 'transition' means the change in work roles of engineers from specialist engineer to 'generalist' or a change from specialist to engineer–manager role. This term is used in this questionnaire to describe this change as a continuous process with no definite beginning and ending.

5. **Specialist engineer**: The term 'specialist engineer' refers to an engineer who has considerable experience in a particular technical area.

6. **Non-technical subjects**: This term refers to non-engineering subjects such as psychology, management, organisational behaviour, accounting and the liberal arts that are offered in undergraduate engineering courses.

To what extent do you agree or disagree with the following statements in relation to your experiences and beliefs on the transition of engineers into generalist roles and/or into management roles. Please circle the appropriate number. If you wish, you may add any comments. The scale moves from Strongly Agree to Strongly Disagree.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Attitude towards transition (35 variables):</strong></td>
<td>Strongly agree</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>------------------------------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Engineers move into management roles attracted by the increased pay and perks</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Engineers who have moved into management roles receive better compensations than those who remained in technical functions</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Higher pay is the attracting factor for moving into management roles rather than a specific attitude towards managerial work for engineers</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Engineers move into management roles to open up new leadership opportunities</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Engineers move into management roles to be able to influence strategic organisational decisions</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Movement into management is a natural career progression for engineers</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>The only way to progress in engineering career is to become a manager.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Engineers must become managers in order to have satisfying careers</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>An engineer’s move into management is NOT because of dissatisfaction with engineering work</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Engineers’ moves into management are NOT an escape route from their technological obsolescence</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Soft skills are necessary for engineers at all responsibility levels</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Soft skills are necessary for engineering specialists also (design, R &amp; D etc.)</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13. Managing human resources is the most difficult part of the move into management roles
   5 4 3 2 1

14. People management is the most challenging part of transition
   5 4 3 2 1

15. The move from the certainty of technical matters to the uncertainty of non-engineering issues is the hardest part of transition
   5 4 3 2 1

16. Returning to the technical field due to an inadequate managerial performance is NOT a failure for engineers
   5 4 3 2 1

17. The technical competence of engineers is undervalued if they accept the change into management roles
   5 4 3 2 1

18. By becoming managers, engineers lose their engineering identity
   5 4 3 2 1

19. Managing non-technical functions successfully or otherwise is influenced by individual personality characteristics
   5 4 3 2 1

20. No significant change even after transition, as management is an integral part of engineering work
   5 4 3 2 1

21. Engineers’ career advancement is limited more by lack of ‘soft skills’ than by engineering skills
   5 4 3 2 1

22. Training in ‘soft’ skills is necessary at the beginning of an engineering career
   5 4 3 2 1

23. Training in ‘soft’ skills is necessary just before moving into management roles
   5 4 3 2 1

24. The expansion of engineers’ work roles into that of generalists is an inevitable move consistent with other contemporary organisational changes
   5 4 3 2 1

25. Enterprise-specific technical job knowledge is important for successful performance as a manager
   5 4 3 2 1
26. Engineering qualifications are a must for senior management positions in engineering-based organisations

27. A separate technical career path for promotions is necessary for engineers to develop their careers

28. Technical ladders for specialists are in general less rewarding than managerial ladders

29. Engineers prefer to remain as technical specialists rather than move into generalist roles

30. Specialist engineers dislike the move away from technical matters in their new work roles

31. Engineers prefer to do things themselves rather than delegate tasks

32. Engineers derive higher satisfaction from technical work than from business-related non-technical functions

33. Engineers are suitable for managerial positions because of their analytical and numeric skills

34. Engineers derive satisfaction by advancing their careers within the organisation rather than from professional recognition from peers

35. I would choose engineering as a career over any other profession, if I had to make the choice again (if not, please indicate your choice)

B. Engineering education (16 variables):

1. Engineering education helps engineers be more focused and goal-oriented during changing times

2. Engineering education acts as a constraint in making this transition successful

3. Increasing business management content in the undergraduate engineering education curriculum prepares engineers better for this transition
4. Engineering students do not realise the importance of non-technical subjects in their engineering course in developing the ‘soft’ skills

5. The nature of the engineering education curriculum creates inadequacies in engineers regarding ‘soft’ skills

6. The type of high school leavers entering engineering education are inadequate in the ‘soft’ skills.

7. Engineering education underdevelops the managerial skills of engineers

8. The heavy emphasis on quantitative issues in undergraduate engineering education makes students inadequate in ‘soft’ skills.

9. Good practising engineers generally have a good grade point average at university/college.

10. Work placements in engineering education help engineers to acquire ‘soft’ skills

11. Working in groups on projects helps engineers acquire ‘soft’ skills

12. The workload in engineering courses is heavier than in other comparative undergraduate courses (commerce, science, law, etc.)

13. The heavier workload in engineering inhibits the development of ‘soft’ skills among engineers

14. There is less emphasis on group work in the present undergraduate engineering courses

15. There is less emphasis on oral presentation and communication in the present undergraduate engineering courses

16. There is heavy emphasis on the content rather than on the process of teaching by the academics in engineering schools
C. Organisational systems & policies (6 variables)

1. Skills and knowledge of engineers in our organisation are relatively underutilised
   5 4 3 2 1

2. The organisation in which I work prepares engineers for future management roles
   5 4 3 2 1

3. We have a separate technical career ladder for engineering specialists in our organisation
   5 4 3 2 1

4. Performance in technical specialist roles is the main basis for promotion into management roles in our organisation
   5 4 3 2 1

5. My organisation encourages engineers to acquire management qualifications
   5 4 3 2 1

6. My organisation provides the necessary training to assist engineers in making this transition
   5 4 3 2 1

D. Status of engineers (7 variables)

1. Engineers are highly valued by our top management
   5 4 3 2 1

2. The higher the status of professional engineers within the organisations, and in society in general, the greater the likelihood of success in the transition
   5 4 3 2 1

3. Engineers as a group have less influence than accountants in the decision-making processes at senior management level
   5 4 3 2 1

4. Engineers as a group have less influence than economists in the decision-making processes at senior management level
   5 4 3 2 1

5. Engineers as a group have less influence than marketing professionals in the decision-making processes at senior management level
   5 4 3 2 1

6. Engineers generally are not compensated well relative to their contribution to the economy
   5 4 3 2 1
The lower tertiary entrance scores required for undergraduate engineering courses when compared with medicine, business and science courses in Australia are generally because of the low status society accords the profession

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>By acquiring tertiary qualifications in business management</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>2.</td>
<td>Studying for an MBA</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>3.</td>
<td>Increasing business management content of undergraduate engineering education.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>4.</td>
<td>Increased utilisation of multidisciplinary teaching in undergraduate level</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>5.</td>
<td>Reducing engineering content in undergraduate engineering courses</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>6.</td>
<td>Increasing the number of group assignments/projects in undergraduate courses (in order to improve group working skills)</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>7.</td>
<td>Increasing number of seminars/presentations in undergraduate courses (in order to improve communication skills)</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>8.</td>
<td>Providing opportunities to take on small managerial assignments on a trial basis</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>9.</td>
<td>Rewarding superiors who provide guidance/counselling/assistance to new managers</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>10.</td>
<td>Providing specially designed training to assist the transition</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>11.</td>
<td>Short training courses on specific skills/areas</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>
12. Providing support to those who want to return to technical positions
   5 4 3 2 1
13. Seeking advice/help from superiors
   5 4 3 2 1
14. Discussions and interaction with peer groups/coworkers
   5 4 3 2 1
15. Being open to constructive criticism
   5 4 3 2 1
16. Job rotation
   5 4 3 2 1
17. Delegation from superior
   5 4 3 2 1
18. Carrying out special projects/assignments that are managerial nature
   5 4 3 2 1
19. Promotion to management roles based on management potential rather than technical performance
   5 4 3 2 1
20. Reflecting and learning from individual experience
   5 4 3 2 1
21. Observing and experimenting (teaching potential manager engineers to learn about managing by doing) on the job
   5 4 3 2 1
22. Reading and interpretation of theoretical knowledge (self-development)
   5 4 3 2 1

Please make any further comments (if any) on the transition of engineers (attach a separate sheet if necessary).

We may interview a sample of the respondents in the future. Please indicate your willingness to be interviewed.

☐ Yes ☐ No

If yes, please give your telephone number and name:

We thank you for your cooperation and help.

Ravi Seethamraju
Quality Productivity and Technology Centre
Faculty of Commerce
University of Western Sydney Nepean
P.O. Box 10, Kingswood NSW 2747

Tel. (02) 685 9239 or 9631

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### Coding System: Definition of Variables in Survey Questionnaire

1. **BRANCH**:  
   - 1 = Civil;  
   - 2 = Mechanical  
   - 3 = Electrical/electronics

2. **AGE**:  
   - 1 = Up to 25 years  
   - 2 = 26 to 30 years  
   - 3 = 31 to 35 years  
   - 4 = 36 to 40 years  
   - 5 = 41 to 50 years  
   - 6 = Over 50 years

3. **GENDER**:  
   - 1 = Male  
   - 2 = Female  
   - 9 = Missing value

4. **DEGREE** (Bachelors degree):  
   - 1 = Yes  
   - 2 = No  
   - 9 = Missing value

5. **CONTQLFN**:  
   (Undergraduate engineering qualification completed in 
   ........................................................................country)  
   - 1 = Australia  
   - 2 = Overseas  
   - 9 = Missing value

6. **HIGHQFN**: Highest qualification in engineering  
   - 1 = Graduate diploma  
   - 2 = Masters degree  
   - 3 = PhD in engineering  
   - 4 = Others  
   - 9 = No higher qualification in engineering

7. **MGT.QLFN**: Management qualifications  
   - 1 = Associate Diploma in Management  
   - 2 = Advanced Certificate  
   - 3 = Graduate Certificate  
   - 4 = Graduate Diploma  
   - 5 = Masters degree  
   - 6 = MBA  
   - 7 = PhD in management  
   - 8 = Other degrees such as Bachelors degree in commerce/business/law or some intensive course in GSM/ Mt. Isa colleges etc.  
   - 9 = No management qualification

8. **MGT.QLFN**: Management qualifications regrouped  
   - 1 = MBA or Graduate Diploma holders (mgt.qlfn. Graduate Diploma, Masters Degree and MBA qualifications, types 4, 5, 6)  
   - 2 = Other qualifications (Mgt.qualifn. Associate Diploma, Advance Certificate, Graduate Certificate, PhD and other qualifications, types 1, 2, 3, 7, 8)  
   - 3 = No management qualifications (mgt. qlfn. type 9)

9. **TECH. EXP**  
   Technical experience in years

10. **MGRL. EXP**  
    Managerial experience in years

11. **COMMERL**  
    Commercial/purchasing experience in years

12. **PRODN**  
    Production/construction/manufacturing experience in years
13. DESIGN  Design & development or research experience in years

14. QUALITY  Quality/inspection experience in years

15. MAINT  Maintenance experience in years

16. MANGT  Management/administration experience in years

17. MARKETG  Marketing/sales experience in years

18. OTHERS  Experience in other areas such as teaching, service etc.

19. ORGNTYPE  Type of organisation in which the respondent is presently working

   1=Consultancy
   3=Laboratory/research & development
   5=Maintenance
   7=Teaching/training
   9=Others(include transport, and other service organisations)

20. IND_GRP Broad grouping of organisations in which the respondent is presently working, for purposes of analysis

   1 = Manufacturing group = Maintenance and manufacturing
       (organisation types 5 and 6)

   2 = Government group = Federal/state, local government and statutory bodies
       (organisation types 2, 4 and 8)

   3 = Consultancy = Consultancy organisations
       (organisation type 1)

   4 = Other service orgns. = Laboratories/research, Teaching/training
       and others (organisation types 3, 7 and 9)

21. LEVELSAB  Levels above.....................

22. LEVELSBE  Levels below............

23. JOBNATUR  Job nature (predominant nature of job)

   1=Technical
   2=Managerial or administration
   3=Managerial and technical equally
Variables - Questions on various dimensions:
5=Strongly agree
3=Neutral
1=Strongly disagree

4=Agree
2=Disagree
9=No response
(missing value)

