# THE RELATIONSHIPS BETWEEN UNDERGRADUATE ENGINEERING EDUCATION, THE NEEDS OF INDUSTRY AND MANAGEMENT SKILLS



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by

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# Chapter One Introduction

Australia needs to become more competitive. For example, Ralph (1991, p. 67) states:

> The World Competitive Report ranked Australia tenth in 1989, thirteenth in 1990 and sixteenth in 1991. Significantly, ... Australia ranked very poorly in 'outward orientation' and 'innovative forward orientation'.

Also, Senator Dawkins (1988, p. 5) in his address to the conference organised by the Institution of Engineers Australia, states:

> ... fully formed engineers need a balance of skills, technical and managerial, with a finely developed social awareness of the impact of their decisions on industry, community and environment.

A further comment relevant to this topic is:

> In relation to undergraduate preparation, Australian engineers are well prepared in engineering technology, but not as well prepared for the full practice of engineering in its managerial and business dimensions. (Association of Professional Engineers and Scientists, Australia, p. 8).

These commentators are saying, in different ways, that Australia has a well-developed technical engineering base, but lacks the management expertise to convert these ideas and innovations into manufactured goods. They are suggesting that engineers are not acting as managers to the extent that they should. In addition, the need for effective management is becoming increasingly important as the Federal government steadily reduces import tariffs and the shrinking manufacturing base within Australia needs to be arrested.

Current research such as the Karpin inquiry shows that Australia requires a stronger focus on management skills in engineers to become more competitive internationally.

At the moment tertiary institutions seem to be lacking in constructive assistance for industry. Consultations held by the Karpin Task Force with industry groups indicate that managers are dissatisfied with much of the curriculum content of Universities and Technical and Further Education colleges and the manner in which it is delivered. They suggest that the educational institutions are failing to respond adequately and effectively. (Barraclough 1994, p.44)

This identifies a misalignment between engineering education and industry needs.

This thesis has two major purposes; first, to investigate whether engineering managers believe their undergraduate studies had a sufficiently strong focus on the development of management skills they need when practising as managers in industry. Secondly, if it is found that this focus needs to be stronger, to determine what additional management skills are required and to recommend a way by which additional management skills can be incorporated into the undergraduate engineering curricula.

## 1.1 Approach

The procedure of this research follows two separate stages. The first stage identifies the general industry perception about the management skills of engineers. The second stage investigates how three universities in Victoria are addressing undergraduate engineering education.

Stage I identifies industry perceptions by:

- identifying the skills required by engineers in management;
- determining whether engineers have these skills;
- if so, at what level of education did they obtain them; and

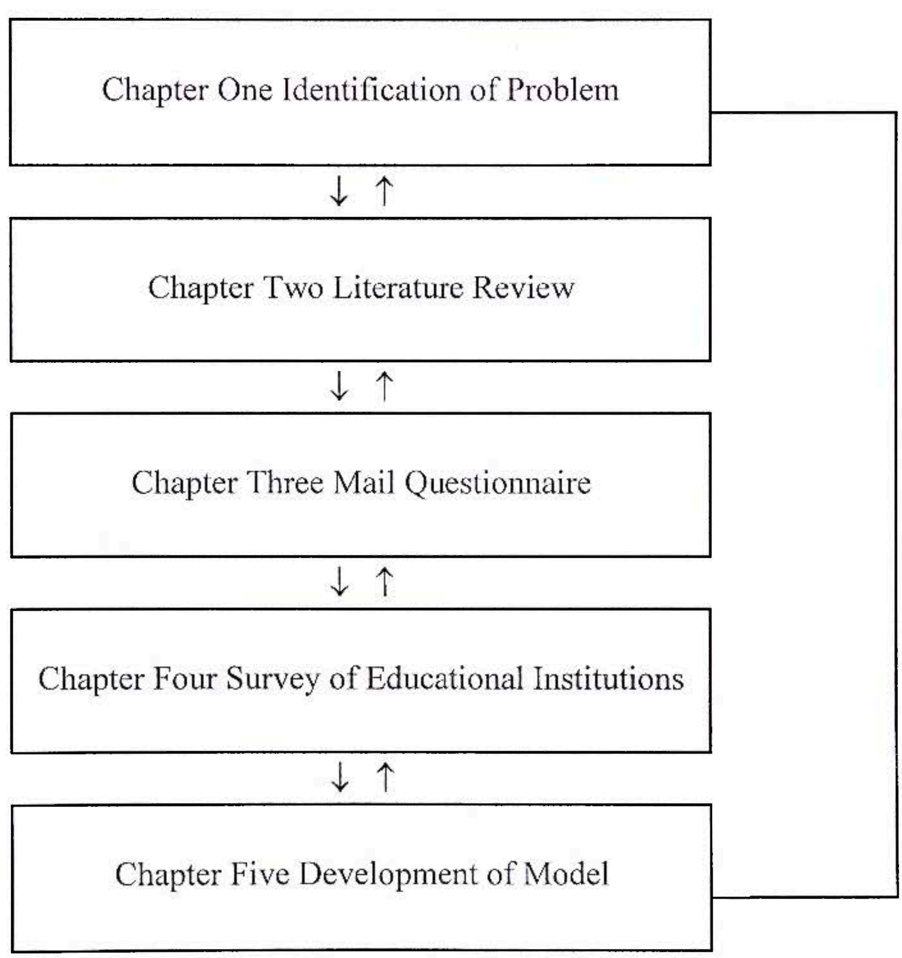
- if not, where are the major inadequacies.

Stage II is a comparative analysis of existing courses by:

- establishing the adequacy of engineering education in Victoria; and
- recommending how engineering undergraduate education may be improved if it is felt to be inadequate.

## 1.2 Methodology

The methodology of this research comprised the following steps.



**Literature Review**

This review helped focus on the important variables that needed to be investigated and provided the framework for the next stage of the thesis. It was achieved by the investigation of available literature sources such as the libraries at the Institution of Engineers Australia, Australian Institute of Management and various universities, conference papers and seminars. It also provided a basis for further research.

**Mail Questionnaire**

A mail questionnaire was chosen as an appropriate means to determine the current thinking of engineering managers in industry. It allowed for the survey of a large number of engineering managers with minimal interruption to their busy schedules. Self administered questionnaires have the advantage that respondents can complete them in their own time without any pressure from an interviewer. In addition, respondents are likely to be more open in their responses because they are able to remain anonymous. Finally, they avoid the personal biases of the interviewer (Sekaran 1992, p. 201).

However, there are disadvantages with the technique of mail questionnaires. They include a possible low rate of return and the lack of opportunity for the respondents to clarify the meaning of the questions. The effects of these difficulties were reduced in this research exercise by keeping the questionnaire short and including a postage paid addressed envelope for its return (Sekaran 1992, p. 201). In addition, a reminder notice was sent to the non respondents after an appropriate time.

The first part of the questionnaire was based on the model proposed by Dunnett (1982). This series of questions investigated the historical situation with closed questions using a five-point Likert attitudinal scale. This helped the respondents to make quick decisions from the choices offered. It also assisted in coding the responses for analysis. A sixth response category of Not Applicable allowed the respondents to distinguish between a skill of low importance and one that was not applicable. A typical question in this part of the questionnaire was:

> As a practising engineer, to what extent in your first two_years were the following management/people skills required?

(Please circle the most appropriate response for each item)

| | Not Applicable | Not Important | | | | Most Important |
|---|---|---|---|---|---|---|
| Establishing Strategies | 0 | 1 | 2 | 3 | 4 | 5 |

The closed question portion of the questionnaire comprised seventeen questions of six options each which gave statistically significant results. The program Stat-View for the MacIntosh computer was used for this analysis. This package was an appropriate vehicle to generate the analysis required.

The second part of the questionnaire investigated the current thinking with open ended questions. These questions gave the respondents the opportunity to make comment and to expand their thoughts. These responses required editing into appropriate categories for analysis. Typical questions in this part of the questionnaire were:

- How did your training as an engineer facilitate or inhibit your movement into management?
- What problems (if any) did you encounter when moving from engineering to management?

- Which management skills do you think are most needed by engineers?
- Which management skills do you find are most lacking in engineers?

In designing the questionnaire the researcher was conscious of the findings of Zikmund (1991), that it be not more than six pages in length and requiring responses to less than 30 questions. Refer to Appendix 1 for the full questionnaire.

These questions were tested on a pilot group of 40 final year engineering students at Victoria University of Technology to establish the current opinion of engineers who are about to graduate. This also served as a guide to the potential of the questionnaire for valid statistical analysis, before its presentation to engineering managers in industry. The major thrust of this survey was to find correlations between practising engineers and engineering management issues.

The surveyed companies were chosen from Who's Who (Francis, 1993) using the basis of manufacturing firms in Victoria with more than one hundred and fifty employees. It was expected that companies of this size would employ qualified engineers. In addition, smaller companies where it was known that engineers are employed as managers were also included. For example, a number of companies in the capital intensive Altona Petrochemical complex were included. The total survey covered one hundred engineering managers.

The survey was mailed to the Engineering manager of the companies selected. These engineer/managers are likely to be in middle management and have less experienced engineers reporting to them. It was expected that these managers are involved in the day to day issues of engineering and management and therefore are very familiar with the current situation in industry. A postage paid return envelope was included with the questionnaire to encourage the return of the document. A reminder notice was sent two weeks after the initial mailing. This strategy gave a response rate of 46 per cent which was considered acceptable for a valid statistical analysis.

### Survey of Educational Institutions

The ways in which three Melbourne based universities are addressing the issue of management education of engineers was investigated and compared with the findings from industry. The universities chosen were the Royal Melbourne Institute of Technology, Swinburne University and Victoria University of Technology. A large disparity was found between industry and academia. The comparative analysis resulted in the development of a model for use in future applications.

## 1.3 Delimitation

The research focused on engineering education in Victoria since it is a major manufacturing state and should be indicative of the national profile. It is contended that a more in-depth research in a smaller geographical area as in this thesis will be of greater community benefit than a 'broad brush' approach over a larger area. This research provides the basis for further studies in the management education of engineers.

## 1.4 Summary

This chapter identified the need for improved management skills of engineers. It then set down the framework for investigation as to how this need could be met. The first stage of the investigation was to develop and administer a mailed questionnaire to engineering managers in industry. The second stage was to investigate educational institutions and make a comparative analysis. This allowed a model to be developed aimed at improving the management skills of engineers.

# Chapter Two Literature Review

The research literature addressing the topic of whether engineers receive sufficient management training in their undergraduate degree is briefly summarised in this chapter.

The review focuses on the situation in Australia and it also incorporates overseas research where relevant to set a broad overview of the issue and to give the research paper a contextual framework.

## 2.1 Research data on engineers becoming managers

A number of researchers have compiled statistical information on the movement of engineers into management.

Badawy (1981) found that in the United States of America nearly 40 per cent of engineers with less than 5 years experience already have substantial managerial responsibilities. In addition, he found that this figure reaches 75 per cent by the time these engineers are 45-50 years old. Similar figures are reported by Bain (1985), Sedge (1985), and Swinyard & Bond (1980). Other research by Dunnett (1982) reinforces this work. He states:

> ... by the time engineers are 40, the statistics show that two-thirds or more will have taken on managerial or supervisory duties of an increasingly responsible nature (p. 8).