111. INTERVIEW:
We may interview a sample of the respondents in future.
Please indicate your willingness to be interviewed:
1=Yes
2=No

112. NAME

113. TELEPHONE:

114. COMMENTS:  1=Yes
2=No

115. REMARKS:

--oOo--
**Appendix XII**

**DESCRIPTIVE STATISTICAL CHARACTERISTICS OF DEMOGRAPHIC VARIABLES (NOMINAL VARIABLES) IN THE SURVEY**

Appendix XII.1: Respondents by branch of engineering

<table>
<thead>
<tr>
<th>Branch of engineering</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil engineers</td>
<td>291</td>
<td>38%</td>
</tr>
<tr>
<td>Mechanical engineers</td>
<td>310</td>
<td>41%</td>
</tr>
<tr>
<td>Electrical/electronics engineers</td>
<td>155</td>
<td>21%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>756</td>
<td>100%</td>
</tr>
</tbody>
</table>

Appendix XII.2: Respondents by job nature

<table>
<thead>
<tr>
<th>Predominant nature of job</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>178</td>
<td>23.5%</td>
</tr>
<tr>
<td>Managerial</td>
<td>174</td>
<td>23.0%</td>
</tr>
<tr>
<td>Both equally</td>
<td>404</td>
<td>53.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>756</td>
<td>100%</td>
</tr>
</tbody>
</table>

Appendix XII.3: Respondents by engineering discipline and job nature

<table>
<thead>
<tr>
<th>Job nature/discipline</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>69 (24%)</td>
<td>69 (22%)</td>
<td>40 (26%)</td>
<td>178</td>
</tr>
<tr>
<td>Managerial</td>
<td>71 (24%)</td>
<td>71 (23%)</td>
<td>32 (21%)</td>
<td>174</td>
</tr>
<tr>
<td>Both equal</td>
<td>151 (52%)</td>
<td>170 (55%)</td>
<td>83 (53%)</td>
<td>404</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>291 (100%)</td>
<td>310 (100%)</td>
<td>155 (100%)</td>
<td>756</td>
</tr>
</tbody>
</table>
Appendix XII.4: Respondents by gender and job nature

<table>
<thead>
<tr>
<th>Job nature</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>175</td>
<td>3</td>
<td>178</td>
</tr>
<tr>
<td>Managerial</td>
<td>166</td>
<td>8</td>
<td>174</td>
</tr>
<tr>
<td>Both equally</td>
<td>399</td>
<td>5</td>
<td>404</td>
</tr>
<tr>
<td>Total</td>
<td>(97.9%) 740</td>
<td>(2.1%) 16</td>
<td>756</td>
</tr>
</tbody>
</table>

Appendix XII.5: Respondents by gender and engineering discipline

<table>
<thead>
<tr>
<th>Branch of engineering</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil</td>
<td>283</td>
<td>8</td>
<td>291</td>
</tr>
<tr>
<td>Mechanical</td>
<td>307</td>
<td>3</td>
<td>310</td>
</tr>
<tr>
<td>Electrical</td>
<td>150</td>
<td>5</td>
<td>155</td>
</tr>
<tr>
<td>Total</td>
<td>(97.9%) 740</td>
<td>(2.1%) 16</td>
<td>756</td>
</tr>
</tbody>
</table>

Appendix XII.6: Respondents by local vs. overseas bachelors qualification and job nature

<table>
<thead>
<tr>
<th>Location of professional training (degree)</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equally</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>(76%) 136</td>
<td>(80%) 139</td>
<td>(80%) 322</td>
<td>597 (79%)</td>
</tr>
<tr>
<td>Overseas</td>
<td>(24%) 42</td>
<td>(20%) 35</td>
<td>(20%) 82</td>
<td>159 (21%)</td>
</tr>
<tr>
<td>Total</td>
<td>(100%) 178</td>
<td>(10%) 174</td>
<td>(100%) 404</td>
<td>756 (100%)</td>
</tr>
</tbody>
</table>

Appendix XII.7: Respondents by local vs. overseas bachelors qualification and engineering discipline

<table>
<thead>
<tr>
<th>Location of professional training</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>(84%) 245</td>
<td>(78%) 241</td>
<td>(72%) 111</td>
<td>(79%) 597</td>
</tr>
<tr>
<td>Overseas</td>
<td>(16%) 46</td>
<td>(22%) 69</td>
<td>(28%) 44</td>
<td>(21%) 159</td>
</tr>
<tr>
<td>Total</td>
<td>291</td>
<td>310</td>
<td>155</td>
<td>(100%) 756</td>
</tr>
</tbody>
</table>
Appendix XII.8: Respondents by industry and job nature

<table>
<thead>
<tr>
<th>Industry group</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>(16%) 43</td>
<td>(27%) 71</td>
<td>(57%) 151</td>
<td>(100%) 265</td>
<td>35%</td>
</tr>
<tr>
<td>Government</td>
<td>(24%) 43</td>
<td>(27%) 48</td>
<td>(49%) 86</td>
<td>(100%) 177</td>
<td>23%</td>
</tr>
<tr>
<td>Consultancy</td>
<td>(30%) 74</td>
<td>(15%) 38</td>
<td>(55%) 136</td>
<td>(100%) 248</td>
<td>33%</td>
</tr>
<tr>
<td>Others</td>
<td>(27%) 18</td>
<td>(26%) 17</td>
<td>(47%) 31</td>
<td>(100%) 66</td>
<td>9%</td>
</tr>
<tr>
<td>Total</td>
<td>178</td>
<td>174</td>
<td>404</td>
<td>756</td>
<td>100%</td>
</tr>
</tbody>
</table>

Appendix XII.9: Respondents by industry and engineering discipline

<table>
<thead>
<tr>
<th>Industry group</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>(18%) 48</td>
<td>(56%) 147</td>
<td>(26%) 70</td>
<td>(100%) 265</td>
<td>35%</td>
</tr>
<tr>
<td>Government</td>
<td>(60%) 106</td>
<td>(28%) 50</td>
<td>(12%) 21</td>
<td>(100%) 177</td>
<td>23%</td>
</tr>
<tr>
<td>Consultancy</td>
<td>(46%) 113</td>
<td>(35%) 87</td>
<td>(19%) 48</td>
<td>(100%) 248</td>
<td>33%</td>
</tr>
<tr>
<td>Others</td>
<td>(27%) 24</td>
<td>(26%) 26</td>
<td>(47%) 16</td>
<td>(100%) 66</td>
<td>9%</td>
</tr>
<tr>
<td>Total</td>
<td>291</td>
<td>310</td>
<td>155</td>
<td>756</td>
<td>100%</td>
</tr>
</tbody>
</table>

Appendix XII.10: Age group of respondents and job nature

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 30 years</td>
<td>(50%) 17</td>
<td>(12%) 4</td>
<td>(38%) 13</td>
<td>(100%) 34</td>
<td>5%</td>
</tr>
<tr>
<td>31 to 40 years</td>
<td>(30%) 60</td>
<td>(23%) 46</td>
<td>(47%) 92</td>
<td>(100%) 198</td>
<td>26%</td>
</tr>
<tr>
<td>41 to 50 years</td>
<td>(20%) 60</td>
<td>(24%) 72</td>
<td>(56%) 169</td>
<td>(100%) 301</td>
<td>40%</td>
</tr>
<tr>
<td>Over 50 years</td>
<td>(18%) 41</td>
<td>(23%) 52</td>
<td>(59%) 130</td>
<td>(100%) 223</td>
<td>30%</td>
</tr>
<tr>
<td>Total</td>
<td>178</td>
<td>174</td>
<td>404</td>
<td>756</td>
<td>100%</td>
</tr>
</tbody>
</table>

Appendix XII.11: Age group of respondents and engineering discipline

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 30 years</td>
<td>(6%) 18</td>
<td>(3%) 9</td>
<td>(5%) 7</td>
<td>(5%) 34</td>
</tr>
<tr>
<td>31 to 40 years</td>
<td>(27%) 78</td>
<td>(22%) 69</td>
<td>(33%) 51</td>
<td>(26%) 198</td>
</tr>
<tr>
<td>41 to 50 years</td>
<td>(42%) 123</td>
<td>(40%) 122</td>
<td>(36%) 56</td>
<td>(40%) 301</td>
</tr>
<tr>
<td>Over 50 years</td>
<td>(25%) 72</td>
<td>(35%) 110</td>
<td>(26%) 41</td>
<td>(29%) 223</td>
</tr>
<tr>
<td>Total</td>
<td>(100%) 291</td>
<td>(100%) 310</td>
<td>(100%) 155</td>
<td>(100%) 756</td>
</tr>
</tbody>
</table>
### Appendix XII.12: Respondents by management qualifications and job nature

<table>
<thead>
<tr>
<th>Management qualifications</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equal</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBA/Dip/Cert.</td>
<td>(18%) 32</td>
<td>(33%) 57</td>
<td>(24%) 97</td>
<td>186</td>
<td>24%</td>
</tr>
<tr>
<td>Other qualifications</td>
<td>(6%) 11</td>
<td>(9%) 15</td>
<td>(12%) 47</td>
<td>73</td>
<td>10%</td>
</tr>
<tr>
<td>No mgt. Quals.</td>
<td>(76%) 135</td>
<td>(58%) 102</td>
<td>(64%) 260</td>
<td>497</td>
<td>66%</td>
</tr>
<tr>
<td>Total</td>
<td>(100%) 178</td>
<td>(100%) 174</td>
<td>(100%) 404</td>
<td>756</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Appendix XII.13: Respondents by management qualification and engineering discipline

<table>
<thead>
<tr>
<th>Management qualifications</th>
<th>Civil</th>
<th>Mech.</th>
<th>Elec.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBA/Dip/Cert.</td>
<td>(20%) 58</td>
<td>(21%) 67</td>
<td>(30%) 47</td>
<td>(24%) 172</td>
</tr>
<tr>
<td>Other qualifications</td>
<td>(8%) 23</td>
<td>(11%) 34</td>
<td>(10%) 16</td>
<td>(10%) 73</td>
</tr>
<tr>
<td>No mgt. qual.</td>
<td>(72%) 210</td>
<td>(68%) 209</td>
<td>(60%) 92</td>
<td>(66%) 511</td>
</tr>
<tr>
<td>Total</td>
<td>(100%) 291</td>
<td>(100%) 310</td>
<td>(100%) 155</td>
<td>(100%) 756</td>
</tr>
</tbody>
</table>
Appendix XII.14: Technical experience of respondents and job nature

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 5 years</td>
<td>8 (4%)</td>
<td>30 (17%)</td>
<td>21 (5%)</td>
<td>59 (8%)</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>30 (17%)</td>
<td>58 (33%)</td>
<td>108 (27%)</td>
<td>196 (26%)</td>
</tr>
<tr>
<td>11 to 15 years</td>
<td>35 (20%)</td>
<td>46 (26%)</td>
<td>110 (27%)</td>
<td>191 (25%)</td>
</tr>
<tr>
<td>16 to 20 years</td>
<td>41 (23%)</td>
<td>21 (12%)</td>
<td>83 (20.5%)</td>
<td>145 (19%)</td>
</tr>
<tr>
<td>Over 20 years</td>
<td>64 (36%)</td>
<td>19 (11%)</td>
<td>82 (20.5%)</td>
<td>165 (22%)</td>
</tr>
<tr>
<td>Total</td>
<td>178 (100%)</td>
<td>174 (100%)</td>
<td>404 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>18.1 years</td>
<td>11.7 years</td>
<td>15.8 years</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.8 years</td>
<td>6.5 years</td>
<td>7.7 years</td>
<td></td>
</tr>
</tbody>
</table>

Appendix XII.15: Technical experience of respondents and engineering discipline

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Civil</th>
<th>Mechanical</th>
<th>Electrical/electronics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 5 years</td>
<td>24 (8%)</td>
<td>26 (8%)</td>
<td>9 (6%)</td>
<td>59 (8%)</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>73 (25%)</td>
<td>83 (27%)</td>
<td>40 (26%)</td>
<td>196 (26%)</td>
</tr>
<tr>
<td>11 to 15 years</td>
<td>76 (26%)</td>
<td>69 (22%)</td>
<td>46 (30%)</td>
<td>191 (25%)</td>
</tr>
<tr>
<td>16 to 20 years</td>
<td>60 (21%)</td>
<td>56 (18%)</td>
<td>29 (19%)</td>
<td>145 (19%)</td>
</tr>
<tr>
<td>Over 20 years</td>
<td>58 (20%)</td>
<td>76 (25%)</td>
<td>31 (20%)</td>
<td>165 (22%)</td>
</tr>
<tr>
<td>Total</td>
<td>291 (100%)</td>
<td>310 (100%)</td>
<td>155 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>15.3 years</td>
<td>15.8 years</td>
<td>14.9 years</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.0 years</td>
<td>8.4 years</td>
<td>7.1 years</td>
<td></td>
</tr>
</tbody>
</table>
Appendix XII.16: Managerial experience of respondents and job nature

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No experience (0)</td>
<td>101 (57%)</td>
<td>4 (2%)</td>
<td>37 (9%)</td>
<td>142 (19%)</td>
</tr>
<tr>
<td>1 to 5 years</td>
<td>39 (22%)</td>
<td>26 (15%)</td>
<td>123 (30%)</td>
<td>188 (25%)</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>22 (12%)</td>
<td>54 (31%)</td>
<td>129 (32%)</td>
<td>205 (27%)</td>
</tr>
<tr>
<td>11 to 15 years</td>
<td>4 (2%)</td>
<td>24 (14%)</td>
<td>57 (14%)</td>
<td>85 (11%)</td>
</tr>
<tr>
<td>Over 15 years</td>
<td>12 (7%)</td>
<td>66 (38%)</td>
<td>58 (15%)</td>
<td>136 (18%)</td>
</tr>
<tr>
<td>Total</td>
<td>178 (100%)</td>
<td>174 (100%)</td>
<td>404 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>2.8 years</td>
<td>13.1 years</td>
<td>8.8 years</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>4.97 years</td>
<td>7.82 years</td>
<td>6.75 years</td>
<td></td>
</tr>
</tbody>
</table>

Appendix XII.17: Managerial experience of respondents and engineering discipline

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Civil</th>
<th>Mechanical</th>
<th>Electrical/electronics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No experience (0)</td>
<td>56 (19%)</td>
<td>56 (18%)</td>
<td>30 (19%)</td>
<td>142 (19%)</td>
</tr>
<tr>
<td>1 to 5 years</td>
<td>89 (30%)</td>
<td>67 (22%)</td>
<td>32 (21%)</td>
<td>188 (25%)</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>81 (28%)</td>
<td>81 (26%)</td>
<td>43 (28%)</td>
<td>205 (27%)</td>
</tr>
<tr>
<td>11 to 15 years</td>
<td>31 (11%)</td>
<td>33 (11%)</td>
<td>21 (13%)</td>
<td>85 (11%)</td>
</tr>
<tr>
<td>Over 15 years</td>
<td>34 (12%)</td>
<td>73 (23%)</td>
<td>29 (19%)</td>
<td>136 (18%)</td>
</tr>
<tr>
<td>Total</td>
<td>291 (100%)</td>
<td>310 (100%)</td>
<td>155 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>7.3 years</td>
<td>9.4 years</td>
<td>8.5 years</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>7.1</td>
<td>8.0</td>
<td>7.1</td>
<td></td>
</tr>
</tbody>
</table>
Appendix XII.18: Number of employees supervised by engineers and job nature

<table>
<thead>
<tr>
<th>No. to be supervised</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nobody (zero)</td>
<td>73 (41%)</td>
<td>10 (6%)</td>
<td>63 (16%)</td>
<td>146 (19%)</td>
</tr>
<tr>
<td>1 to 2 employees</td>
<td>55 (31%)</td>
<td>12 (7%)</td>
<td>69 (17%)</td>
<td>136 (18%)</td>
</tr>
<tr>
<td>3 to 4 employees</td>
<td>25 (14%)</td>
<td>50 (29%)</td>
<td>83 (21%)</td>
<td>158 (21%)</td>
</tr>
<tr>
<td>5 to 10 employees</td>
<td>25 (14%)</td>
<td>75 (43%)</td>
<td>154 (38%)</td>
<td>254 (34%)</td>
</tr>
<tr>
<td>Over 10 employees</td>
<td>----------</td>
<td>27 (15%)</td>
<td>35 (8%)</td>
<td>62 (8%)</td>
</tr>
<tr>
<td>Total</td>
<td>178 (100%)</td>
<td>174 (100%)</td>
<td>404 (100%)</td>
<td>756 (100%)</td>
</tr>
</tbody>
</table>

Appendix XII.19: Number of employees supervised by engineers and engineering discipline

<table>
<thead>
<tr>
<th>No. to be supervised</th>
<th>Civil</th>
<th>Mechanical</th>
<th>Electrical/electronics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nobody (zero)</td>
<td>63 (22%)</td>
<td>70 (23%)</td>
<td>35 (23%)</td>
<td>168 (19%)</td>
</tr>
<tr>
<td>1 to 2 employees</td>
<td>47 (16%)</td>
<td>46 (15%)</td>
<td>43 (28%)</td>
<td>136 (18%)</td>
</tr>
<tr>
<td>3 to 4 employees</td>
<td>57 (20%)</td>
<td>74 (24%)</td>
<td>27 (17%)</td>
<td>158 (21%)</td>
</tr>
<tr>
<td>5 to 10 employees</td>
<td>109 (37%)</td>
<td>106 (34%)</td>
<td>39 (25%)</td>
<td>254 (34%)</td>
</tr>
<tr>
<td>Over 10 employees</td>
<td>15 (5%)</td>
<td>14 (4%)</td>
<td>11 (7%)</td>
<td>40 (8%)</td>
</tr>
<tr>
<td>Total</td>
<td>291 (100%)</td>
<td>310 (100%)</td>
<td>155 (100%)</td>
<td>756 (100%)</td>
</tr>
</tbody>
</table>
Appendix XII.20: Number of levels below the respondents and job nature

<table>
<thead>
<tr>
<th>No. of Levels below</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No levels</td>
<td>32 (18%)</td>
<td>8 (5%)</td>
<td>38 (9%)</td>
<td>78 (10%)</td>
</tr>
<tr>
<td>One level</td>
<td>39 (22%)</td>
<td>14 (8%)</td>
<td>47 (12%)</td>
<td>100 (13%)</td>
</tr>
<tr>
<td>2 levels below</td>
<td>47 (26%)</td>
<td>46 (26%)</td>
<td>104 (26%)</td>
<td>197 (26%)</td>
</tr>
<tr>
<td>3 levels below</td>
<td>28 (16%)</td>
<td>33 (19%)</td>
<td>96 (24%)</td>
<td>157 (21%)</td>
</tr>
<tr>
<td>4 levels below</td>
<td>18 (10%)</td>
<td>39 (22%)</td>
<td>55 (14%)</td>
<td>112 (15%)</td>
</tr>
<tr>
<td>More than 4 levels</td>
<td>14 (8%)</td>
<td>34 (20%)</td>
<td>64 (16%)</td>
<td>112 (15%)</td>
</tr>
<tr>
<td>Total</td>
<td>178 (100%)</td>
<td>174 (100%)</td>
<td>404 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>3 levels</td>
<td>1.9 levels</td>
<td>2.2 levels</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.45 levels</td>
<td>2.1 levels</td>
<td>1.7 levels</td>
<td></td>
</tr>
</tbody>
</table>

Appendix XII.21: Number of levels below respondents and engineering discipline

<table>
<thead>
<tr>
<th>No. of Levels below</th>
<th>Civil</th>
<th>Mechanical</th>
<th>Electrical/electronics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No levels</td>
<td>27 (9%)</td>
<td>38 (12%)</td>
<td>13 (8%)</td>
<td>78 (10%)</td>
</tr>
<tr>
<td>1 level below</td>
<td>32 (11%)</td>
<td>49 (16%)</td>
<td>19 (12%)</td>
<td>100 (13%)</td>
</tr>
<tr>
<td>2 levels below</td>
<td>78 (27%)</td>
<td>68 (22%)</td>
<td>51 (33%)</td>
<td>197 (26%)</td>
</tr>
<tr>
<td>3 levels below</td>
<td>53 (18%)</td>
<td>75 (24%)</td>
<td>29 (19%)</td>
<td>157 (21%)</td>
</tr>
<tr>
<td>4 levels below</td>
<td>43 (15%)</td>
<td>44 (14%)</td>
<td>25 (16%)</td>
<td>112 (15%)</td>
</tr>
<tr>
<td>More than 4 levels</td>
<td>58 (20%)</td>
<td>36 (12%)</td>
<td>18 (12%)</td>
<td>112 (15%)</td>
</tr>
<tr>
<td>Total</td>
<td>291 (100%)</td>
<td>310 (100%)</td>
<td>155 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2.56 levels</td>
<td>2.31 levels</td>
<td>2.01 levels</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.2 levels</td>
<td>2.7 levels</td>
<td>2.8 levels</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix XII.22: Number of levels above respondents and job nature

<table>
<thead>
<tr>
<th>Levels above</th>
<th>Technical</th>
<th>Managerial</th>
<th>Both equal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No levels</td>
<td>28 (16%)</td>
<td>29 (17%)</td>
<td>86 (21%)</td>
<td>143 (19%)</td>
</tr>
<tr>
<td>One level above</td>
<td>29 (16%)</td>
<td>42 (24%)</td>
<td>79 (20%)</td>
<td>150 (20%)</td>
</tr>
<tr>
<td>2 levels above</td>
<td>37 (21%)</td>
<td>52 (30%)</td>
<td>114 (28%)</td>
<td>203 (27%)</td>
</tr>
<tr>
<td>3 levels above</td>
<td>45 (25%)</td>
<td>27 (15%)</td>
<td>74 (18%)</td>
<td>146 (19%)</td>
</tr>
<tr>
<td>4 levels above</td>
<td>23 (13%)</td>
<td>14 (8%)</td>
<td>30 (8%)</td>
<td>67 (9%)</td>
</tr>
<tr>
<td>More than 4 levels</td>
<td>16 (9%)</td>
<td>10 (6%)</td>
<td>21 (5%)</td>
<td>47 (6%)</td>
</tr>
<tr>
<td>Total</td>
<td>178 (100%)</td>
<td>174 (100%)</td>
<td>404 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>3.0 levels</td>
<td>1.9 levels</td>
<td>2.2 levels</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.56 levels</td>
<td>1.3 levels</td>
<td>1.45 levels</td>
<td></td>
</tr>
</tbody>
</table>

### Appendix XII.23: Number of levels above respondents by engineering discipline

<table>
<thead>
<tr>
<th>No. of Levels above</th>
<th>Civil</th>
<th>Mechanical</th>
<th>Electrical/electronics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No levels</td>
<td>57 (20%)</td>
<td>55 (18%)</td>
<td>31 (20%)</td>
<td>143 (19%)</td>
</tr>
<tr>
<td>1 level above</td>
<td>52 (18%)</td>
<td>74 (24%)</td>
<td>24 (15%)</td>
<td>150 (20%)</td>
</tr>
<tr>
<td>2 levels above</td>
<td>78 (27%)</td>
<td>77 (25%)</td>
<td>48 (31%)</td>
<td>203 (27%)</td>
</tr>
<tr>
<td>3 levels above</td>
<td>59 (20%)</td>
<td>61 (19%)</td>
<td>26 (17%)</td>
<td>146 (19%)</td>
</tr>
<tr>
<td>4 levels above</td>
<td>30 (10%)</td>
<td>22 (7%)</td>
<td>15 (10%)</td>
<td>67 (9%)</td>
</tr>
<tr>
<td>More than 4 levels</td>
<td>15 (5%)</td>
<td>21 (7%)</td>
<td>11 (7%)</td>
<td>47 (6%)</td>
</tr>
<tr>
<td>Total</td>
<td>178 (100%)</td>
<td>174 (100%)</td>
<td>404 (100%)</td>
<td>756 (100%)</td>
</tr>
<tr>
<td>Average</td>
<td>3.0 levels</td>
<td>1.9 levels</td>
<td>2.2 levels</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.66 levels</td>
<td>1.8 levels</td>
<td>1.6 levels</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix XIII