This research demonstrates that engineers in the United States of America move into management quite early in their professional careers.

In addition, Dunnett found that foreign engineers, particularly from developing nations, are even more likely to obtain positions of managerial responsibility when they return to their native country.

A study of 284 respondent undergraduate engineers conducted by Rynes (1987) found that 36 per cent of respondents already had long term career aspirations in management. This research is also important because it shows that a significant proportion of engineering undergraduates intend to move into management before they had even begun to be practising engineers. In other words, approximately one in three undergraduates see engineering merely as a stepping stone to their longer term goal of attaining a management position.

A 1987 survey of 2220 members of the Institution of Professional Engineers, New Zealand conducted by Batley (1990) indicated that the average professional engineer in New Zealand spends more than half of their time on managerial work.

> The large majority of professional engineers (with an average of 16 years experience) have responsibilities at senior management level with budget, profit or cost responsibilities. The majority (67%) are responsible for management or supervision of other engineers, but a significant minority (28%) has general management responsibility for other staff (pp 12, 13).

The conclusion to be drawn from this major New Zealand study is similar to the United States research in that many engineers aspire to senior positions in organisations. In most cases this means they must move into management.

Keenan & Newton (1984) studied 800 mechanical, electrical, civil and chemical engineers from six British universities one year after their graduation. They found that engineers required people skills and that their involvement as an engineer was more than just the solution to technical problems.

More recent research by Oakland & Sohal (1989) states "... that the Production Manager's job is primarily managerial, not technical." (p. 89). However, they also stress the need for training in technically oriented subject areas.

Whilst Ahlstrom (1982) indicates that today's information society expects professional engineers to provide the technical leadership in knowledge and skills in the various specialisations of engineering, the need for leadership of people is becoming more important as technology is developing ever more quickly.

A number of Australian researchers have found similar results to their United States, New Zealand and British colleagues. For example, the studies by Crisp (1980), Lloyd (1979 & 1982), Skothicki (1986), Smith (1987) and Young (1988) all found that many engineers become involved in management activities at a very early stage of their professional life.

Hessami & Frith (1992) investigated mechanical engineers who had graduated from Footscray Institute of Technology (now Victoria University of Technology), between 1984 and 1989. Their study sought responses to thirty-nine separate questions. Thirty-six of these questions related to technical subjects such as computing, thermodynamics and robotics. In contrast, there were only three questions related to areas of communication and management, communication studies, engineering management and report writing. They found that graduates supported the need for engineering staff and curriculum to be closer to the 'real world'. The response by graduates with less than 10 year's experience was that over half believed that the three topics related to management were relevant or invaluable and that these topics should receive more time and emphasis. This need for additional management skills was perceived to be much greater than for the engineering discipline subjects covered in the questionnaire. In addition, the two areas most recommended for inclusion in an undergraduate degree were project/engineering management and industrial relations. In other words, these recent graduates believed that their degree gave adequate coverage of the technical content whereas the management content needed to be increased.

Hessami and Eley (1992) extended this research nationally and concluded that the results from the Western suburbs of Melbourne were reasonably held to apply generally across the nation. They found qualified satisfaction with the technical knowledge of recent graduate employees, but that there was a need to improve the skills of graduands in the areas of communication and working cooperatively in an industrial environment.

The published data on engineers becoming managers strongly identifies that the majority of engineers move into management positions early in their career (at least in the Western world). Therefore, it follows that these skills need to be developed in their undergraduate degree.

## 2.2 Reasons for engineers moving into management

Many researchers, Badawy (1983), Bailyn (1980), Roth (1982) and Zalenik, Dalton & Barnes (1970) have investigated why engineers move into management and reached the conclusion that the reward structure favours managers over engineers. This is because higher organisational status, authority and income are only available when the engineer abandons their technical specialty and moves into the more general area of management.

This conclusion is not surprising. As a person moves upward through the organisational hierarchy their promotion generally results in an increased remuneration package. Generally the higher within an organisation a person moves, the greater their managerial responsibility becomes. For example, they are likely to have a greater number of subordinates to implement the technical and mechanical activities as a consequence of their decisions.

This means that an increase in managerial responsibility generally relates to an increase in remuneration and a reduction in technical specialisation. Alternatively, to gain greater remuneration an engineer needs to move away from their technical specialisation and move towards management - from being a specialist towards becoming a generalist.

Also, with increasing experience and responsibilities, an increasing demand is made on engineers to act as lower and middle level managers. This requires them to move into an area in which they have had very little formal training, and hence they look to their superiors as role models. Their superiors are often engineers who also lack formal training in management and who have had to learn by experience.

Career progression of engineers in organisations is mostly linked to levels of managerial or administrative responsibilities and with correspondingly higher remuneration, status and other rewards. It becomes almost inevitable that the most dominant and pervasive function of the majority of engineers is management, especially management of their engineering activities or engineering management.

Oakland & Sohal (1989) also recommend that Production Managers receive remuneration packages which are comparable to those which are available to their peers. This has the implication that currently this is not the situation.

Further, the research by Muspratt (1982) concluded that the top management positions in public instrumentalities are being filled increasingly by non-technical and non-engineering people, even where engineering expertise might be assumed to be necessary. To be more competitive in the area of upper management, engineers need to broaden their management skills. They need to become more active in non-technical areas and project a stronger and more visible leadership posture. They also need to express opinions on a wider range of issues other than engineering. Muspratt concludes that engineers are being stereotyped as technically preoccupied and unwilling, or unable, to assume the wider responsibilities of management.

The days and the opportunities of the purely technical engineer seem to be numbered. The technical design process is faster and provides more alternatives with the rapid development of computer software and hardware. Technical decisions still need to be made, however, the non-technical aspects of decision making are becoming increasingly complex. This means there needs to be a shift in engineering philosophy and training towards management if engineers are to retain their upward mobility and influence.

## 2.3 Skills required for managers and engineers

> Engineers strive for efficiency in the sense of using energy and materials in the least wasteful way possible and they seek to maximise utilities by satisfying the material needs of humanity while making the most efficient use possible of the resources provided by nature. Management involves primarily the organising, motivating and supervising of people (Donovan 1987, p. 120).

The overwhelming conclusion of researchers was an affirmative response - management skills are different to engineering skills.

Keenan and Newton (1984) found the consensus for the majority of their respondents was that there was insufficient time devoted to management studies in their undergraduate courses. In addition, they felt training in the skills dealing with people was more important than training in financial skills. Keenan and Newton concluded that since the most common difficulty faced by graduate engineers in their first 18 months on the job was in dealing with people, and not in solving technical problems, the argument for leaving management studies to after graduation was not a convincing one.

In other words, engineering generally has rigidly defined theorems and usually there are outcomes that follow a set of defined conditions and these can be predicted with a high level of certainty. This approach indicates that 'black is black and white is white, and there are very few shades of grey'. Management, however, means dealing with people, in different situations, which means that outcomes can rarely be predicted with certainty.

Engineering competency is obviously very different to management competency and, since many engineers move into management, undergraduate engineers should develop competency in management as part of their undergraduate degree studies.

### *2.3.1 Engineering thinking versus management thinking*

Millar (1988) explored the difference between engineering and management thinking by looking at the operation of the human brain. He differentiated between two types of thinking - 'Left Brain' and 'Right Brain'.

'Left Brain' thinking controls sequential processing and analysis such as solving complex technical and mathematical problems in a step-by-step controlled procedural manner with close attention to detail and with all information known and precise. This is the situation generally involved in technical problems such as engineering design situations. The emotional or interpersonal aspects tend to be ignored or overlooked. This results in a linear approach to the solution.

On the other hand, 'Right Brain' thinking develops and expresses ideas with an understanding of the interpersonal climate of the work group. This approach to problem solving is more intuitive and uses feelings more than facts. Right Brain thinking can conceptualise, synthesise and innovatively create new ideas within the overall situation and has far less attention to detail. This lateral type of thinking is necessary when dealing with people, such as in management situations.

Current management theories accept that management is both an art and a science, and therefore managers need to have both Right and Left Brain skills. The graduating engineer is strong technically with highly developed Left Brain skills. In addition, current management subjects in the undergraduate degrees tend to focus on the logical, analytical problem solving aspects of management, further developing the Left Brain skills.

Engineers produce ideas and designs that are translated into reality by others such as draughtsmen, para-professionals, technicians, tradespeople and operatives working under the guidance of engineers. Thus engineers are getting things done through others and by definition are managers. It follows that the more successful engineer will have developed a measure of Right Brain thinking.

For example, a newly qualified engineer designs a piece of equipment and then requires a draughts person to make a drawing - the engineer is already acting as a manager! To be effective, the engineer must use people skills (Right Brain) but may have no natural aptitude in this area and certainly has had very little formal education.

When considering the motivation of engineers towards management, the National Aeronautical Space Administration (NASA) studies by Bayton and Chapman (1972, p. 105) found three types of engineers.

- The Type I engineer has strong managerial motivation and is active in moving to managerial roles usually achieving a high degree of success in management.

- The Type II engineer has initially specialist motivation but once in managerial roles finds them satisfying and challenging, and generally succeeds.

- The Type III engineer is the pure technical specialist who if promoted into managerial roles becomes the classic case of 'good engineer but poor manager'. He has only technical specialist motivation and if put into managerial roles, would find such dissatisfying and frustrating.

The majority of current engineering courses focus on the development of the Type III engineer. However since research shows that there is significant movement of engineers into management, there needs to be development of Types I and II engineers.

## 2.4 Current engineering courses and industry needs

The consensus of writers is that there is insufficient management training in engineering undergraduate degree courses.

Lloyd et al, (1979) found that the career development for the majority of engineers involved an increasing concern for the motivation of people and for administration. He also found that the engineering manager is unlikely to achieve real success at the executive level unless their original education is augmented by education in management.

In quoting the Australian situation, Smith (1987, p. 92) states that engineers generally lack financial expertise and human relations skills and are "... flocking back to college to arm themselves with management qualifications". Surely it is time that the educators at undergraduate level truly recognise the need for management skills.

Crisp (1980) acknowledges that education has <u>begun</u> to reflect the need to provide engineering graduates with management and other skills, but it has been ad hoc, occurring too slowly and insufficiently coordinated.

Six years later, Skothicki (1986, p. 120) quotes Crisp "... if manufacturers are going to recover from their present morass, the lead will have to come from engineers with strong management skills". The message is clear that Australia needs engineers who can manage people as well as innovation and technology. Clearly one aim of the Federal Government is to reduce tariffs which means this country must become more competitive on an international scale. World Competitive Manufacturing will need engineers who can effectively and efficiently manage human as well as physical resources in a variety of situations to fulfil these objectives.

The Victoria University of Technology Undergraduate Engineering Handbook (1992) recognises that management is important to the engineering profession.