**SUMMARY OF DETAILED RESPONSES OF ENGINEERS ON ALL THE STATEMENTS IN THE QUESTIONNAIRE**

<table>
<thead>
<tr>
<th>Degree of agreement/disagreement</th>
<th>Symbol</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>SA</td>
<td>5</td>
</tr>
<tr>
<td>Agree</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>Neutral</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>Disagree</td>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>SD</td>
<td>1</td>
</tr>
</tbody>
</table>

#### 13.1: Attitude towards transition

<table>
<thead>
<tr>
<th>No</th>
<th>Variable/statement</th>
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<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Attracted by higher pay and perks (at 01)</td>
<td>18%</td>
<td>51%</td>
<td>15%</td>
<td>13%</td>
<td>3%</td>
</tr>
<tr>
<td>2.</td>
<td>Better compensation than those remaining in technical functions (at 02)</td>
<td>46%</td>
<td>28%</td>
<td>14%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>3.</td>
<td>Higher pay rather than specific managerial aptitude (at 03)</td>
<td>14%</td>
<td>40%</td>
<td>28%</td>
<td>15%</td>
<td>3%</td>
</tr>
<tr>
<td>4.</td>
<td>It opens up new leadership opportunities (at 04)</td>
<td>42%</td>
<td>45%</td>
<td>8%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>5.</td>
<td>To be able to influence strategic organisational decisions (at 05)</td>
<td>20%</td>
<td>52%</td>
<td>19%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>6.</td>
<td>It is a natural career progression (at 06)</td>
<td>18%</td>
<td>41%</td>
<td>22%</td>
<td>16%</td>
<td>3%</td>
</tr>
<tr>
<td>7.</td>
<td>As it is the only way to achieve career progress (at 07)</td>
<td>13%</td>
<td>36%</td>
<td>14%</td>
<td>27%</td>
<td>10%</td>
</tr>
<tr>
<td>8.</td>
<td>Must become manager to have a satisfying career (at 08)</td>
<td>15%</td>
<td>50%</td>
<td>23%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>9.</td>
<td>Transition into managerial roles is not due to dissatisfaction in technical aspects of engineering (at 09)</td>
<td>19%</td>
<td>48%</td>
<td>19%</td>
<td>13%</td>
<td>1%</td>
</tr>
<tr>
<td>10.</td>
<td>It is not an escape route for engineers from technological obsolescence (at 10)</td>
<td>23%</td>
<td>39%</td>
<td>20%</td>
<td>15%</td>
<td>3%</td>
</tr>
<tr>
<td>11.</td>
<td>‘Soft’ skills necessary for engineers at all responsibility levels (at 11)</td>
<td>44%</td>
<td>46%</td>
<td>7%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>12.</td>
<td>‘Soft’ skills necessary for engineering specialists in Design, R&amp;D etc. (at 12)</td>
<td>29%</td>
<td>43%</td>
<td>14%</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>13.</td>
<td>Managing human resources is the most difficult part of the move into management roles (at 13)</td>
<td>21%</td>
<td>43%</td>
<td>20%</td>
<td>14%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>People management is the most challenging part of transition (at 14)</td>
<td>36%</td>
<td>40%</td>
<td>14%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>15</td>
<td>Move from certainty of technical matters to uncertainty of non-engineering issues is the hardest part (at 15)</td>
<td>10%</td>
<td>37%</td>
<td>23%</td>
<td>21%</td>
<td>9%</td>
</tr>
<tr>
<td>16</td>
<td>Returning to technical field due to inadequate managerial performance is not a failure (at 16)</td>
<td>16%</td>
<td>37%</td>
<td>22%</td>
<td>21%</td>
<td>4%</td>
</tr>
<tr>
<td>17</td>
<td>Technical competence undervalued if engineers move into management roles (at 17)</td>
<td>11%</td>
<td>29%</td>
<td>18%</td>
<td>31%</td>
<td>11%</td>
</tr>
<tr>
<td>18</td>
<td>Loss of engineering identity by becoming a manager (at 18)</td>
<td>7%</td>
<td>20%</td>
<td>17%</td>
<td>43%</td>
<td>13%</td>
</tr>
<tr>
<td>19</td>
<td>Successful management of non-technical functions is influenced by individual personality (at 19)</td>
<td>31%</td>
<td>53%</td>
<td>12%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>20</td>
<td>No significant change even after transition as management is an integral part of engineering work (at 20)</td>
<td>25%</td>
<td>20%</td>
<td>26%</td>
<td>19%</td>
<td>10%</td>
</tr>
<tr>
<td>21</td>
<td>Engineers career advancement is limited more by lack of ‘soft’ skills rather than by technical ability (at 21)</td>
<td>36%</td>
<td>30%</td>
<td>21%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>22</td>
<td>Training in ‘soft’ skills necessary at the beginning of engineering career (at 22)</td>
<td>35%</td>
<td>44%</td>
<td>14%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>23</td>
<td>Training in ‘soft’ skills necessary just before moving into management roles (at 23)</td>
<td>17%</td>
<td>24%</td>
<td>22%</td>
<td>28%</td>
<td>9%</td>
</tr>
<tr>
<td>24</td>
<td>Expansion of engineer’s work role into generalist role is inevitable consistent with present organisational changes (at 24)</td>
<td>15%</td>
<td>42%</td>
<td>18%</td>
<td>20%</td>
<td>5%</td>
</tr>
<tr>
<td>25</td>
<td>Enterprise-specific technical job knowledge is important for successful performance of an engineer–manager (at 25)</td>
<td>16%</td>
<td>48%</td>
<td>18%</td>
<td>15%</td>
<td>3%</td>
</tr>
<tr>
<td>26</td>
<td>Engineering qualifications a must for senior management positions in engineering-based organisations (at 26)</td>
<td>10%</td>
<td>25%</td>
<td>16%</td>
<td>38%</td>
<td>11%</td>
</tr>
<tr>
<td>27</td>
<td>Separate technical career path necessary for engineers (at 27)</td>
<td>15%</td>
<td>29%</td>
<td>28%</td>
<td>22%</td>
<td>6%</td>
</tr>
<tr>
<td>28</td>
<td>Technical ladders are less rewarding than managerial ladders (at 28)</td>
<td>32%</td>
<td>40%</td>
<td>22%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>29</td>
<td>Engineers prefer to remain as technical specialists rather than moving into generalist role (at 29)</td>
<td>5%</td>
<td>26%</td>
<td>36%</td>
<td>26%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Specialist engineers dislike move away from technical matters in their new work roles (at 30)</td>
<td>16%</td>
<td>48%</td>
<td>21%</td>
<td>13%</td>
<td>2%</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>31</td>
<td>Engineers prefer to do things themselves rather than delegate tasks (at 31)</td>
<td>7%</td>
<td>46%</td>
<td>30%</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>32</td>
<td>Engineers derive higher satisfaction in carrying out technical functions than business-related non-technical functions (at 32)</td>
<td>11%</td>
<td>35%</td>
<td>20%</td>
<td>20%</td>
<td>14%</td>
</tr>
<tr>
<td>33</td>
<td>Engineers are suitable for managerial positions because of their analytical and numeric skills (at 33)</td>
<td>22%</td>
<td>36%</td>
<td>18%</td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td>34</td>
<td>Engineers derive satisfaction from career advancement rather than professional recognition from peers (at 34)</td>
<td>20%</td>
<td>48%</td>
<td>15%</td>
<td>10%</td>
<td>7%</td>
</tr>
<tr>
<td>35</td>
<td>Prefer engineering as a career over any other profession, if I had to make the choice again (at 35)</td>
<td>33%</td>
<td>28%</td>
<td>13%</td>
<td>13%</td>
<td>13%</td>
</tr>
</tbody>
</table>
### 13.2: Engineering education

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particular question/item</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>S D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Helps engineers become more focused and goal-oriented (ed. 01)</td>
<td>14%</td>
<td>45%</td>
<td>28%</td>
<td>11%</td>
<td>2%</td>
</tr>
<tr>
<td>2</td>
<td>Acts as a constraint in making successful transition (ed. 02)</td>
<td>3%</td>
<td>18%</td>
<td>36%</td>
<td>34%</td>
<td>9%</td>
</tr>
<tr>
<td>3</td>
<td>Increasing management content prepares engineers better for transition (ed. 03)</td>
<td>14%</td>
<td>52%</td>
<td>23%</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td>4</td>
<td>Engineers do not realise the importance of non-technical subjects in developing ‘soft’ skills (ed. 04)</td>
<td>26%</td>
<td>40%</td>
<td>18%</td>
<td>12%</td>
<td>4%</td>
</tr>
<tr>
<td>5</td>
<td>Curriculum creates inadequacies in ‘soft’ skills (ed. 05)</td>
<td>10%</td>
<td>38%</td>
<td>30%</td>
<td>18%</td>
<td>4%</td>
</tr>
<tr>
<td>6</td>
<td>Engineering recruits lack these ‘soft’ skills (ed. 06)</td>
<td>9%</td>
<td>35%</td>
<td>38%</td>
<td>13%</td>
<td>5%</td>
</tr>
<tr>
<td>7</td>
<td>Curriculum underdevelops managerial skills among engineers (ed. 07)</td>
<td>9%</td>
<td>35%</td>
<td>28%</td>
<td>22%</td>
<td>6%</td>
</tr>
<tr>
<td>8</td>
<td>Its heavy emphasis on quantitative issues makes engineers inadequate in ‘soft’ skills (ed. 08)</td>
<td>7%</td>
<td>34%</td>
<td>31%</td>
<td>23%</td>
<td>5%</td>
</tr>
<tr>
<td>9</td>
<td>Good academic performance leads to effective practice (ed. 09)</td>
<td>3%</td>
<td>37%</td>
<td>26%</td>
<td>22%</td>
<td>12%</td>
</tr>
<tr>
<td>10</td>
<td>Work placements help engineers acquire ‘soft’ skills (ed. 10)</td>
<td>9%</td>
<td>49%</td>
<td>28%</td>
<td>12%</td>
<td>2%</td>
</tr>
<tr>
<td>11</td>
<td>Working in groups on projects helps engineers acquire ‘soft’ skills (ed. 11)</td>
<td>11%</td>
<td>54%</td>
<td>28%</td>
<td>6%</td>
<td>1%</td>
</tr>
<tr>
<td>12</td>
<td>Heavier workload in engineering than other comparative undergraduate courses (ed. 12)</td>
<td>24%</td>
<td>59%</td>
<td>13%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>13</td>
<td>Heavy workload inhibits the development of ‘soft’ skills (ed. 13)</td>
<td>21%</td>
<td>50%</td>
<td>21%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>14</td>
<td>Less emphasis on group work in engineering schools (ed. 14)</td>
<td>20%</td>
<td>49%</td>
<td>26%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>15</td>
<td>Less emphasis on communications (eg, presentations/seminars, written reports) in the course (content, delivery and assessment) (ed. 15)</td>
<td>21%</td>
<td>60%</td>
<td>15%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>16</td>
<td>Heavy emphasis on content by academics in engineering schools (ed. 16)</td>
<td>10%</td>
<td>58%</td>
<td>21%</td>
<td>8%</td>
<td>3%</td>
</tr>
</tbody>
</table>
### 13.3: Organisational systems and policies

<table>
<thead>
<tr>
<th>No.</th>
<th>Variable/statement</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Skills and knowledge of engineers are underutilised (og_01)</td>
<td>13%</td>
<td>29%</td>
<td>17%</td>
<td>27%</td>
<td>14%</td>
</tr>
<tr>
<td>2</td>
<td>Organisation prepares engineers for future management roles (og_02)</td>
<td>5%</td>
<td>31%</td>
<td>27%</td>
<td>25%</td>
<td>12%</td>
</tr>
<tr>
<td>3</td>
<td>Our organisation has a separate technical career ladder for engineers (og_03)</td>
<td>5%</td>
<td>18%</td>
<td>25%</td>
<td>29%</td>
<td>23%</td>
</tr>
<tr>
<td>4</td>
<td>Performance in technical roles is basis for promotion into management roles (og_04)</td>
<td>14%</td>
<td>36%</td>
<td>14%</td>
<td>24%</td>
<td>12%</td>
</tr>
<tr>
<td>5</td>
<td>Organisation encourages engineers to acquire management qualifications (og_05)</td>
<td>10%</td>
<td>26%</td>
<td>32%</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>6</td>
<td>Organisation provides necessary training to make this transition (og_06)</td>
<td>6%</td>
<td>24%</td>
<td>38%</td>
<td>22%</td>
<td>10%</td>
</tr>
</tbody>
</table>