> Engineering is a profession which is concerned with the economic use of materials, money and manpower to provide a broad range of services and facilities to satisfy human needs, through proper planning, design, construction and management (p. 189).

An engineer is expected to make the most economic use of the resources available. Resources often mean material resources (for which the engineer has been well trained) and ignores people resources (for which they have received minimal training). The more successful engineer will combine the use of material resources with human resources. It follows then, that the engineer who makes efficient use of their people resources must have management skills.

This question is addressed by Young (1988) who proposes that all engineering activities require management. He concluded that management is pervasive in all engineering design, research and development, construction, production, operations, maintenance or project work. He referred to Fayol's five functions of management - Planning, Organising, Commanding, Coordinating and Controlling - and pointed out that some or all of these functions are operative from small engineering groups, teams, sections and departments to the total enterprise whether it be a major project or an entire organisation.

Further, Young states:

> ... the increasing complexity of modern industry, growth of large scale technology based organisations, accelerating rate of scientific discoveries and technical changes, and especially more recent advances in high technology, have focussed increasing attention on the need for professional engineers for leadership and managerial roles (p. 83).

However, many undergraduate engineering degrees do not adequately prepare engineers for the managerial aspects of their future careers.

When they join the workforce, the majority of engineers are employees of organisations rather than sole practitioners as often happens in other professions such as medicine or law. Modern engineering work requires teamwork and coordination of both human and material resources to achieve engineering objectives. Again management skills, especially interpersonal skills, are needed.

To meet this dual need for technical and interpersonal skills, Young (1988) suggests that engineering education should provide for two main streams of engineers, the technical specialist engineer and the management oriented generalist engineer. If these two types of engineers are identified early in the undergraduate course, it will allow education, training and career development programs to focus on the two streams. This would lead to improved performance and efficiency by reducing waste and personal frustration in these engineering students.

Surely, trial and error learning on whether an engineer would make a good manager is no longer satisfactory in the 1990s. The expensive effects of a poor decision by engineering managers using trial and error methods must be reduced.

Further, Young (1988) found that the engineering profession should be more assertive in that the management of engineering activities and also that engineering management is an integral function of engineering. This occurs in an engineering group, team, department, function, project or total enterprise. Engineering management is part of engineering practice and is not a separate and distinct function performed by non-engineers in the engineering environment.

The need for broadening the content of the undergraduate engineering curricula in Australia is stressed particularly by Lloyd (1982) and Jaafari (1986). In addition, studies of the engineering profession by Dunn, Fensham & Strong (1970), Finniston (1980) and Crisp (1980) found that the topics commonly deficient in the basic education of engineers included management, human relations, costing, marketing and communications.

It follows then, that until engineering students, as well as graduate engineers, realise that engineering management is an integral and essential component of the practice of engineering, the engineering profession will have difficulty in accepting the importance of management education of engineers.

Engineering education should provide for the preparation of two types of engineers - the technical specialist engineer and the managerial generalist engineer. The evidence indicates that the generalist will become the majority of engineers. These people are engineers just the same as the technical specialist engineers but they are also leaders of people, groups and organisations rather than just leaders in technical knowledge and skills.

The current conventional engineering education program is based largely on technical subjects and teaches young engineers how to solve the technical problems they are likely to face early in their professional careers. This concentration on engineering science does not prepare the undergraduate engineer adequately for overall professional practice and especially for their likely future career development in management.

A negative response is provided by Williamson (1961) who found that the common perception of the field of engineering is solely concerned with material things is a factor that acts against the engineer in managerial roles. This factor attracts candidates to the profession who are concerned more with "things" rather than with people.

This view is reinforced by Goshen (1969) who asserts that the stereotype of an engineering student tends to be one who possesses high mathematical and scientific abilities but whose skill in communicating with others, dealing with people and socio-political acumen seems to be low.

To answer the question of whether engineers make good managers, the answer would be, some do. However, more engineers will make good managers if they are provided with the right training and understand the problems faced by engineers in management. This paper argues that understanding starts with quality engineering management education.

William's (1988) study of engineering schools found that employers, recent graduates and students all desired more emphasis on communication skills in undergraduate engineering courses, while Henshaw (1991) found that employers rated communication skills as desirable as problem solving ability and that these two skills rated ahead of all others. Henshaw and Williams both found that oral communication skills were poor amongst graduates.

The work by Varcoe (1990) found that new graduates have to develop teamwork and communication skills quickly after entering the workforce and recommended they be taught more effectively at University.

Quite recent research by Roulston & Black (1992) concluded strongly that communication skills are considered to be essential for engineers and furthermore, undergraduates, recent graduates, academic staff and employers perceive engineering graduates to be lacking in these skills. Roulston & Black recommend that more teaching time needs to be spent on developing these skills, particularly oral communication skills. In addition, they recommend that introducing teamwork skills early in an undergraduate engineering course will allow these vital skills to be practised throughout the degree course and that this will result in a graduate engineer more suited to employer expectations.

The origin of the engineer's low public image was investigated by Gaskell & Wheatley (1992). They concluded that universities currently produce competent technical people. However, other skills were under-developed, particularly leadership and communication skills, and they recommended a broadening of business, management and interpersonal skills. They acknowledged that it is very difficult to increase the content of an engineering undergraduate course and suggested that these additional skills be presented throughout all parts of the course, rather than through additional subjects.

To start addressing this deficiency, Inglis & Ball (1992), responded to the demand from the engineering profession for a greater emphasis on management education in undergraduate programs. They redeveloped part of the engineering curriculum at RMIT towards a more experiential approach to learning. They believed a broad based series of small scale incremental innovations would be more effective than a wholesale restructuring of their engineering courses. Their method was to replace the lecture/tutorial approach to the final year subject 'Advanced Heat Transfer' with an experiential project group charged with solving a specific problem. This project allowed students to develop competency in leadership, teamwork and interpersonal and group communication skills.

The philosophy of the State Electricity Commission of Victoria (1990) considered management to be an integral component of engineering work and that management studies should be integrated appropriately with technology and engineering studies. The Institution of Engineers, Australia, has realised the need for managerial competency as part of undergraduate study by requiring a minimum of 10 per cent management education.

The recently completed 'Skills for the Future' study (1992) states:

> In relation to undergraduate preparation, Australian engineers are well prepared in engineering technology, but not prepared well for the full practice of engineering in its managerial and business dimensions (p. 8).

This study also refers to the Williams Review of the Discipline of Engineering (1988) where the majority of employers judged as "unsatisfactory" the emphasis given to oral and written communications, industrial relations and the management of people, costs and resources in the education of engineers.

As Lloyd (1993) reported:

> Developing management skills and an understanding of the international labour market could prove the key to success for Australian engineers as we move towards the 21st Century. (Melbourne Age, Sat. April 24th, 1993)

## 2.5 Summary

The literature review demonstrated that the majority of engineers move into management roles at an early stage of their professional career.

The major reason for this is career advancement. The associated increased remuneration and organisational status can only be achieved by moving upwards in the organisation. This means moving away from technical specialisation and into the more general area of management.

Also, the skills required in management are very different to those required in technical engineering. Technical engineering generally has defined conditions, procedures and processes with a single defined outcome that is highly predictive and needs to be approached in an analytical and linear fashion with close attention to detail. Management however, means dealing with people in different situations, with a multiplicity of outcomes. This requires a person to be able to think laterally using intuition and with far more personal creativity.

Furthermore, research shows that engineers need well-developed interpersonal skills such as communication immediately on graduation. Since the young engineer is usually working as part of a team, there needs to be interdependence between the team members for successful outcomes.

The general feeling among researchers was that engineers lack these necessary skills on graduation and that the undergraduates need to spend more time on the development of management skills.

# Chapter Three Industry Perceptions

The purpose of this chapter is to ask engineering managers in industry their perceptions of management education of undergraduate engineers. It will establish the management skills required and discuss how closely aligned undergraduate current engineering degree courses are to these industry requirements. This will be achieved by a mailed questionnaire. Appropriate findings and comments from the literature review in Chapter Two will be used in the design of the questionnaire. The first part of the chapter discusses the steps taken in its' design. The chapter continues with the administration of the questionnaire. The documentation relating to this aspect is provided in Appendices 2 and 3. The major part of this chapter is devoted to analysing and interpreting the results of the survey. The raw analysis of the survey is provided in Appendix 4.

## 3.1 Design of questionnaire

### Rationale

The aim of this survey was to test the hypothesis that undergraduate engineering degrees do not adequately equip engineers with the management skills necessary for their working life. The literature review had indicated that this would be the situation.

A mailed questionnaire was chosen to test this hypothesis since it would allow the survey of a large number of respondents. It also means that the minimum amount of the valuable time of a busy engineering manager would be required to obtain the data for analysis and that they would be more likely to be open in their responses. Further, it avoided any personal biases on the part of the interviewer should this method of gathering data have been chosen.

Factors considered in the design of the questionnaire included:

**The questionnaire should be brief**

Engineering Managers are very busy people and have many interruptions. The time required to respond should be short. This is important since the managers are being asked to give their valuable time to an activity that is not related directly to their business function. The questionnaire should be able to be completed in a single attempt as a questionnaire that is too long to be completed at one attempt is less likely to be completed at all.

**The questionnaire should be non-threatening**

The covering letter stated that the manger's anonymity would be respected. In addition, the first three questions required statements of fact, not opinion, which gave a 'soft' lead into the questionnaire.

**The questionnaire must be presented in a professional manner**

Each covering letter was presented on original Victoria University of Technology letterhead and signed personally in a blue pen. This indicated a more personal approach rather than a single letter that had been photocopied a number of times. See Appendix 2 for a copy of this covering letter.

The questionnaire was mailed in an A4 envelope rather than being folded into a smaller envelope. This meant the manager received an unfolded document. The extra expense in postage was considered worthwhile in preserving the professional image of Victoria University of Technology.

**Each question should be short**

Questions requiring much reading are less likely to be answered.

**The questionnaire should be easy to return**

The manager has been asked for their time and opinions and courtesy dictates they should not pay for return postage. Therefore, a postage paid addressed envelope was included with the questionnaire. This allowed the manager to answer the questionnaire, place it in the envelope and return it without any further effort, including arranging for the cost of postage. The enclosed envelope was a postage paid envelope rather than one that had stamps attached. This meant there would be no postage cost to Victoria University of Technology for those questionnaires <u>not</u> returned.

**A follow up letter would probably be required**

It was expected that some questionnaires would not be returned, possibly because they would be 'forgotten'. This reminder helped to jog the memory of managers who had set aside the questionnaire for another time. When the questionnaire was developed, a reminder letter was also written along with the covering letter for continuity of language and layout. This reminder letter was sent approximately two weeks after the initial mailing of the survey. See Appendix 3 for a copy of this reminder letter.

After a number of drafts and revisions taking considerable time and effort, eleven questions were originally written which covered six pages. Constructive criticism was sought from a number of sources and areas of improvement were identified. Some people considered that parts of these questions were duplicated. These duplications were removed or combined into other questions. Other parts of the questionnaire were confusing or ambiguous and these were simplified. The finished questionnaire had seven questions covering only three pages. This was a vast improvement over the original questionnaire since the same spread of investigative material was covered in a more efficient and therefore more effective manner.

When the questionnaire was considered ready for publication it was shown to one Senior Lecturer and three Lecturers from Victoria University of Technology for comment. The purpose of this was two-fold. Firstly, they were asked to consider the document from an ethical, moral and discriminatory viewpoint, and secondly, to judge the response from seeing the questionnaire for the first time (an attempt to gauge the reaction of the intended manager). All four academics felt it met the ethical, moral and discriminatory criteria. One lecturer found one item ambiguous and asked for clarification. This identified a potential ambiguity with the target group and the item was reworded.

The questions were printed on blue paper. This was intended to make it more noticeable and easily identified. It was assumed that the majority of paperwork crossing the desk or entering the 'In Tray' of a busy Engineering Manager would be white. A questionnaire on white paper is more likely to be lost in this paperwork.

## 3.2 Administration of survey

One hundred letters were mailed with reply paid envelopes on 4 May 1994 and thirty-six responses were received. Twenty-seven respondents had fully completed the questionnaire, one had omitted to answer five of the seventeen closed choice questions and eight had returned it unanswered. These unanswered responses were categorised as *Returned Without Response (RWR)*. One phone call regarding the survey was received from a manager who received his Diploma in 1966 from the Gordon Institute of Technology. This manager was uncertain whether he should respond since the survey specified an undergraduate Degree. In 1966 a Diploma provided admission to full membership of the Institute of Engineers Australia so he was considered to be suitable to respond within the context of this study.

It is worth noting that three returned questionnaires had the postage paid section of the envelope highlighted. It is assumed this was to draw attention to the person arranging for mailing that the company did not have to pay for postage.

A reminder notice was sent to those people who had not responded by 17 May. Four phone calls were received as a result from this notice. Three were from managers who had received the survey and had discarded it since they were not graduate engineers. These people were added to the number of *Returned without Response*.

The fourth call was from a manager who had responded immediately he had received the survey and had identified himself and his organisation, but received a reminder notice. The reminder notice caused him to think his response must have gone astray in the mail due to the time delay between his response and the reminder notice. A facsimile copy of the survey was offered and accepted by this respondent. This was sent on 20 May and returned on 26 May.

A further five (completed) responses were received by mail some days after the reminder notice was sent. The additional nine responses after the reminder notices were sent increased the response rate by 25 per cent. This reaffirms that the success of a survey reflects the amount of work done in its preparation.

### 3.3 Response to survey

The response rates are shown in Table 1 on the following page.

**Table 1. Analysis of response rates**

| | Number | Number |
|---|---|---|
| Surveys Mailed | 100 | |
| Returned Wrong Address | 3 | |
| Sample Size | 97 | |
| | Before Reminder | After Reminder |
| Total Returned | 36 | 45 |
| Returned Without response | 8 | 11 |
| Number for Analysis | 28* | 34 |

* Includes 1 survey (entry 4) with 5 of 17 Likert questions not answered.

Includes 1 survey (entry 10) with every skill ranked as not important.

The response rate of 47 per cent was pleasing and reflects the effort put into proper preparation of the questionnaire.

## 3.4 Analysis of survey

The MacIntosh software package Stat-View was used to analyse the closed choice scaled questions. Statistics generated were:

- Mean for each variable;
- Frequency Distribution for each variable;
- Standard Deviation for each variable; and
- Correlation Matrix between all variables.

### *3.4.1 Introductory questions*

Question 1 asked the respondent to state their current position and title. Question 2 asked how long the respondent had held their current position. These questions required statements of fact, not opinion. They were intended to be non-threatening and provide a 'soft' lead into the questionnaire.

**Question 3: From which institution, and in what year, did you acquire your undergraduate engineering degree?**

This data is summarised in Table 2.

**Table 2. Institutions where respondents studied**

| Institution | Number of Respondents |
|---|---|
| RMIT | 7 |
| Swinburne | 6 |
| Melb University | 6 |
| Monash University | 5 |
| Other Victorian | 2 |
| Interstate | 1 |
| Britain | 3 |
| Other Overseas | 2 |
| Not answered | 2 |
| TOTAL | 34 |

Referring to Table 2, seventy-one per cent of respondents obtained their degree from universities located in Melbourne. This was a pleasing result since it meant that the majority of engineers surveyed had studied at universities in the target geographical area of this research.

The respondent data shown in Table 3 was classified into six groups, each covering a five year period, with the exception of the first group which covered a six year period to include the earliest respondent graduate. This enabled it to be statistically analysed in a similar manner to the closed choice based questions further in the questionnaire.

**Table 3. Year of graduation**

| Year of Graduation | Number of Engineers Responding |
|---|---|
| 1963 - 1968 | 4 |
| 1969 - 1973 | 5 |
| 1974 - 1978 | 4 |
| 1979 - 1983 | 9 |
| 1984 - 1988 | 4 |
| 1989 - 1993 | 6 |

Two engineers who responded obtained their degree in 1992, giving them just over 1 year's experience at the time of the survey.

The earliest engineer graduated in 1963 giving him 30 years experience at the time of the survey.

The average time since graduation was 15 years (1978).

An unexpected result was the number of respondent engineers (6) who had graduated since 1989 and were not the Engineering Manager to whom the survey was directed. It appears the Engineering Manager of these companies delegated the questionnaire to a subordinate as identified in Table 4. There is no indication whether the Manager felt they could not answer, did not want to answer, or felt a subordinate would be able to provide a better response.

**Table 4. Classification of six most recent respondent graduates**

| Year of Graduation | Title |
|---|---|
| 1992 | Project Engineer |
| 1992 | Project Engineer |
| 1991 | Fan Engineer/Workshop Engineer |
| 1991 | Environmental Specialist |
| 1990 | Technical Manager |
| 1989 | Process/Project Engineer |

### *3.4.2 Mean and frequency distributions*

These questions were divided into the four general management groups of planning, organising, controlling and leading. The analysis considered each part of the questions separately and then combined the results for that question.

The weighted mean for each category was calculated using the mathematical formula $\bar{x} = \frac{\sum fx}{\sum x}$.

The mean for each group was calculated using the mathematical formula $\bar{x} = \frac{\sum f}{n}$.

This procedure was used throughout the subsequent calculations for Tables 5, 6, 7 and 8 and Appendix 5. For example, referring to Table 5, the weighted mean for the category of 'Defining goals for non-technical people' is:

$$\frac{8*0+6*1+5*2+8*3+5*4+2*5}{8+6+5+8+5+2} = \frac{70}{34} = 2.1$$

The mean for the group 'Not Applicable is: $\frac{8+4+7+1}{4} = \frac{20}{4} = 5.0$

**Question 4: As a practising engineer, to what degree in your first two years were the following management/people skills needed to a significant extent?**

**a. Planning**

The responses and the calculated means for planning are shown in Table 5 on the next page.

**Table 5. Responses to Planning**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Defining goals for non technical people | 8 | 6 | 5 | 8 | 5 | 2 | 2.1 |
| Defining goals for technical people | 4 | 7 | 4 | 10 | 6 | 3 | 2.5 |
| Establishing strategies | 7 | 5 | 6 | 7 | 8 | 1 | 2.2 |
| Developing plans to co-ordinate activities | 1 | 2 | 4 | 4 | 14 | 9 | 3.6 |
| **Mean of Planning** | **5.0** | **5.0** | **4.8** | **7.3** | **8.3** | **3.8** | **2.6** |

* Not Applicable + Not Important ~ Most Important

The mean of 3.6 for developing plans indicates the greater importance placed on this criterion compared to the other criteria in this group.

The high response rate which considered goals for technical and non-technical people and strategies as Not Applicable or Not Important probably shows that engineers in their first two years have not had the opportunity or obtained the experience required to set goals for other people. This is reinforced by the small number of engineers who saw these categories as Most Important.

The opposite occurred with developing plans to co-ordinate activities with only 2 responses given as Not Applicable and only 1 response of Not Important. The 9 responses of Most Important and 14 who gave a rating of 4 demonstrate that engineers in their first two years in the workplace require some people skills at this early stage of their career, even though they have not yet reached the level of defining goals or establishing strategies. This supports the findings of many researchers discussed in the literature review.

### b. Organising

The responses and the calculated means for organising are shown in Table 6.

**Table 6. Responses to Organising**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Work routines of non technical people | 6 | 4 | 6 | 7 | 6 | 4 | 2.5 |
| Work routines of technical people | 5 | 2 | 7 | 9 | 6 | 4 | 2.6 |
| Grouping of work tasks | 2 | 4 | 6 | 8 | 9 | 5 | 3.0 |
| Reporting relationships | 4 | 7 | 5 | 8 | 7 | 3 | 2.5 |
| **Mean of Organising** | **4.3** | **4.3** | **6.0** | **8.0** | **7.0** | **4.0** | **2.6** |

* Not Applicable + Not Important ~ Most Important

The majority of respondents rated these skills with some degree of importance. This spread is considered to reflect the differing nature of work tasks performed by young engineers.

The conclusion drawn from this is that those engineers who are involved in organising see these skills as Most Important, and those engineers not involved in organising see these skills as Not Important. This is discussed further in section 3.4.4.

**c. Controlling**

The responses and the calculated means for controlling are shown in Table 7.

**Table 7. Responses to Controlling**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Monitoring people activities | 5 | 5 | 3 | 6 | 9 | 6 | 2.8 |
| Correcting deviations | 8 | 6 | 4 | 4 | 6 | 6 | 2.4 |
| **Mean of Controlling** | **6.5** | **5.5** | **3.5** | **5.0** | **7.5** | **6.0** | **2.6** |

* Not Applicable + Not Important ~ Most Important

These results in Table 7 show the different experiences of engineers during their first two years whilst working in the profession.

Whilst the mean between Organising and Controlling are very similar the results are more polarised for Controlling activities with an extra two engineers in each of the boundary ratings Not Applicable, Not Important and Most Important. This indicates that when engineers are involved in Controlling they need these skills.

Of particular note is the high number of engineers involved in controlling others ie managing, within two years of graduation.

### d. Leading

The responses and the calculated means for leading are shown in Table 8.

**Table 8. Responses to Leading**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Motivating others | 1 | 4 | 4 | 12 | 12 | 3 | 3.0 |
| Directing others | 0 | 3 | 4 | 11 | 11 | 4 | 3.3 |
| Resolving conflicts | 1 | 8 | 6 | 6 | 10 | 2 | 2.7 |
| Negotiating with superior levels | 1 | 2 | 5 | 7 | 15 | 4 | 3.3 |
| Negotiating with peer level | 2 | 1 | 2 | 9 | 15 | 5 | 3.4 |
| Negotiating with subordinate levels | 1 | 4 | 5 | 8 | 8 | 8 | 3.2 |
| Negotiating with unions | 16 | 9 | 2 | 3 | 2 | 2 | 1.2 |
| **Mean of Leading** | **3.1** | **4.4** | **4.0** | **7.3** | **9.9** | **3.9** | **2.9** |

* Not Applicable + Not Important ~ Most Important

Table 8 shows that all of the skills of leading were found to be very important apart from negotiating with unions.