### 13.4: Status of engineers

<table>
<thead>
<tr>
<th>No</th>
<th>Variable/statement</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Top management values engineers highly (st_01)</td>
<td>11%</td>
<td>24%</td>
<td>27%</td>
<td>27%</td>
<td>11%</td>
</tr>
<tr>
<td>2</td>
<td>Higher the status, the greater the probability of success of transition (st_02)</td>
<td>19%</td>
<td>49%</td>
<td>17%</td>
<td>13%</td>
<td>2%</td>
</tr>
<tr>
<td>3</td>
<td>Engineers have less influence than accountants in organisational decision-making (st_03)</td>
<td>22%</td>
<td>39%</td>
<td>12%</td>
<td>19%</td>
<td>8%</td>
</tr>
<tr>
<td>4</td>
<td>Engineers have less influence than economists in organisational-decision making (st_04)</td>
<td>19%</td>
<td>33%</td>
<td>18%</td>
<td>22%</td>
<td>8%</td>
</tr>
<tr>
<td>5</td>
<td>Engineers have less influence than marketing professionals in organisational decision-making (st_05)</td>
<td>16%</td>
<td>32%</td>
<td>24%</td>
<td>19%</td>
<td>7%</td>
</tr>
<tr>
<td>6</td>
<td>Engineers are not compensated well relative to their contribution to the organisation/economy (st_06)</td>
<td>23%</td>
<td>38%</td>
<td>20%</td>
<td>17%</td>
<td>2%</td>
</tr>
<tr>
<td>7</td>
<td>Lower tertiary entrance score for engineering is because of its lower status in society (st_07)</td>
<td>30%</td>
<td>42%</td>
<td>13%</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>
13.5: Strategies for managing transitions

<table>
<thead>
<tr>
<th>No</th>
<th>Variables/statements</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acquiring postgraduate management qualifications (mg_01)</td>
<td>17%</td>
<td>50%</td>
<td>18%</td>
<td>12%</td>
<td>3%</td>
</tr>
<tr>
<td>2</td>
<td>Studying MBA (mg_02)</td>
<td>9%</td>
<td>22%</td>
<td>31%</td>
<td>24%</td>
<td>14%</td>
</tr>
<tr>
<td>3</td>
<td>Increasing management content in undergraduate engineering education (mg_03)</td>
<td>11%</td>
<td>31%</td>
<td>13%</td>
<td>29%</td>
<td>16%</td>
</tr>
<tr>
<td>4</td>
<td>Utilisation of multidisciplinary teaching in undergraduate engineering course (teaching cross-faculty) (mg_04)</td>
<td>7%</td>
<td>41%</td>
<td>34%</td>
<td>15%</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>Reducing technical content in undergraduate courses (mg_05)</td>
<td>21%</td>
<td>51%</td>
<td>16%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>6</td>
<td>Increasing number of group assignments/projects in undergraduate course (mg_06)</td>
<td>15%</td>
<td>59%</td>
<td>21%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>7</td>
<td>Increasing number of seminars/presentations in undergraduate courses (opportunities for improving communication skills) (mg_07)</td>
<td>18%</td>
<td>58%</td>
<td>15%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>8</td>
<td>Providing opportunities to take on small managerial assignments on trial basis (mg_08)</td>
<td>10%</td>
<td>41%</td>
<td>22%</td>
<td>20%</td>
<td>7%</td>
</tr>
<tr>
<td>9</td>
<td>Rewarding (encouraging) superiors who provide assistance to new engineer–managers (mg_09)</td>
<td>17%</td>
<td>62%</td>
<td>16%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>10</td>
<td>Providing specially designed training to assist the transition (mg_10)</td>
<td>17%</td>
<td>57%</td>
<td>20%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>11</td>
<td>Short training courses on specific areas/skills (mg_11)</td>
<td>58%</td>
<td>20%</td>
<td>14%</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td>12</td>
<td>Providing support to those who want to return to technical positions (mg_12)</td>
<td>46%</td>
<td>36%</td>
<td>4%</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>13</td>
<td>Encouraging them to seek advice (mg_13)</td>
<td>14%</td>
<td>42%</td>
<td>16%</td>
<td>21%</td>
<td>7%</td>
</tr>
<tr>
<td>14</td>
<td>Discussion with peer groups (mg_14)</td>
<td>10%</td>
<td>52%</td>
<td>30%</td>
<td>7%</td>
<td>1%</td>
</tr>
<tr>
<td>15</td>
<td>Being open to constructive criticism (mg_15)</td>
<td>12%</td>
<td>55%</td>
<td>14%</td>
<td>12%</td>
<td>7%</td>
</tr>
<tr>
<td>16</td>
<td>Job rotation (mg_16)</td>
<td>13%</td>
<td>52%</td>
<td>24%</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>17</td>
<td>Delegation from superior (mg_17)</td>
<td>13%</td>
<td>55%</td>
<td>22%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>18</td>
<td>Carrying out special projects/assignments that are managerial in nature (mg_18)</td>
<td>20%</td>
<td>58%</td>
<td>14%</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Promotion to management roles based on management potential rather than technical performance (mg_19)</td>
<td>15%</td>
<td>49%</td>
<td>22%</td>
<td>12%</td>
<td>2%</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>20</td>
<td>Teaching new managers to reflect and to learn from their experiences (mg_20)</td>
<td>18%</td>
<td>51%</td>
<td>17%</td>
<td>10%</td>
<td>4%</td>
</tr>
<tr>
<td>21</td>
<td>Observing and experimenting (teaching them to learn about managing by doing) on the job (mg_21)</td>
<td>15%</td>
<td>54%</td>
<td>20%</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>22</td>
<td>Reading and interpretation of theoretical knowledge (self-development) (mg_22)</td>
<td>6%</td>
<td>36%</td>
<td>31%</td>
<td>22%</td>
<td>5%</td>
</tr>
</tbody>
</table>
### Appendix XIV

**RESULTS OF FACTOR ANALYSIS FOR VARIOUS DIMENSIONS OF TRANSITION**

**Appendix XIV.1: Factors identified from factor analysis; general attitude to transition**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Dimension—Attitude towards transition</th>
<th>Variables grouped under each factor (in data codes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Softskill—Soft skills</td>
<td>at_11, at_12, at_21, at_22, at_23</td>
</tr>
<tr>
<td>2</td>
<td>Nat_prog—Management natural career progression and integrated part of engineering work</td>
<td>at_04, at_05, at_06, at_20</td>
</tr>
<tr>
<td>3</td>
<td>Pay_perk—Pay and perks main reasons for transition than managerial aptitude</td>
<td>at_01, at_02, at_03</td>
</tr>
<tr>
<td>4</td>
<td>Careerpa—Becoming manager is the only way to progress in engineering career</td>
<td>at_07, at_08</td>
</tr>
<tr>
<td>5</td>
<td>Dissatis—Dissatisfaction with technical work</td>
<td>at_09, at_10, at_16</td>
</tr>
<tr>
<td>6</td>
<td>Problems—People management and move from certainty to uncertainty</td>
<td>at_13, at_14, at_15</td>
</tr>
<tr>
<td>7</td>
<td>Underval—Undervalue and loss of engineering identity</td>
<td>at_17, at_18</td>
</tr>
<tr>
<td>8</td>
<td>Individu—Success is dependent upon individual</td>
<td>at_19</td>
</tr>
<tr>
<td>9</td>
<td>Generali—Move into generalists roles inevitable</td>
<td>at_24</td>
</tr>
<tr>
<td>10</td>
<td>Techknow—Technical job knowledge important for successful managerial performance</td>
<td>at_25</td>
</tr>
<tr>
<td>11</td>
<td>De_engg—Engineering qualifications a must for senior management positions</td>
<td>at_26</td>
</tr>
<tr>
<td>12</td>
<td>Dual_lad—Separate technical career path necessary for engineers</td>
<td>at_27</td>
</tr>
<tr>
<td>13</td>
<td>Rew_lad—Technical ladders less rewarding than managerial ladders</td>
<td>at_28</td>
</tr>
<tr>
<td>14</td>
<td>Techorie—Technical orientation</td>
<td>at_29, at_30</td>
</tr>
<tr>
<td>15</td>
<td>Delegate—Prefer to do themselves than delegate</td>
<td>at_31</td>
</tr>
<tr>
<td>16</td>
<td>Disinter—Disinterested in non-technical work</td>
<td>at_32</td>
</tr>
<tr>
<td>17</td>
<td>Suitable—Engineers suitable due to their analytical and numerical skills</td>
<td>at_33</td>
</tr>
<tr>
<td>18</td>
<td>Satisfy—Satisfied more by career progression than by professional recognition from peers</td>
<td>at_34</td>
</tr>
<tr>
<td>19</td>
<td>Preferen—Prefers engineering as a career</td>
<td>at_35</td>
</tr>
</tbody>
</table>
## Appendix XIV.2 : Factors identified from factor analysis; engineering education

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor description</th>
<th>Grouping of variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Strengths—Positive aspects of engg. education</td>
<td>ed_01, ed_02, ed_09</td>
</tr>
<tr>
<td>2</td>
<td>Weakness—Weaknesses in engg. education</td>
<td>ed_05, ed_07, ed_08</td>
</tr>
<tr>
<td>3</td>
<td>Content—Business management content in engg. education and its importance</td>
<td>ed_03, ed_04</td>
</tr>
<tr>
<td>4</td>
<td>Recruits—Engineering recruits lack necessary skills for transition</td>
<td>ed_06</td>
</tr>
<tr>
<td>5</td>
<td>Workload—Heavy workload in engg. education</td>
<td>ed_12, ed_13</td>
</tr>
<tr>
<td>6</td>
<td>Emphasis—Less emphasis on process-related issues in engg. education teaching and learning</td>
<td>ed_14, ed_15, ed_16</td>
</tr>
<tr>
<td>7</td>
<td>Strategy—Strategies employed to develop ‘soft’ skills—work placement and group projects</td>
<td>ed_10, ed_11</td>
</tr>
</tbody>
</table>

## Appendix XIV.3: Factors identified from factor analysis; organisational support

<table>
<thead>
<tr>
<th>Factor</th>
<th>Organisational support (name and meaning of factors)</th>
<th>Variables grouped under each factor (in data codes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Underutil—Under utilisation of engineers' skills</td>
<td>og_01</td>
</tr>
<tr>
<td>2</td>
<td>Support—Support provided by management</td>
<td>og_02, og_06</td>
</tr>
<tr>
<td>3</td>
<td>Tech_lad—Separate technical ladder for engineering specialists</td>
<td>og_03</td>
</tr>
<tr>
<td>4</td>
<td>Pro_base—Technical performance as basis for promotion into management</td>
<td>og_04</td>
</tr>
<tr>
<td>5</td>
<td>Mgt_qlfn—Organisation encourages engineers to acquire management qualifications</td>
<td>og_05</td>
</tr>
</tbody>
</table>
### Appendix XIV.4: Factors identified from factor analysis; status

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dimensions—Attitude towards transition</th>
<th>Variables grouped under each factor (in data codes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Topmgt—Top management perception of engineers</td>
<td>st_01</td>
</tr>
<tr>
<td>2</td>
<td>Orgnstat—Organisational status in comparison with other professions</td>
<td>st_03, st_04, st_05</td>
</tr>
<tr>
<td>2</td>
<td>Society—Status in the society</td>
<td>st_06, st_07</td>
</tr>
<tr>
<td>4</td>
<td>Status_s—Higher the status, greater the probability of success in management roles</td>
<td>st_02</td>
</tr>
</tbody>
</table>

### Appendix XIV.5: Factors identified from factor analysis; strategies for managing transitions

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dimensions—Attitude towards transition</th>
<th>Variables grouped under each factor (in data codes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Postgrad—Postgraduate management education</td>
<td>mg_01, mg_02</td>
</tr>
<tr>
<td>2</td>
<td>Eduncont—Changes in the content of engg. education</td>
<td>mg_03, mg_04</td>
</tr>
<tr>
<td>3</td>
<td>Edunproc—Changes in the process of engineering education</td>
<td>mg_05, mg_06, mg_07</td>
</tr>
<tr>
<td>4</td>
<td>Orgnsupp—Organisational support systems</td>
<td>mg_08, mg_09, mg_10, mg_11, mg_12</td>
</tr>
<tr>
<td>5</td>
<td>Expelmg—Experiential learning</td>
<td>mg_13, mg_14, mg_15, mg_16, mg_17, mg_18, mg_19, mg_20, mg_21</td>
</tr>
<tr>
<td>6</td>
<td>Indideve—Individual development</td>
<td>mg_22</td>
</tr>
</tbody>
</table>
### Appendix XV

**SUMMARY OF T-TEST RESULTS (TEST OF SIGNIFICANCE OF DIFFERENCES BETWEEN TECHNICAL VS. MANAGERIAL ENGINEERS)**

#### Appendix XV.1: Summary of t-test results; general attitude towards transition

(Sample size: Technical engineers = 170 to 178; Managerial engineers = 170 to 174)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Dimensions—Attitude towards transition</th>
<th>Tech. engineer (mean 1)</th>
<th>Mgrl. engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Softskill—‘Soft’ skills</td>
<td>15.114</td>
<td>16.474</td>
<td>0.000*</td>
</tr>
<tr>
<td>2</td>
<td>Nat_prog—Management natural career progression and an integrated part of engineering work</td>
<td>13.817</td>
<td>15.9885</td>
<td>0.000*</td>
</tr>
<tr>
<td>3</td>
<td>Pay_perk—Pay and perks main reasons for transition rather than managerial aptitude</td>
<td>11.384</td>
<td>10.448</td>
<td>0.000*</td>
</tr>
<tr>
<td>4</td>
<td>Careerpa—Becoming manager is the only way to progress in engineering career</td>
<td>6.629</td>
<td>6.057</td>
<td>0.000*</td>
</tr>
<tr>
<td>5</td>
<td>Dissatis—Dissatisfaction with technical work</td>
<td>10.8068</td>
<td>10.753</td>
<td>0.826</td>
</tr>
<tr>
<td>6</td>
<td>Problems—People management and move from certainty to uncertainty are problems in transition</td>
<td>10.825</td>
<td>11.017</td>
<td>0.009*</td>
</tr>
<tr>
<td>7</td>
<td>Underval—Undervaluing and loss of engineering identity</td>
<td>6.305</td>
<td>5.465</td>
<td>0.000*</td>
</tr>
<tr>
<td>8</td>
<td>Individu—Success is dependent upon individual</td>
<td>4.0899</td>
<td>4.127</td>
<td>0.653</td>
</tr>
<tr>
<td>9</td>
<td>Generali—Move into generalist roles inevitable</td>
<td>3.330</td>
<td>3.683</td>
<td>0.002*</td>
</tr>
<tr>
<td>10</td>
<td>Techknow—Technical job knowledge important for successful managerial performance</td>
<td>3.57</td>
<td>4.60</td>
<td>0.771</td>
</tr>
<tr>
<td>11</td>
<td>Deengg—Engineering qualifications a must for mgmt. positions in engg. orgns.</td>
<td>3.39</td>
<td>2.32</td>
<td>0.000*</td>
</tr>
<tr>
<td>12</td>
<td>Dual_lad—Separate technical career path necessary for engineers</td>
<td>3.396</td>
<td>3.023</td>
<td>0.002*</td>
</tr>
<tr>
<td>13</td>
<td>Rew_lad—Technical ladders less rewarding than managerial ladders</td>
<td>4.017</td>
<td>4.180</td>
<td>0.085</td>
</tr>
<tr>
<td>14</td>
<td>Techorie—Technical orientation</td>
<td>7.084</td>
<td>6.410</td>
<td>0.000*</td>
</tr>
<tr>
<td>15</td>
<td>Delegate—Prefer to do things themselves rather than delegate</td>
<td>3.466</td>
<td>3.267</td>
<td>0.293</td>
</tr>
<tr>
<td>16</td>
<td>Disinter—Disinterested in non-technical work</td>
<td>2.562</td>
<td>2.086</td>
<td>0.000*</td>
</tr>
</tbody>
</table>
### Appendix XV.2: Summary of t-test results; engineering education

Significance of differences between technical and managerial engineers  
(Sample size: Technical engineers = 170 to 178; Managerial engineers = 170 to 174)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor description</th>
<th>Tech. engineer (mean 1)</th>
<th>Mgrl. engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Strengths—Positive aspects of engg. education</td>
<td>9.735</td>
<td>9.742</td>
<td>0.972</td>
</tr>
<tr>
<td>2</td>
<td>Weakness—Weaknesses in engg. education</td>
<td>9.217</td>
<td>9.901</td>
<td>0.028*</td>
</tr>
<tr>
<td>3</td>
<td>Content—Business management content in engg. education and its importance</td>
<td>7.073</td>
<td>7.607</td>
<td>0.005*</td>
</tr>
<tr>
<td>4</td>
<td>Recruits—Engineering recruits lack necessary skills for transition</td>
<td>3.231</td>
<td>3.358</td>
<td>0.201</td>
</tr>
<tr>
<td>5</td>
<td>Workload—Heavy workload in engg. education</td>
<td>7.352</td>
<td>7.290</td>
<td>0.719</td>
</tr>
<tr>
<td>6</td>
<td>Emphasis—Less emphasis on process-related issues in engg. education teaching and learning</td>
<td>9.020</td>
<td>9.686</td>
<td>0.018*</td>
</tr>
<tr>
<td>7</td>
<td>Strategy—Strategies employed to develop ‘soft skills’—work placement and group projects</td>
<td>7.136</td>
<td>7.284</td>
<td>0.325</td>
</tr>
<tr>
<td>8</td>
<td>ED_Score—Total score on engineering education index</td>
<td>53.052</td>
<td>54.729</td>
<td>0.035*</td>
</tr>
</tbody>
</table>
Appendix XV.3: Summary of t-test results; organisational support for transition

Significance of differences between technical and managerial engineers
(Sample size: Technical engineers = 170 to 178; Managerial engineers = 170 to 174)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factors—Organisational support (name and meaning of factors)</th>
<th>Tech. engineer (mean 1)</th>
<th>Mgrl. engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Underuti—Underutilisation of engineers’ skills</td>
<td>3.170</td>
<td>2.936</td>
<td>0.038*</td>
</tr>
<tr>
<td>2</td>
<td>Support—Support provided by management</td>
<td>8.207</td>
<td>9.543</td>
<td>0.000*</td>
</tr>
<tr>
<td>3</td>
<td>Pro_base—Technical performance as basis for promotion into management</td>
<td>3.393</td>
<td>2.873</td>
<td>0.000*</td>
</tr>
<tr>
<td>4</td>
<td>Techlade—Separate technical career ladder for engineers</td>
<td>2.598</td>
<td>2.603</td>
<td>0.969</td>
</tr>
<tr>
<td>5</td>
<td>Og_Score—Total score on organisational support index</td>
<td>17.341</td>
<td>17.966</td>
<td>0.054*</td>
</tr>
</tbody>
</table>

Appendix XV.4: Summary of t-test results; status of engineers

Significance of differences between technical and managerial engineers
(Sample size: Technical engineers = 170 to 178; Managerial engineers = 170 to 174)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dimensions—Attitude towards transition</th>
<th>Tech. engineer (mean 1)</th>
<th>Mgrl. engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Topmgt—Top management’s perception of engineers</td>
<td>2.770</td>
<td>3.086</td>
<td>0.009*</td>
</tr>
<tr>
<td>2</td>
<td>Orgnstat—Organisational status in comparison with that of other professions</td>
<td>10.508</td>
<td>9.773</td>
<td>0.029*</td>
</tr>
<tr>
<td>2</td>
<td>Society—Status in society</td>
<td>7.202</td>
<td>7.075</td>
<td>0.573</td>
</tr>
<tr>
<td>4</td>
<td>Status_s—The higher the status, the greater probability of success in management roles</td>
<td>3.593</td>
<td>3.484</td>
<td>0.331</td>
</tr>
<tr>
<td>5</td>
<td>ST_score—Total score on status index</td>
<td>24.067</td>
<td>23.391</td>
<td>0.141</td>
</tr>
</tbody>
</table>
Appendix XV.5: Summary of t-test results; strategies for managing transition

Significance of differences between technical and managerial engineers
(Sample size: Technical engineers = 170 to 178; Managerial engineers = 170 to 174)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dimensions—Attitude towards transition</th>
<th>Tech. engineer (mean 1)</th>
<th>Mgrl. engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Postgrad—Postgraduate management education</td>
<td>6.265</td>
<td>6.920</td>
<td>0.038*</td>
</tr>
<tr>
<td>2</td>
<td>Eduncont—Changes in the content of engg. education</td>
<td>6.367</td>
<td>6.775</td>
<td>0.029*</td>
</tr>
<tr>
<td>3</td>
<td>Edunproc—Changes in the process of engineering education</td>
<td>10.694</td>
<td>11.123</td>
<td>0.014*</td>
</tr>
<tr>
<td>4</td>
<td>Orgnsupp—Organisational support systems</td>
<td>17.180</td>
<td>17.145</td>
<td>0.878</td>
</tr>
<tr>
<td>5</td>
<td>Expelrng—Experiential learning</td>
<td>33.389</td>
<td>33.635</td>
<td>0.602</td>
</tr>
<tr>
<td>6</td>
<td>Indideve—Individual development</td>
<td>3.176</td>
<td>3.063</td>
<td>0.273</td>
</tr>
<tr>
<td>7</td>
<td>Mg_score—Total score on managing strategies index</td>
<td>77.348</td>
<td>78.383</td>
<td>0.201</td>
</tr>
</tbody>
</table>
## SUMMARY OF T-TEST RESULTS
### (TEST OF SIGNIFICANCE OF DIFFERENCES BETWEEN VARIOUS DISCIPLINES OF ENGINEERS)

### Appendix XVI.1: Significant differences between civil and mechanical engineers
(Sample size: Civil engineers = 288 to 291; Mechanical engineers = 302 to 307)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Dimensions—Attitude towards transition</th>
<th>Civil engineer (mean 1)</th>
<th>Mech. engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attitude towards transition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Problems—People management and move from certainty to uncertainty of problems in transition</td>
<td>10.57</td>
<td>11.10</td>
<td>0.005*</td>
</tr>
<tr>
<td></td>
<td>2. Underval—Undervaluing and loss of engineering identity</td>
<td>6.05</td>
<td>5.65</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>3. Techknow—Technical job knowledge important in transition</td>
<td>6.84</td>
<td>7.14</td>
<td>0.024*</td>
</tr>
<tr>
<td></td>
<td>4. De-engg—Engg. qualifications a must for senior management positions</td>
<td>3.55</td>
<td>3.32</td>
<td>0.005*</td>
</tr>
<tr>
<td></td>
<td>5. Preferenc—Preference for an engineering career</td>
<td>3.42</td>
<td>3.73</td>
<td>0.008*</td>
</tr>
<tr>
<td></td>
<td>6. Overall index on attitude</td>
<td>109.56</td>
<td>108.65</td>
<td>0.725</td>
</tr>
<tr>
<td>2</td>
<td>Organisational Support:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Techlade—Technical ladder</td>
<td>2.63</td>
<td>2.43</td>
<td>0.034*</td>
</tr>
<tr>
<td></td>
<td>Overall index on Orgn. support</td>
<td>17.61</td>
<td>17.53</td>
<td>0.325</td>
</tr>
<tr>
<td>3</td>
<td>Status:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Topmgt—Top management’s perception of low status of engineers</td>
<td>2.87</td>
<td>3.08</td>
<td>0.041*</td>
</tr>
<tr>
<td></td>
<td>Overall index on status</td>
<td>24.27</td>
<td>223.69</td>
<td>0.096</td>
</tr>
<tr>
<td>4</td>
<td>Managing transitions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>77.82</td>
<td>78.12</td>
<td>0.662</td>
</tr>
</tbody>
</table>
**Appendix XVI.2: Summary of t-test results; significant differences between civil and electrical engineers**