Very few engineers believed these skills were Not Applicable during their first two years and a large number rated these skills as either Most Important or gave a rating of 4. The conclusion is that engineers need leading skills immediately they enter the work force.

The low level of importance given to negotiating with unions in the first two years of an engineer's working life is indicative that engineers are unlikely to be in the position of negotiating with unions.

To illustrate this the mean for leading was recalculated excluding Negotiating with Unions.

These results are shown in Table 9.

**Table 9. Mean excluding Negotiating with Unions**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Mean of Leading | 1.0 | 3.7 | 4.3 | 7.0 | 11.2 | 4.3 | 3.2 |

The exclusion of Negotiating with Unions from the Leading category shows a significant increase in the mean from 2.9 to 3.2.

The responses to the 17 Likert based questions were sorted by Mean, Most Important and Not Applicable. These tables are shown in Appendix 5.

The largest number of categories ranked *Most Important* by the respondents were:

- Developing plans to co-ordinate activities;
- Negotiating with subordinate levels;
- Monitoring people activities;
- Correcting deviations;
- Negotiating with peer level; and
- Grouping of work tasks.

These are the management skills that some engineers required in the early years of their professional life. A large number of respondents also ranked the above skills at 4, immediately below Most Important. These skills should have a high focus in management training in an undergraduate degree.

The categories with the highest *Mean* response were:

- Developing plans to co-ordinate activities;
- Negotiating with peer level;
- Negotiating with superior levels;
- Directing others; and
- Negotiating with subordinate levels.

These are the management skills that engineers give the highest importance. They show the skills which engineers believe they need early in their career.

The skills rated as *Not Applicable* by the fewest numbers of respondents were:

- Negotiating with subordinate levels;
- Negotiating with peer level;
- Grouping of work tasks;
- Reporting relationships; and
- Defining goals for technical people.

That the fewest engineers rated these skills as Not Applicable indicates their relevance early in an engineer's professional life. They have applicability in an undergraduate degree.

That a number of skills had the highest number of responses in the category of Most Important, as well as the highest number of responses for the Mean and the lowest number of responses in the category on Not Important indicates their relevance in an undergraduate degree.

### *3.4.3 Standard deviation*

The standard deviation was calculated for each section of the closed questions. The results ranged from 1.12 to 1.87. Comparing these results with their respective means do not show any significant difference between the various sections and do not add insight to the results or conclusions. These results of the analysis are included in Appendix 4.

### *3.4.4 Correlation between skills importance*

Besides the results of each skill being addressed singly a correlation was performed between each skill. This explored those skills that were jointly given the same level of importance by the respondents.

The higher the correlation the greater the number of engineers giving the particular pair of skills the same importance. The greatest correlations are depicted in Table 10.

**Table 10. Extract of correlation matrix**

| Function of Management | Work Routines of Technical People | Grouping of Work Tasks | Monitoring People Activities |
|---|---|---|---|
| Grouping of Work Tasks | 0.746 | | |
| Reporting Relationships | | 0.699 | |
| Monitoring People Activities | 0.863 | 0.732 | |
| Correcting Deviations of Behaviour | 0.770 | | 0.853 |

The highest correlation in the questionnaire focused on the areas of Leading and Controlling.

The correlation of 0.746 between the work routines of technical people and grouping of work tasks means that 0.746 x 0.746 = 0.56 i.e. 56 per cent of respondents had the same degree of importance for both.

Seventy-four per cent of people rated technical work and monitoring with the same degree of importance and 59 per cent rated technical work and correcting behaviour at equal importance. Fifty-five per cent rated monitoring and groups equally important and 72 per cent rated monitoring and correcting with equal importance.

It is not surprising that technical work, working with groups, monitoring and correcting all very closely interrelated. Previous research has shown this is the likely situation.

## 3.5 Analysis of responses to open ended questions

**Question 5: When you completed your undergraduate engineering degree, were you equipped with those skills you identified as important?**

This question asked the respondents to assess their perception of the effectiveness of their undergraduate engineering training. A summary is given in Table 11.

**Table 11. Important skills**

| Did Undergraduate Degree give skills? | | |
|---|---|---|
| Response | Number | Percentage |
| Yes | 6 | 18 % |
| No | 28 | 82 % |
| | | |
| **Did you subsequently acquire Skills?** | | |
| Response | Number | Percentage |
| Yes | 30 | 88 % |
| No | 1 | 3 % |
| N/A | 3 | 9 % |

The high response (82 per cent) that the undergraduate degree does not give adequate management skills is not surprising and reflects literature results.

The results also indicate that engineers need these skills early in their professional life and that universities need to be addressing this problem at the undergraduate level.

Fortunately, most engineers reported that they had subsequently acquired the skills lacking in their undergraduate degree, although it is questionable how effectively or efficiently these skills were acquired. However it is the engineers themselves who are saying they have acquired these skills. This is likely to be a very biased view since it is based on a personal reflection about one's self.

An area of further research would be to investigate whether the engineer's superiors and subordinates support this view.

**Question: Which skills were not addressed?**

Some responses addressed specific items in the forced choice questions and were classified as specific. Other responses addressed the more general category of Planning, Organising, Controlling or Leading. It was assumed this general response covered all items in that category.

This is shown in Table 12 on the next page.

**Table 12. Skills not addressed in undergraduate degree**

| Type of Skill | Number of Responses | Allocated Classification |
|---|---|---|
| Interpersonal Negotiating | 7 | Specific |
| General Management. | 6 | General |
| People Management | 6 | General |
| Conflict Resolution | 5 | Specific |
| Motivation | 4 | Specific |
| Planning | 3 | General |
| Controlling | 2 | General |
| Leading | 2 | General |
| Monitoring | 1 | General |
| Team Building | 1 | Specific |

A total of 37 responses was identified from the answer to this question. There was an overwhelming response indicating that the skills of leading were most lacking in undergraduate degrees. Of the 20 general responses 14 relate to leading ie general management (6), people management (6) and leading (2). Of the 17 specific responses 16 relate to the management function of leading. Interpersonal skills (7) rate ahead of Conflict Resolution (5) and Motivation (4).

It is likely that different people gave a different interpretation to the same words. For example, one person may refer to team building (specific) whilst another person may refer to this activity as people management (general).

In future work a glossary of terms may assist engineers to have a more common interpretation by using a common field of language. However, caution must be exercised so that this additional information:

- does not make the questionnaire more difficult to read (and hence complete);
- does not make the questionnaire less non-threatening; and
- focus thoughts too much on only the terms stated in the glossary and hence limit the opportunity for lateral thinking.

An extension of this work would be to interview managers. These interviews would allow a more common language to be used since face to face contact and discussion would enable the terms to be better defined.

A comment against this trend came from a 1990 graduate from Swinburne University who identified the questionnaire as driven towards people skills.

> People skills ... is an area which cannot be driven via a course or a unit within an engineering degree... it is personal development. This can only be developed if an individual has some form of work experience prior to graduation. (entry 19)

A counter comment came from an engineer (who graduated in from Swinburne in 1973) who responded positively that his undergraduate training was adequate, and yet identified 5 of the 7 leading skills as important or most important felt it was an "... inherent skill - not covered apart from social sciences". (entry 17)

**Question: Did you subsequently acquire these skills?**

The manner in which respondents subsequently acquired their management skills is summarised in Table 13 on the next page.

**Table 13. Acquisition of skills**

| Manner additional skills were acquired. | Number of Responses |
|---|---|
| Another degree | 0 |
| Postgraduate courses | 6 |
| Professional short courses | 12 |
| Experience | 28 |

Almost every engineer who felt their undergraduate degree did not cover these skills felt they had subsequently acquired them. Over 90 per cent felt they had acquired management skills by experience many with additional short course training in specific areas.

There were three exceptions, two engineers (one graduated in 1973 and one in 1990) felt their undergraduate degree gave them all skills required and that no further training was necessary and that their experience did not add to their knowledge.

Only 6 (19 per cent) engineers undertook further postgraduate study. This was in either a Master of Business Administration or a Graduate Diploma of Business Management. This was counter to Smith's (1987) comment in the literature review that engineers are "... flocking back to college to arm themselves with management qualifications". (p. 92)

The low response to formal postgraduate studies some years after graduation is not surprising. As an engineer develops in their profession the demands of the job are likely to increase which makes it more difficult to find the time for additional study. In addition their family responsibilities are likely to have increased since graduation further adding to the difficulty of study.

Twelve engineers (39 per cent) had undertaken a variety of professional short courses, many of them more than one. These ranged from company in house courses to one four-week and one five-week course and attending seminars. The subject content of these courses covered Total Quality Management, production management, supervision, leadership and communication.

A similar number of engineers responded that they gained experience by being appointed to management. It is difficult to understand how the appointment to management suddenly gave the engineers much experience.

Surely we can produce better engineers/managers if they have some training and experience before being appointed to the role of management, rather than gain it after appointment. The learning curve must be narrower which means a shorter time to reach a given level of effectiveness and efficiency and fewer mistakes.

One engineering graduate from 1980 acquired his skills "The Hard Way". (entry 18) His responses to the Likert scale questions were mostly 4 indicating significant importance. He attended supervisory training in 1982, Trade Union Training in 1984 and obtained a Graduate Diploma of Management in 1990.

A 1990 graduate with no postgraduate training felt the best way to acquire skills was to "Look before you Leap" (entry 19) and a 1986 graduate had acquired his skills only by "Exposure and Hard Work". (entry 26) Surely the learning curve must be longer in this situation with a greater chance of mistakes occurring.

**Question 6: Do you believe that the current undergraduate engineering courses have adequate management training?**

This is shown in Table 14.

**Table 14. Management in current courses**

| Do current Undergraduate Degrees give skills? | | |
|---|---|---|
| Response | Number | Percentage |
| Yes | 2 | 6 % |
| No | 21 | 62 % |
| Don't Know | 9 | 26 % |
| No response | 2 | 6 % |

The 21 (62 per cent) of negative answers to this question indicates a general feeling that the current undergraduate degrees do not have adequate management training. Again the need for a greater management component in the undergraduate degree is highlighted.

The 9 (26 per cent) responses of Don't Know could be an indication that universities need to market their courses more to industry. This provides an opportunity for academia to adopt a higher profile and become more aligned with industry needs.

Only 2 (6 per cent) felt that undergraduate degrees have adequate management training.

Specific comments in response to this question included:

- Current Graduate engineers have no better level of management skills than 20 years ago (1973 graduate, entry 1);

- No ... but ... there doesn't seem to be time to fit any extra subjects into the four year period (1992 graduate, entry 20);

- Listening/negotiating skills of graduate engineers are generally weak, particularly when dealing with people with less formal education (1974 graduate, entry 6); and

- I have seen many new engineers simply stagnate without this skill ... [of people management] ... engineering degrees typically do not offer this type of feature [of adequate management training] (1990 graduate, entry 19).

The skills identified as not being addressed are summarised in Table 15.

**Table 15. Skills not being addressed**

| Skill required | Number | Allocated Classification |
|---|---|---|
| Conflict Resolution | 5 | Specific |
| Negotiation | 5 | Specific |
| People | 4 | General |
| Broad Spectrum | 2 | General |
| Planning/Strategies | 2 | Specific |
| Organisational Behaviour | 1 | Specific |

Ten of the thirteen responses in Table 15 classified as specific were related to leadership.

**Question 7: In your opinion, what recommendations would you make for the training and development in management skills for engineers?**

This question allowed the respondent to comment on their perception of current courses. Their responses are likely to be influenced by a number of factors:

- their perception of their own undergraduate degree;
- their perception of their subordinates and colleagues to handle various management tasks;
- the personalities of the engineers with whom they interact; and
- their perception of current undergraduate engineering courses.

The collated responses to this question are provided in Table 16.

**Table 16. Recommended Skills to be included in further courses**

| Skill required | Number of Responses |
|---|---|
| People Management/supervision | 5 |
| Team Building | 5 |
| Negotiation | 5 |
| Conflict Resolution | 5 |
| Sandwich Courses | 4 |
| General Management | 4 |
| Planning | 3 |
| IR | 3 |
| Industrial Experience | 2 |
| Case Studies of Management problems | 2 |
| Double Degrees | 1 |
| Interpersonal | 1 |
| Profit/loss | 1 |
| Human Behaviour | 1 |

Again the major response was the perceived need for more leadership skills, particularly in the areas of conflict resolution and negotiation.

A number of respondents saw industrial experience as an important item to be included in undergraduate engineering degrees. One way of achieving this is the structure of a 'Sandwich' course which comprises a combination of formal study and industrial experience as part of the undergraduate degree.

It is important to note that industry sees additional training being performed at the work site using in-house courses rather than necessarily involving tertiary institutions in further formal study. There may be significant opportunities for universities such as the Victoria University of Technology to develop other forms of management training for engineers based on in-house/work-site courses for specific industries and/or companies.

**Question: Would you be prepared to take part in further research?**

Respondents were asked if they would be willing to participate in follow up research. Their responses are provided in Table 17 on the next page.

**Table 17. Willingness of respondents to be further involved**

| Participation in Further Research | | |
|---|---|---|
| Yes | 21 | 62 % |
| No | 12 | 35 % |
| No Response | 1 | 3 % |
| Name Supplied by Respondent | | |
| Response | Number | Percentage |
| | | |
| Yes | 21 | 62 % |
| No | 13 | 38 % |

Twenty-one (62 per cent) respondents indicated they would be willing to participate in further research. This is an indication that managers see there is still work to be done in this area and that they are willing to be involved in this work. It is also a recognition of a well-presented survey.

## 3.6 Summary

To investigate the industry perceptions of the alignment of the outcomes of undergraduate engineering courses in Melbourne and the needs of industry a questionnaire survey was designed and mailed to 100 Manufacturing Managers who were likely to be engineers. The survey had two types of questions. Firstly, a Likert attitudinal scale where responses ranged from Not Important to Most Important with a category of Not Applicable. Secondly, open ended questions that gave managers the opportunity to comment in their own words.

Much time was spent in developing the questionnaire since it was believed that a well-designed questionnaire would give a good response rate whereas a poorly designed document would be more likely to be ignored.

The finished document was short, non-threatening, easy to return to the sender and professionally presented. In addition, a follow-up letter was sent to those non respondents two weeks after the initial mailing. The pleasing response rate of almost 50 per cent demonstrates the effort put into the preparation and presentation was rewarded.

There was a strong response that engineers need well-developed leadership communication skills at the start of their professional life. Unfortunately, respondents felt they did not receive adequate training in this area as part of their undergraduate degree. However, many respondents felt they had subsequently acquired the necessary management skills. This is a subjective assessment using the opinion of the engineer about himself and is likely to be rather biased. A large number of respondents indicated their willingness to participate in further research which demonstrates they see that work in this area is important.

# Chapter Four Current Undergraduate Engineering Courses

The findings from the survey were generally compatible with the conclusions drawn from the literature review. That is, engineers have not learnt sufficient management skills in their undergraduate degree, and also that industry expects them to be better prepared on graduation. Eighty-two per cent of the respondent engineers expressed this view. Eighty-eight per cent of engineers also stated they had subsequently acquired the necessary management skills for them to perform their tasks. Much of this learning had come either from experience or learning from other engineers, who also would have received little formal training in management - only nineteen per cent of the respondents had undertaken further study. At face value this would seem a case of the 'blind leading the blind' approach, where the bad (or, at least, not the best) techniques of one engineer being passed on to another engineer is reinforced. Surely a formal training program in any format must be better than this ad hoc approach of engineers learning management by experience alone.

The manner in which three Melbourne based universities are addressing this problem was investigated to determine how their courses are addressing the management training of undergraduate engineers and whether their course objectives match the requirements of industry.

Royal Melbourne Institute of Technology was chosen for its long standing reputation in the community as a centre for engineering excellence.

Swinburne University was chosen since four respondents in the survey specifically recommended the Swinburne Sandwich course and a fifth respondent referred to its structure as one way of improving the management skills of engineers.

Victoria University of Technology was chosen since it is a new university with a major focus on industrial co-operation. This university has as part of its mission statement the design of innovative courses with educational programs being a co-operative effort between academic and industry requirements.

These three universities have different approaches to teaching management skills to engineers. Therefore it is of particular interest to compare and contrast their curricula.

## 4.1 Royal Melbourne Institute of Technology (RMIT)

RMIT has tackled the problem that engineers do not have sufficient management skills by introducing a Double Degree in Business Administration and Engineering. The expectation from this course is that students will have a better appreciation of the workplace where they will become practising engineers. RMIT has developed integrated programs into their undergraduate double degree to emphasise practical applications and therefore enhance career opportunities by increasing the level of management skills of those engineers.

One limitation of this double degree program is that the intake is restricted to only twenty per cent of the total undergraduate engineers, or, only one in five students. The students accepted into the double degree program must have shown high levels of academic achievement and the ability and desire to carry a significantly extra workload over a five year period. This twenty per cent acceptance into the program means that four out of every five engineering students at RMIT will <u>not</u> have an equal opportunity of learning important management skills!

A major component of the double degree is the Comprehensive Performance Evaluation (CPE) program of five components. This is designed to integrate knowledge, skills and practical experience as well as providing a common thread to the various formal subjects by linking them and showing how they become integrated into the functional organisation.

RMIT recognises that these studies are seen by the students as being relevant, practical and connected to their long term career goals and not just a series of individual unrelated subjects.

There is a significant emphasis on involvement with professional bodies. Students are required to join the appropriate professional body and attend workshops and seminars as part of the double degree program. This aspect is valuable to students since they are required to develop networks and develop interpersonal skills with experienced engineers before they graduate.

Another area of significant emphasis is research. Students are required to become familiar with major journals related to their area of specialisation and evaluate articles showing their understanding of the content and how it is applied to their profession.

The first component - Orientation Workshop - is conducted in semester six. At this time the students have completed 2½ years of engineering studies and should have an understanding of technical engineering concepts.

In semesters' seven, eight and nine students undertake Directed Management Projects (DMP) which comprise research in organisations chosen by the students. These organisations must be from both government and private sectors and the focus is on six focal values that are evident in successful organisations. Students are taught how to develop and maintain networks and are actively encouraged to develop these with practising engineers and managers. This forms part of the Professional Experience Program within the DMP's.

In the final semester the students are involved in Management Simulation Exercises that give them the opportunity to experiment with a management situation and develop their management skills. Since it is a simulation a poor decision does not have real world consequences. Students can make mistakes during the simulation that will not have negative effects in industry.

At the end of the degree a panel consisting of a senior business person, an academic and an administrator interviews each student individually on his/her research. The panel is looking for evidence of practical insight and personal and professional development. A comprehensive, graded, formal examination using case studies and reflective exercises completes the CPE process.

RMIT states that student comments are that the long arduous program is worthwhile. (Tracey & Walters 1993)

> Graduates in the workforce have indicated that their experiences have justified their extra effort during the program (p. 6).

This is an area for further research to determine why they felt it to be worthwhile. Areas to be investigated could include:

- Did their management training make them more employable?
- Did it mean they gained promotion faster?
- Would they have reached their achievements without the double degree given they are the technical elite of the engineering faculty?

- Does management at the undergraduate level necessarily produce a better engineer?

The double degree program may produce an engineer better suited to the workplace than the basic engineering degree but it is not available to every student. The double degree at RMIT caters for an elite group of students with superior academic skills, superior motivation to work hard and sufficient financial support from whatever source to study for five years rather than four to obtain their undergraduate engineering/management qualification.

Engineers already suffer an image problem in industry. Literature indicates that engineers have difficulty relating to many people because of their highly developed technical skills and poorly developed management and people skills (Dunn, Fensham and Strong 1970, Finniston, 1980, Crisp 1980, Muspratt 1982, and Smith 1987). Students entering an engineering course have demonstrated a higher proficiency in technical subjects such as mathematics, physics and chemistry than many of the people they will manage and interact with throughout their professional life. Engineering degrees focus towards increasing these technical skills thereby widening the technical gap between engineers and the majority of their subordinates. In this instance, double degree students are the elite of these technical people. This technically 'elite' double degree engineer must have a significantly greater development of interpersonal skills that will enable them to manage and interact with others. Many of those people with whom the engineer will interact will not be so highly technically trained, but nevertheless quite correctly see themselves with other valuable skills to offer.

## 4.2 Swinburne University

Four respondents to the survey, (of which only one was a Swinburne graduate), recommended the Swinburne 'Sandwich' course as one way of improving the situation of engineers acquiring management skills at undergraduate level. Presumably these engineers have either worked with Swinburne graduates to have sufficient knowledge of the benefits the Sandwich course, or, they have obtained information concerning the course by other means such as professional or industrial associations through their networks. Since graduates from RMIT and Melbourne University also recommended the Swinburne Sandwich course makes it worthy of investigation. That only one respondent of six Swinburne graduates recommended the course indicates it may not be the complete answer.

Swinburne University chose a different approach to the management education of engineers with their Sandwich course. The 'Cooperative Education' is integral to their degree and requires a minimum of 48 weeks of industry based learning in two placements as part of the undergraduate degree. Each placement is for approximately six months. This gives sufficient time for the student to see processes at work and to see major progress in various tasks. Students often perform a wide range of tasks associated with the engineering profession and are under the guidance of a professional engineer. There is a preference for these placements to be at two different organisations (including overseas placements). In addition, the graduand has twelve months industrial experience with two companies upon their graduation.

The first placement is in semester one of the third year and only after the student has passed the first two years of their degree course. At this time the student has a general knowledge of common technical engineering subjects and some knowledge of their specialisation of either Civil, Electrical, Mechanical or Manufacturing Engineering. At this time these students are very inexperienced and require close supervision by an experienced engineer. The recommended rate of payment for this employment is sixty per cent of a graduate engineer.