(Sample size: Civil engineers = 279 to 291; Electrical engineers = 150 to 156)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Dimensions—Attitude towards transition</th>
<th>Civil engineer (mean 1)</th>
<th>Electrical engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General attitude towards transition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Generalis—Transition into generalist role inevitable</td>
<td>3.40</td>
<td>3.70</td>
<td>0.008*</td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>110.14</td>
<td>110.63</td>
<td>0.400</td>
</tr>
<tr>
<td>2</td>
<td>Engineering education:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Emphasis—Less emphasis on process of teaching and learning</td>
<td>9.15</td>
<td>9.71</td>
<td>0.010*</td>
</tr>
<tr>
<td></td>
<td>Overall index on engg. education</td>
<td>53.67</td>
<td>54.10</td>
<td>0.590</td>
</tr>
<tr>
<td>3</td>
<td>Organisational support:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Techlade—Technical ladder</td>
<td>2.63</td>
<td>2.42</td>
<td>0.050*</td>
</tr>
<tr>
<td></td>
<td>Overall index on orgn. support</td>
<td>17.61</td>
<td>17.07</td>
<td>0.109</td>
</tr>
<tr>
<td>4</td>
<td>Status:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Society—Lower status in society</td>
<td>7.60</td>
<td>7.11</td>
<td>0.020*</td>
</tr>
<tr>
<td></td>
<td>Overall index on status</td>
<td>24.27</td>
<td>24.09</td>
<td>0.680</td>
</tr>
<tr>
<td>5</td>
<td>Managing transitions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Postgrad—Postgraduate management education</td>
<td>6.35</td>
<td>6.81</td>
<td>0.010*</td>
</tr>
<tr>
<td></td>
<td>2. Orgnsupp—Organisational support</td>
<td>17.33</td>
<td>16.80</td>
<td>0.015*</td>
</tr>
<tr>
<td></td>
<td>3. Explrlng—Experiential learning</td>
<td>33.65</td>
<td>32.71</td>
<td>0.032*</td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>77.82</td>
<td>77.18</td>
<td>0.416</td>
</tr>
</tbody>
</table>
Appendix XVI.3: Summary of t-test results; significant differences between mechanical and electrical engineers

(Sample size: Civil engineers = 301 to 310; Electrical engineers = 150 to 156)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Dimensions</th>
<th>Mech. engineer (mean 1)</th>
<th>Electrical engineer (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General attitude towards transition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Natprog—Natural career progression</td>
<td>14.69</td>
<td>15.57</td>
<td>0.002*</td>
</tr>
<tr>
<td></td>
<td>2. Generalis—Transition into generalist role inevitable</td>
<td>3.32</td>
<td>3.69</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>3. Techknow—Technical job knowledge important for managerial performance</td>
<td>6.84</td>
<td>7.34</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>86.28</td>
<td>87.93</td>
<td>0.033*</td>
</tr>
<tr>
<td>2</td>
<td>Engineering education:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall index on engg. education</td>
<td>53.28</td>
<td>54.09</td>
<td>0.312</td>
</tr>
<tr>
<td>3</td>
<td>Organisational support:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>17.33</td>
<td>17.07</td>
<td>0.454</td>
</tr>
<tr>
<td>4</td>
<td>Status:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall index on status</td>
<td>23.68</td>
<td>24.10</td>
<td>0.331</td>
</tr>
<tr>
<td>5</td>
<td>Managing transitions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Orgnsupp—Organisational support</td>
<td>17.19</td>
<td>16.80</td>
<td>0.035*</td>
</tr>
<tr>
<td></td>
<td>2. Explrng—Experiential learning</td>
<td>33.75</td>
<td>32.71</td>
<td>0.018*</td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>78.12</td>
<td>77.17</td>
<td>0.223</td>
</tr>
</tbody>
</table>
Appendix XVI

Appendix XVII.1: Significant differences between management-qualified engineers and engineers without management qualifications

(Sample size: Management-qualified engineers = 180 to 186; Engineers with no management qualifications = 486 to 497)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Dimensions—Attitude towards transition</th>
<th>With mgt qlfns. (mean 1)</th>
<th>No mgt. qlfns. (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General attitude towards transition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Softskil—‘Soft’ skills</td>
<td>16.08</td>
<td>15.63</td>
<td>0.030*</td>
</tr>
<tr>
<td></td>
<td>2. Natprog—Natural career progression</td>
<td>15.84</td>
<td>14.68</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>3. Dissatis—Dissatisfaction with engineering work</td>
<td>10.55</td>
<td>10.96</td>
<td>0.029*</td>
</tr>
<tr>
<td></td>
<td>4. Training—Training in ‘soft’ skills at beginning of engineering career</td>
<td>3.46</td>
<td>3.26</td>
<td>0.042*</td>
</tr>
<tr>
<td></td>
<td>5. Disinter—Disinterest in non-technical work</td>
<td>2.19</td>
<td>2.43</td>
<td>0.012*</td>
</tr>
<tr>
<td></td>
<td>6. Preferen—Career preference to engineering</td>
<td>3.33</td>
<td>3.61</td>
<td>0.020*</td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>110.24</td>
<td>109.58</td>
<td>0.042*</td>
</tr>
<tr>
<td>2</td>
<td>Engineering education:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Workload—Heavier workload in engineering than in other courses</td>
<td>7.38</td>
<td>7.07</td>
<td>0.022*</td>
</tr>
<tr>
<td></td>
<td>2. Strategy—Work placements and group assignments</td>
<td>7.39</td>
<td>7.09</td>
<td>0.010*</td>
</tr>
<tr>
<td></td>
<td>Overall index on engg. education</td>
<td>54.40</td>
<td>52.32</td>
<td>0.017*</td>
</tr>
<tr>
<td>3</td>
<td>Organisational support:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall index</td>
<td>17.39</td>
<td>17.36</td>
<td>0.929</td>
</tr>
<tr>
<td>4</td>
<td>Status:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Status s—The higher the status, the greater the probability of success</td>
<td>3.71</td>
<td>3.53</td>
<td>0.040*</td>
</tr>
<tr>
<td>Overall index on status</td>
<td>24.05</td>
<td>23.87</td>
<td>0.618</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing transitions:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Postgrad—Postgraduate management education</td>
<td>7.35</td>
<td>6.18</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>2. Eduncont—Changes in the content of engineering education</td>
<td>6.86</td>
<td>6.55</td>
<td>0.043*</td>
<td></td>
</tr>
<tr>
<td>3. Edunproc—Changes in the process of engineering education</td>
<td>11.52</td>
<td>10.49</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>4. Orgnsupp—Organisational support</td>
<td>16.82</td>
<td>17.34</td>
<td>0.009*</td>
<td></td>
</tr>
<tr>
<td>Overall index</td>
<td>78.97</td>
<td>77.29</td>
<td>0.016*</td>
<td></td>
</tr>
</tbody>
</table>
Appendix XVII

Appendix XVII.2: Significant differences between engineers employed in Manufacturing (Mnfg.) vs. Government (Govt.) and Consultancy (Consl.) sectors

(Sample size: Manufacturing industry = 260 to 265; Government sector = 170 to 177; Consultancy sector = 240 to 248)

<table>
<thead>
<tr>
<th>Dimensions—Attitude towards transition</th>
<th>Mnfg. (mean1)</th>
<th>Govt. (mean2)</th>
<th>Consl. (mean3)</th>
<th>Signif. (1vs.2)</th>
<th>Signif. (1vs.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude towards transition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Techorie—Technical orientation</td>
<td>6.48</td>
<td>6.86</td>
<td>6.66</td>
<td>0.016*</td>
<td>0.186</td>
</tr>
<tr>
<td>2. Preferen—Prefers engineering career</td>
<td>3.71</td>
<td>3.34</td>
<td>3.51</td>
<td>0.006*</td>
<td>0.095</td>
</tr>
<tr>
<td>Organisational support:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Underuti—Under-utilisation of engineers’ skills</td>
<td>2.92</td>
<td>3.51</td>
<td>2.66</td>
<td>0.000*</td>
<td>0.018*</td>
</tr>
<tr>
<td>2. Support—Support provided by management</td>
<td>9.46</td>
<td>8.01</td>
<td>8.87</td>
<td>0.000*</td>
<td>0.026*</td>
</tr>
<tr>
<td>3. Pro_base—Technical performance as basis for promotion into management</td>
<td>2.96</td>
<td>3.23</td>
<td>3.06</td>
<td>0.034</td>
<td>0.247</td>
</tr>
<tr>
<td>4. Techlade—Separate technical career ladder for engineers</td>
<td>2.24</td>
<td>2.67</td>
<td>2.65</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Status:</td>
<td>1. Topmgt—Top management perception of engineers</td>
<td>2. Orgnstat—Organisational status in comparison with other professions</td>
<td>3. Society—Status in society</td>
<td>Overall index on status</td>
<td>Managing transitions:</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
<td>3.16</td>
<td>2.68</td>
<td>3.08</td>
<td>0.000*</td>
<td>0.470</td>
</tr>
<tr>
<td></td>
<td>9.57</td>
<td>10.316</td>
<td>10.313</td>
<td>0.012*</td>
<td>0.010*</td>
</tr>
<tr>
<td></td>
<td>6.78</td>
<td>7.54</td>
<td>7.61</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>23.13</td>
<td>24.09</td>
<td>24.57</td>
<td>0.020</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>6.59</td>
<td>6.75</td>
<td>6.25</td>
<td>0.347</td>
<td>0.026*</td>
</tr>
</tbody>
</table>
Appendix XVII

Appendix XVII.3: Significant differences between male engineers and female engineers

(Sample size: male engineers = 730 to 740; female engineers = 15 to 16)

<table>
<thead>
<tr>
<th>Dimensions—Attitude towards transition</th>
<th>Male engineers (mean 1)</th>
<th>Female engineers (mean 2)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude towards transition:</td>
<td></td>
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Transition of Engineers into Management roles
An Exploratory Study in Australia

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September 1997
**PLEASE NOTE**

The greatest amount of care has been taken while scanning this thesis,

and the best possible result has been obtained.
ABSTRACT

A significant number of engineers move into management positions, their numbers increasing with their length of service. However, engineers are not considered to be effective managers and are generally considered inadequate in soft skills. Given the centrality of engineers and management, understanding this transition is essential in order to develop strategies for managing.

This research is an exploratory field-based study of the transition of professional engineers into management roles (engineer-managers) in Australia, from the perspective of the individual engineer. The study investigates the attitudes of engineers towards such areas as engineering education, towards managerial transition, status, organizational support systems, and strategies for managing transition, and examines their influence on the process of transition. Importantly, this research examines the influence of factors such as job nature, management qualifications, age, employing organizations, and other variables on their attitudes, and studies the differences between various subgroups of engineers.

This research is based on the results of a case study and a questionnaire survey. Based on an exploratory study of the case study organization, and analysis and literature review, several research questions and propositions were developed. Questions relating to the extent of this phenomenon, and the general attitude of engineers towards various aspects of it, were investigated based on the responses from 756 practicing professional engineers in Australia. The respondents in this study included civil, mechanical and electrical/electronics engineers, who constitute about 85 per cent of the total engineering population in Australia.

This study concludes that this transition is a continuous process and that such factors as the managerial content of the job, management qualifications, the employing industry and the discipline of engineering all have an influence. A conceptual model of the transition is proposed indicating the influence of individual, educational, organizational and societal factors.
An important outcome of this research is the focus on the process of engineering education. This research concludes that different emphases in the process of teaching and learning would contribute, in the long run, to engineers developing soft skills, and so make their transition into management easier and more successful.

This study found that electrical engineers are more proactive than civil or mechanical engineers, are more likely to acquire management qualifications and are less likely to expect organizational support. Similarly, engineers who have a managerial role are more positive about management education and are better prepared for change than are the technical engineers. It also appeared that engineers working in the manufacturing sector are less dependent on organizational support, are less technically oriented, are better disposed towards change and, in general, perceive higher status in a managerial role, than do those working in the government sector. Taking these differences into consideration, it is necessary to develop different strategies for different groups of engineers.

The study observed that the higher the status of professional engineers within an organization, the greater was the likelihood of success. Supporting the anecdotal evidence from the case study, it is noted that the more engineers there are in management positions, the better the perception of senior management about their capabilities.

This study found that management education for engineers has a strong influence, both in terms of their acquiring managerial skills as well as enhancing their status within their organization. Experiential learning, though, is the most common method by which engineers acquire managerial skills, the study also found that this is the least-managed strategy in Australian organizations; learning is left entirely to the individual. For engineers to be able to take advantage of experiential learning, better management is necessary.
DECLARATION OF ORIGINALITY

This is to certify that the research work reported in this thesis is original and has not been submitted to any other university or institution for the award of a higher degree.

Ravi Chandra Murthy, Šeethamraju
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EXTENDED SUMMARY

Introduction
Though a majority of engineers are moving into managerial roles, this transition is found to be difficult because of the inadequacy of engineers in terms of ‘soft’ skills. Given the centrality of engineers and management in industrial organizations, it is important to understand this transition better and to develop strategies for managing them effectively, for both the individual engineers and their employing organizations. This chapter provides a comprehensive summary of the thesis, detailing its aims and scope, research questions, significance, gaps in the literature, research methodology and methods employed in this study, analysis and findings, and implications of this research.

Aims and research questions:
This research aims to analyse the transition into management roles specifically in the Australian context, with reference to the attitudes of engineers towards transition, engineering education, status, organizational support systems, and strategies employed in managing these transitions. The main research questions postulated in this study are i) what factors influence the transition of engineers in Australia and how do they influence the transition?, and ii) what are the differences between various subgroups of engineers in their attitude towards these factors?

Scope and limitations
This study is concerned with employee professional engineers practicing in Australia and excludes those technicians such as fitters, welders, electricians, who are sometimes referred to as engineers. Transition investigated in this research refers to the ‘engineers’ move into ‘engineer-manager’ roles and the terms ‘manager’ or ‘engineer-manager’ are used interchangeably throughout this thesis. Factors such as individual personality, quality of high school leavers entering engineering, secondary education in engineering-related subjects, value added by engineers to society, although they play a role in influencing these transitions, are beyond the scope of this study.
In view of the great variety of individual roles and specialisations within engineering, the field study in this research is confined to civil, mechanical and electrical/electronics engineers, who constitute about 85% of the total professional engineering population in Australia. The findings are based on the responses from 756 practicing professional engineers. This research study attempts to analyse issues from the individual engineer's perspective and, therefore, does not consider the views of employers and other members of the organization.

**Significance of this study**

Engineers are the second-largest group of professionals in Australia, and constitute a significant proportion of the managerial pool in Australian infrastructure and manufacturing sectors. This research is significant because of the centrality of engineers and management in industrial organizations, the critical role of engineers in integrating various functions, their multiple roles as representatives of labour and capital; their role in designing and managing changes, and the extent of such transitions.

The literature on engineers and their managerial roles in Australia is limited. Most of the past literature on engineers came from studies in the USA and the UK. Since the educational systems, professional formation, occupational control and status of engineers are different in Australia when compared to the UK and the USA, a specific investigation in the Australian context is necessary. Moreover, past research has indicated that engineering education is the main reason for the inadequacy of engineers, and relatively ignored other factors such as status, organizational systems, and general attitude of engineers towards managerial roles.

**Literature review**

The review highlighted the limited nature of literature on engineers' transition into management roles in the Australian context, and mainly focused on overseas research. The limited studies in Australia concentrated on engineering education, and relatively ignored other factors such as engineers' attitudes and orientation, the changing nature
of engineering and managerial work, status, organizational support systems, organizational and individual management of experience, and career management policies.

Although the engineer’s role has been changing continuously in line with changes in organizational structures and changes in the management paradigms from time, the literature reveals that professional engineers generally lack ‘soft’ skills which are so essential to succeed in management roles. The inadequacy of the engineering education curriculum in imparting these ‘soft’ skills is well-established in the literature. Therefore, new approaches to engineering education and training emphasising entrepreneurial and managerial skills, are considered critical to improving Australia’s international competitiveness. Consistently, past studies have recommended an increase in the non-technical content of management and social sciences courses in the undergraduate engineering curriculum, relatively ignoring the process of education.

The literature, through isolated studies overseas on engineers, has pointed out the influence of other factors such as individual personality characterised by an engineer’s orientation towards managerial work, the stereotyping of engineers, organizational policies on promotions and dual ladders, and the status of engineers within organizations as well as in society and organizational support systems. However, no empirical evidence is available in the Australian context.

The literature identified postgraduate management education as the most popular strategy in managing these transitions. Though a majority of engineers acquire management skills through experience on the job, anecdotal evidence from the USA and the UK suggests that management of experiential learning has been largely left to the individual. According to the review, the importance of a good organizational climate, reflected in terms of good promotional policies and support systems, is an important factor that facilitates smoother and successful transition.
Importantly, most of the past research, both in Australia and overseas, treated engineers as a homogenous group, and drew conclusions from that. Though there was some evidence highlighting the differences within engineers in attitude, depending upon the nature of their work, area of work, engineering discipline and type of employing industry, no detailed investigation of these differences was reported.

Research methodology
A combination of qualitative (case study) and quantitative methodology (questionnaire survey) was employed in this research. Exploratory case study methodology was chosen to develop detailed research questions and propositions. These were tested for their generalisability with the help of a large questionnaire survey.

Queensland Transport, a state government engineering-based organization in Australia, was the case study organization and their senior engineers and engineer-managers were the units of analysis in the first phase. Semi-structured interviews (refer appendices VI and VII) and documents analysis were the methods employed in this part of the study. Interview transcripts and documents were analysed with reference to a framework developed, based on the literature review, and propositions were developed on several issues relevant to transition.

A structured questionnaire was designed using the 5-point Likert scale and mailed to 3000 professional engineers, randomly selected from the membership register of the Institution of Engineers Australia. A valid response rate of 27 per cent (756 responses) was achieved. The questionnaire consisted of several statements referring to various issues influencing the transition (refer appendix - X). In addition questions concerning general demographic details such as engineering discipline, age, gender, engineering qualifications, management qualifications, employing industry, responsibility levels and nature of job were included. Using SPSS 6.1 (Statistical Package for Social Sciences - Version 6.1) software, several statistical techniques such as cross-tabulations, discriminant analysis, factor analysis and t-tests were employed in the
analysis of the data. The research questions were answered on the basis of this analysis.

**Findings about research questions/propositions**

According to the study, job nature and management qualifications are the most influential factors on transition. The study finds that the transition into managerial roles is a continuous process and the probability of its success is enhanced by the managerial content of the engineer’s work, the acquisition of postgraduate management qualifications, a relatively higher perception of status, and effective management of experiential learning. The research concludes that engineering education, organizational support, status and the general attitude towards managerial work are the most significant factors influencing the transition.

Importantly, this research concluded that stereotyping all engineers into a single homogenous group is no longer valid and there are significant differences within and between them. The study finds that there are differences in attitude towards transition between various groups of engineers classified with reference to their predominant job nature—technical or managerial; type of employing industry—government sector, manufacturing or services sector; possession of management qualifications or not; gender—male or female; and discipline of engineering—civil, mechanical or electrical/electronics.

On engineering education, the study concludes that a shift towards the ‘process’ related issues in education curriculum is necessary for imparting ‘soft’ skills, as against an increase in the non-technical content. This research finds that engineering education, in its present focus on quantitative and substantive issues, is underdeveloping generic competencies such as communication, interpersonal, and entrepreneurial skills. This research contends that there should be a change in the focus from a simple increase of non-technical content in undergraduate curriculum, to an effective process of delivering the technical as well as the non-technical content.
The study finds that engineers moving into management roles are mostly attracted by the higher pay, status and prestige, rather than through any dissatisfaction in engineering work. According to the study, people management is the most challenging and difficult aspect of transition for Australian engineers. It is generally perceived as a problem by all the engineers irrespective of their age and experience, job nature and engineering discipline.

The general thrust towards the expansion in the engineer's role into generalist roles, though it is inevitable in the changing organizational environment, is not welcomed by many of the engineers, according to this study. The study observes that engineers in Australia generally do not like to move from the technical aspects of engineering work.

The study observes that career advancement of engineers in Australia is limited more by the lack of 'soft' skills rather than lack of technical skills. Importantly, these 'soft' skills are found to be necessary at all responsibility levels and in all roles, and lacking them makes the transition difficult.

According to the study, technical engineers prefer a separate technical career ladder for their career development, while engineer-managers believe that the managerial path is a natural career progression. Confirming US studies, this study found that technical ladders are less rewarding than managerial paths in Australia.

With regard to the differences between the various subgroups of engineers, the study finds that electrical engineers are more positively oriented towards managerial roles, are less dependent upon organizational support, and are more likely to acquire management qualifications and are better prepared for change than civil and mechanical engineers. Similarly, engineer-managers, engineers with management qualifications, have more strongly supported a shift towards process-related issues in engineering education curriculum than others have.
According to the study, engineers working in the manufacturing sector are less dependent on organizational support, are less technically oriented, are better disposed towards change and, in general, perceive higher status in a managerial role, than do those working in the government sector. Government engineers, according to this study, perceive a general loss of engineering identity in management, a perception not generally held by those working as consultants, as well as those in the manufacturing sector.

The study concludes that the responsibility for managing and coping with these career transitions is primarily left to the individual, with minimum or negligible support and resources provided by Australian organizations. The research observes that support by way of effective organizational systems and policies is an important factor in the successful management of these transitions. In relative terms, organizational support is better in the manufacturing sector than in other sectors.

General status as perceived by engineers within the organization is relatively low. The study finds that this low self-image, together with a similar perception by top management, perpetuates the low status of engineers. The study observes that the higher the status of engineers within an organization, the greater the probability of success. According to the study, management qualifications positively influence the status perception of engineers. The study concludes that status is relatively higher in the manufacturing sector than in other employment sectors, with a better self-image and a better perception by top management.

Based on the analysis and findings, a conceptual model for the transition of engineers into management roles is proposed in this study. This model depicts individual, educational and organizational factors influencing this transition, and the simultaneous influence of societal factors on all of them. According to this model, individual, educational and organizational factors, influence the process of transition and as well as each other, within the overarching influence of societal factors. A visual representation of the model is given below.
Some of the individual factors include personality, occupational orientation, and self-perception of profession; while organizational factors are type of employing industry, career management policies, status relative to other occupations, management of experiential learning, changing nature of engineering/managerial work, pay and perks associated with managerial positions. Educational factors include engineering discipline, process of engineering education, content in engineering education, management education, workload in engineering education relative to other undergraduate courses, and secondary and primary school education; and the societal factors specific to a particular nation include status of profession, professional formation influenced by professional associations, intensity of engineering and technology, gender imbalance in engineering profession, and de-engineering trends.
Implications

To reposition the engineering profession into the twenty-first century, a significant shift in academic thinking and traditional teaching and learning processes in universities is necessary. Curriculum and teaching and learning strategies for postgraduate and undergraduate courses in engineering and engineering management need to be redesigned. Considering the differences between the different subgroups of engineers, organizations may have to devise appropriate policies and systems for managing these transitions successfully. In order to understand the process and the influence of several factors, the conceptual model, explained in the previous section, needs to be further tested empirically.

Individual motivation and orientation to managerial work is an important factor influencing the process. As the transition is continuous, longitudinal studies are necessary in order to measure the effectiveness of management qualifications, management of experiential learning, changes in the teaching and learning strategies in engineering curriculum, and the occupational orientation of the students and engineering recruits. By determining their orientation and by managing the process effectively and efficiently, the enormous cost of promoting individual engineers who are neither interested in management nor have any aptitude for it, can be avoided.
LIST OF PUBLICATIONS ON TIS RESEARCH BY THE AUTHOR

A. Refereed articles in international journals:


B. Refereed conference papers (in proceedings)


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