For six months the students leave the surroundings of the relatively narrow band of technical training existing in the university environment and experience the wider range of attitudes, abilities and levels of motivation that exists in the workplace. They observe the different methods which engineers and managers achieve their tasks in the workforce and should be able to form some broad opinions concerning appropriate action in some situations.

There is an understanding in industry that these people are still students and have a significant period of training to go before they become qualified engineers. It follows that they have not yet acquired all the skills to be fully functional as an engineer. Industry expectations are therefore less than they would be if the engineer had graduated. The salary of only 60 per cent of a graduate engineer recognises the substantive contribution being made by the student to the employing organisation. They are still in a learning environment and therefore require close supervision. They are, however, working in an industrial situation and need to be responsible and accountable for their actions.

This industry placement also has the benefit of giving students an income (significant in their eyes) for six months. From the employing organisation's viewpoint, whilst their expectations will be lower than for a graduate engineer, they are still paying some thousands of dollars to the student and will have expectations of accountability and responsibility in return.

After this first industry placement, the students return to the university for another two semester block of study. Their second placement is in semester two of the fourth year. By this time the students should understand and accept workplace targets, relationships and disciplines. They receive a task or project based position where they can apply their three years of formal study and six months industrial experience. They should work with less supervision than in their first placement. The recommended rate of payment is 80 per cent of a graduate engineer.

The recommended payment of eighty per cent in the second placement reflects an expectation of significantly increased professional knowledge and ability to perform engineering functions, whilst recognising that the undergraduate student still has to undertake a significant amount of formal training.

By the time of the first industry placement the students will have some level of technical engineering skills. This six month period gives sufficient time for the student to perform useful engineering activities for the employer, since they have skills in basic engineering subjects. A student in his/her second industry placement already has work place experience and a greater engineering knowledge base. It is reasonable to expect a more result oriented approach and to be able to work with less supervision.

In the longer term this industry placement gives the employer an opportunity to assess the student as a prospective employee for the organisation. Students may also work on projects designed to reduce cost or improve productivity and provide long term savings to the employer.

The interaction of the three parties - students, industry employers and academia - can only serve to bring all three closer together as there is continual evaluation being made by each party of the success of the course. It serves to highlight strengths and weaknesses that gives the opportunity to build on the strengths and correct the weaknesses.

The student should display initiative and approach employers directly for a placement although the Cooperative Education Office also seeks placements for students who have attained the required amount of formal study. An Academic Supervisor oversees the period of the placement. Close liaison occurs between the university, employer and student during the placement period.

Although the Swinburne degree takes 4½ years to complete, the student graduates with twelve months experience in the profession and some income during this period together with greater opportunities for employment since they have already worked with two organisations.

## 4.3 Victoria University of Technology (VUT)

As a newly formed university, Victoria University of Technology has just undergone an accreditation process for its engineering degree courses. This has provided the incentive for new subjects and alternative teaching methods to be introduced. The reduced infrastructure of a young university enhances the implementation of new ideas and teaching methods. In addition, VUT sought considerable assistance from industry in determining their requirements from undergraduate courses. VUT is not unique in seeking assistance from industry, and some of the aims and objectives of VUT may be similar to other universities.

In February 1991, the Victorian Education Foundation (VEF) gave a seeding grant to the Engineering Faculty of VUT and Aptech Australia Pty. Ltd. to develop management case study material for inclusion in civil, building, mechanical and electrical/electronic engineering degree courses. This proposal used the World Competitive Manufacturing and Total Quality Management materials Aptech proposed for the National Industry Extension Service. The aim of this project was to develop an innovative and co-operative approach to management training of engineering undergraduates. The extensive management training in industry provided by Aptech for the National Industry Extension Service was coupled with the academic knowledge of the Faculties of Business and Engineering. During 1992 and 1993 the staff from the Faculties of Engineering and Business and Aptech worked on this project. The writer was a member of this team and participated in the development of the course.

In 1994, the Footscray campus of VUT introduced three management subjects into the final year curriculum of the undergraduate electrical and mechanical engineering degrees. The first subject, Engineers and Process Management, was first conducted in semester one. Engineering and Organisation Systems and Engineers and Human Relations Management are being offered in semester 2. The content of Engineers and Process Management was studied by means of experiential exercises and instructor led discussions. The latter two subjects employ both experiential exercises and material based on the case studies developed in 1992 and 1993.

The rationale for the course covers three broad areas:

- the process perspective of the engineer's role;
- managing processes; and
- improving processes.

A paper, written by the author of this thesis, discussing the first subject, Engineers and Process Management, was presented at the Engineering Management Educators Conference 1994 (Rosan & Waddell). At the Open Forum to conclude the Conference, the innovative approach of combining the 'soft' options of management with the 'hard' or technical aspects of engineering in experiential exercises received a commendation for its creativity and innovation.

The course aims to develop the management skills and processes that students already have and use (often without realising it) into a more structured and conscious awareness how they could and should use these skills and processes in engineering and management roles. In other words the students are already managers! Underlying concerns that some students have in the relevance of management in an engineering course, particularly those who do not see themselves as a future manager, are addressed by three key points:

- Engineering students already manage processes such as their financial affairs, study habits, personal relationships and time allocation;
- Processes are the building blocks of enterprises; and
- Managing processes is an inevitable and integral part of an engineer's function.

Students have little difficulty in understanding that they work on processes. They need to understand that they also work in processes, and that their ability to influence the process they work in will determine their success as an engineer. Students accept the notion that effective involvement in both physical and interpersonal processes is critical to the success of the engineering function although they may not fully appreciate the implications.

The course aims to draw on similarities between management and technical processes by extending knowledge of technical processes into management skills. For example, the design of a heat exchanger follows a set procedure without much opportunity for innovation. The inputs are the details of the requirements of the heat exchanger, various design standards and the technical skills of the engineer. The combinations of these inputs are processed to produce the output - the design specifications.

Management is also a process requiring inputs and generating outputs. Inputs include people's values, attitudes, personality and expectations. The process is the combining of these to produce a reasonable output for the particular situation such as a change of behaviour.

The difference between the technical and management process is that the management process will not always follow the same procedure. In addition, the complex models involving many parameters and interpersonal processes will often yield a model that is not highly predictive. It will predict general trends rather than precise outcomes. The idea of a process producing a satisfactory result without a precise outcome can be a difficult one for some students to grasp but it is necessary for an understanding of management skills.

These engineering management subjects are part of the final year curriculum. The question could be asked If this innovative approach is effective and worthwhile, then why wait until the final year to introduce it? The answer may be Do not wait, but introduce management training into lower levels of the undergraduate degree. Management is an integral part of an engineer's training and should be incorporated as core subjects with similar prominence to Mathematics and Physics. If management skills are introduced in the first year of the degree, this will help to focus the student's attention towards management over four years instead of just one. It could be argued that students in their first year would not have sufficient maturity to study management. However, they should be sufficiently mature to start developing communication and team building skills. After all, other undergraduate degrees such as accounting, business and commerce introduce management subjects in the first semester of the course.

It may be considered that there is insufficient time available to incorporate additional subjects into the early years of the undergraduate degree. An alternative could be to review the curricula of existing (technical) subjects to encompass development of interpersonal skills such as practical work being done in groups. For example, a simple Physics practical experiment is usually conducted with a class of students doing the experiment alone, and each person writing a separate report for assessment. Experiments could be conducted using groups of three or four students, with each group providing a single report to be assessed. This requires the group to develop interpersonal skills such as communication and leadership to achieve a satisfactory result. Each group makes a short oral presentation of their results to the rest of the class once or twice a semester. This has the beneficial effects of presenting the technical aspects of a physics experiment (and requiring possibly a greater understanding of the content) and gaining experience of enhanced communication skills. It may also allow the experiment itself to cover a wider scope since there would be a number of students working on it.

Work is done in groups. When engineers are in industry they will often be working in groups and interacting with other people. Much of an undergraduate student's work is done alone - they do not have to rely on other members of the group to achieve a satisfactory result.

Students need experience in management processes. This can be demonstrated by a simple exercise such as the construction of paper planes as a group according to a specification. Before students can work <u>on</u> the process they have to work <u>in</u> the process by selecting a manager and a quality control inspector and decide how they would achieve the overall task by allocating tasks to each group member.

Groups could form a production line where each person makes a part of the finished product. These groups interact well, have a manager who manages, and a quality control inspector who acts in that role and produces satisfactory planes. Groups where the members work in isolation show poor results. At the feedback session at the end of the semester, this tutorial was noted as one that broke the ice and helped develop teamwork. It was a simple activity that some engineers thought they could use a technical approach to solve, but found they needed management skills to be successful. Another management exercise requires the students to choose one process from a number of processes such as the design of, or tender preparation for, a major item such as an electrical substation or a freeway overpass. The processes chosen were representative of those students are likely to be involved in soon after graduation. In this case the major input is information, technical skills and the interpersonal skills of working with a group of professional and para-professional people. Each group is required to identify the balance of operating influence for three processes they had chosen. This reinforced that engineers may have to work in processes before they can work on them.

Having to select one process from a number showed the uncertainty of management. Students develop their chosen processes over many weeks considering aspects of feedback and the effect of external influences. This demonstrates that the ability to respond to change quickly and appropriately is important and reinforces the need for management skills when working in a process - they could not change the initial group decision. If a particular group member was not happy with a group choice he/she still had to work in the process for the success of the group. Management skills, such as leadership, are developed over this time.

Students choose their own groups. This makes them responsible for their group as they had chosen the members. They have to organise time apart from class to complete the work. Some group members contribute less than others, which puts more pressure on those members contributing and wanting a good result. This relates to industry where there will be times when other group members will not contribute as much as others and management skills are needed in these situations for the group to produce a satisfactory result. The open ended nature of the processes and the lack of one clear path or only one correct procedure again reinforces the need for management skills in a technical situation.

Experiments such as 'White Beads' as proposed by Deming (1982), to demonstrate that processes undergo natural variation, are conducted. This area of the course requires an individual submission interpreting the results of a group experiment and common data. These mathematically based experiments are stable since the outcomes are predicted using statistical techniques. They also demonstrate that reducing the variation in a process, or, increasing the certainty of an outcome, will improve the process. A major component of management processes is to reduce uncertainty.

Students have to present their findings to the class on one of their nominated processes. This exercise can be difficult and threatening, if they are not used to formally discussing their thoughts in front of their fellow students with the possibility that other people would have a different (and therefore maybe wrong) viewpoint. This aspect was not popular at the feedback session although most agreed it was worthwhile.

In the feedback session at the end of semester the students were very supportive of the concept and approach taken. They had initially thought they would be learning about management and were not particularly enthusiastic. Instead, they were doing management and they learnt much through experience. There was a feeling that groups should be changed part way through the semester to weed out those who not pulling their weight. The students felt that a common thread running through the subject would make it easier to understand, although they acknowledged this could make the subject too focussed. The continuous assessment through out the semester proved very popular. An interesting point from the feedback session was the concern that no reference books prescribed for the subject. This reflected that some students felt they could learn management by reading a book, rather than experiencing it. Some students still had difficulty in being involved in a dynamic course that is undergoing ongoing development.

VUT has the worthy elements in that its course is being developed by a co-operative effort between industry management trainers and academia. VUT is thus able to combine the requirements of both interests.

VUT is not necessarily the only university that is developing management skills through experiential learning. It is included to demonstrate how one educational institution is addressing the problem.

## 4.4 Summary

In this chapter the operation of how three universities in Melbourne incorporate management training into the undergraduate engineering courses was investigated.

The Royal Melbourne Institute of Technology offers a Double Degree in Business Administration and Engineering. This course is five years long and management training is achieved by incorporating additional management subjects from the Business degree. Positive features of this course are the requirement of the undergraduate engineer to develop network links with professional bodies and the wide reading of published material related to the profession. Less desirable features are the extra time (and therefore cost) required and that the double degree is only available to students who have demonstrated a high level of academic achievement.

The Swinburne University 'Sandwich' course incorporates management training by giving students experience in industry for two six month periods. This highly desirable feature gives students twelve months 'hands on' industrial exposure whilst still within the learning umbrella of the University.

The newly developed course at the Victoria University of Technology involves experiential learning and was developed in conjunction with management trainers to industry. It uses material based on industry training programs that make it more relevant. This innovative approach builds on a student's knowledge of technical processes and shows how these need to be integrated with management processes.

# Chapter Five Model for future development

In this Chapter a number of options in which management training can be incorporated into the undergraduate engineering degree are developed. The advantages of the three universities investigated are considered and a model is developed that takes one more step in the improvement of management skills in engineers.

## 5.1 Underlying Rationale of the Model

### *5.1.1 Technical*

An important feature is that the technical content of existing engineering courses be preserved. To merely replace the existing technical content with management content tends to dilute the technical competency of engineers. This could make them less effective. It could also serve to make the profession less attractive, particularly to those who see themselves as a professional engineer with a very high degree of technical competence and with little need of management skills.

In addition, some engineering academics may resist incorporation of management techniques, particularly those who are engineering specialists, since they believe that undergraduate engineering courses should focus on the 'hard' technical aspects of engineering and leave the study of the 'soft' options of management until that time an engineer moves into management. These specialists will have a far greater resistance to change if they perceive dilution of the technical content. The commonly accepted management theories indicate that people often resist change because they are uncertain about how they will be personally affected by the outcomes. Dilution or reduction of the technical content may be construed as a personal threat to the knowledge, ability and power base of such academic specialists.

Further, industry quite rightly demands (and the general community expects) a high level of technical competence from its engineers. This aspiration of technical excellence should not be diminished by a downgrading of technical expertise.

This rationale is that while the technical content of undergraduate engineering degrees remains essentially the same, there may be a better way of teaching it.

### *5.1.2 Management*

The many literature articles, referred to in Chapter Two, reached the conclusions that:

- engineers lack management skills upon graduation; and
- many engineers need these management skills early in their professional career.

Also, the results of the survey discussed in Chapter Three agrees with published literature with an 82 per cent response that engineers should be better equipped with management skills on graduation and yet that only 19 per cent return to formal study to acquire these skills.

Therefore, the question is not

> <u>Should</u> engineers be trained in management skills as part of their undergraduate degree? but rather
>
> <u>How</u> should engineers be trained in management skills as part of their undergraduate degree?

The technical constraint of the rationale indicates that to integrate management with technical skills, teaching methods may need review.

Successful interaction with people at all levels - unskilled, semi-skilled, para-professionals and professionals - is a vital competency that the majority of engineers need to gain if they are to be successful in their professional life. Many engineers need these competencies to be highly developed on graduation so they can contribute quickly and effectively when they join the work force. These skills are also important in gaining entry to the work force. Management and interpersonal skills need to be taught as a component integrated with the technical specialisation of all engineers. It is vital that engineers understand the integration of management and technical aspects.

So that students have a greater appreciation of this technical/management link, every management subject introduced as a separate subject must be tailored to the needs of engineers and not just directly imported from another discipline without revision. These subjects must not be perceived by the students as some 'afterthought' added to their degree course but rather as a core component integrated with the technical aspects of engineering.

Communication is one of the vital skills an engineer must develop to high degree if they are to be successful. Part of the definition of management is getting things done through other people. A successful manager must be able to communicate their requirements to those who are to perform the tasks. This communication needs to be in a way the subordinate can understand and therefore managers must be able to express themselves in a way that is meaningful to their subordinates.

Initially, the graduate engineer is unlikely to be directly managing people, but more likely to be involved as a junior member of a particular work team - it is unlikely he/she will be working in isolation. The importance of well-developed communication skills is just important in this situation even though the newly graduated engineer is not directly controlling the activities of others.

### *5.1.3 Timing*

The current length of most engineering undergraduate degrees is four years study on a full time basis beyond the Victorian Certificate of Education. One desirable feature of the model is to retain the minimum length of full time formal classroom study at four years. It is acknowledged that other professions, such as Medicine and Law, require a study commitment of more than four years, and that this is accepted by the community at large.

If the study program was extended beyond four years there could be a significant change of community attitudes towards engineering. Whilst change is not necessarily bad, community perceptions of engineers being elitist and requiring a high intelligence to achieve an engineering degree, may be reinforced by an increase in the duration of the course.

In addition, increasing the time of formal study will mean additional Higher Education Contribution Scheme, University fees and living expenses during this extra time. It also means the undergraduate will take longer to start earning an income in his/her chosen profession.

This means that groups of people such as the relatively less financially advantaged could see this additional expense as too daunting. This could dissuade people who could become very good engineers rejecting the profession for purely financial reasons.

In addition, the prospective students themselves are more likely to question whether the extra time of formal study is worth the results, or whether other disciplines should be studied purely because they will graduate sooner.

The recommendations proposed include a total of twelve months industrial experience during which time the student is paid at 60 per cent (for six months) and 80 per cent (for six months) of the graduate rate. Whilst this particular recommendation increases the total length of an engineering degree by one year, the student is earning a significant amount of money during this extra time. What is more important, this industrial experience should give the graduate greater access to employment opportunities as well as making them more employable.

## 5.2 Recommendations

All three Universities considered have positive features in their courses aimed towards meeting the needs of engineers in industry. An integrated combination of the positive aspects from the Royal Melbourne Institute of Technology, Swinburne University and the Victoria University of Technology engineering courses should provide an engineer that can better operate in the profession. It seems appropriate that a collation of the positive aspects of the various courses be done. Constructive collaboration between academics from different universities will allow the cross pollination of ideas and hasten the evolution of the 'perfect' model. The recommendations that follow are compatible and complement each other.

The interactive and experiential nature of the final year engineering management subjects at the Victoria University of Technology, which was commended at the Engineering Management Educators Conference 1994, should be introduced at the commencement of all engineering undergraduate degree courses. This could be as separate subjects, but should also be as an assessable component of a number of technical subjects.

Also, the development of professional networks by interacting with professional engineers as required by the Double Degree of the Royal Melbourne Institute of Technology is an important aspect in the development of a young engineer. This feature should be required of all engineers, not just those with above average technical skills. This should start early in the course and not later than the commencement of the second year.

The Swinburne University block industry placements featured in their Sandwich course will enable the undergraduate engineer to better integrate their studies with the industry requirements of graduates. It will also serve to enhance links between industry and academia. This placement would not be appropriate until the undergraduate has had a significant amount of formal education. A minimum of two years of formal study is recommended before the first industry block placement.

The following recommendations are presented in the knowledge that successful implementation will:

- improve the image of engineers in the general community;
- more closely align academia with industry;
- enhance a graduate's opportunity of finding employment as a practising engineer on graduation;
- enable engineers to better communicate with their superiors and subordinates and others they interact with when they join the workforce;
- enable engineers to function better as managers when that time comes; and
- increase the opportunity of engineers rising to the highest levels of organisations.

It is recognised there may be community, political, academic and industrial barriers that need to be overcome. However, opportunities need to be actively sought to incorporate wherever possible the basic interpersonal skills of leadership and communication and also to continually reinforce these as an integral part of engineering training.
Consideration of the benefits from implementing different educational strategies from a number of major recommendations are as follows.

**Recommendation 1**

*Technical subjects without a recognised practical component such as mathematics should require each student to complete a problem and formally present their solution to the class.*

The purpose of this recommendation is to give students experience at formally presenting their work to their peers. An engineering undergraduate's peers are the most likely group of people he/she will meet who have the same modes of thinking, similar levels of intelligence and who are most likely to adopt a similar approach to solving a technical problem. This should be the easiest group for an undergraduate to communicate with since the perceiver's mode of assimilation is similar to the sender's.

Examples of technical problems include:

- the rate of filling of a conical container using differential calculus; and
- the characteristics of a grouped distribution using statistical analysis.

The above examples are 'black and white' problems with only one correct solution. Students should feel comfortable about the technical solution and could then take a further small step forward by formally communicating the theory to their peers. This would be relatively non-threatening since they would be on 'home ground' concerning the technical solution. The solution to a mathematics problem is often discussed in an informal environment - students discuss their answers to assignments. To speak formally in front of the class on a 'black and white' issue would require relatively little additional skills in requiring students to formally present their solution to their peers. They would be talking of their own work on a topic that has an absolutely certain, correct and best single outcome. Mathematics is a core component beginning in the first semester of all engineering degrees and is an appropriate vehicle to initially demonstrate that engineering is more than just technical solutions - effective communication of the solution is also important.

It is important to note that there has been no dilution of the technical component of the subject whatsoever. The presentation of the solution has merely passed from the tutor to the student. The advantage of this mode of communication is that the student must consider how he/she will present the solution. A poor presentation would result in a low mark and cause the student to ponder how it could be improved. Observation of the presentations of their peers would help the undergraduate to think more laterally.

It is expected students would present two solutions during the semester, each taking less than three minutes. Assessment would comprise a minor amount say 5 per cent of the overall result, reflecting the minor emphasis given.

**Recommendation 2**

*Technical subjects with a recognised practical component such as Physics or Chemistry should incorporate group work in half of the practical component.*

This recommendation is to give students experience at developing interpersonal skills by working in groups on technical problems. Initially this will be in a very structured technical environment that would progress to less structured exercises within a technical environment.

Half of the practical component remains as individual investigations and experiments to allow students to develop the highly important individual investigative skills. In the first year group work would comprise existing experiments that are designed by the lecturer/tutor and currently performed as individual experiments. These experiments would be performed in a group, reported as a group and assessed as a group, with each group member receiving the same assessment result. Presentation would again be an absolutely certain outcome based on their experimental results (which may differ between groups), although a discussion on factors affecting their results would be expected.

The small reduction in time available for laboratory work because of the requirement for formal presentation will be more than compensated by the group being able to share the work in the experiment and investigation so that the experimental tasks will be completed in a shorter time. This group work will also assist in developing the management skills of leadership, delegation and co-ordination of tasks.

To be successful, the experiment must be distributed to the students before the laboratory session so they can prepare their group strategy for conducting their work. Students will quickly realise that time spent in using the managerial skill of planning before an experiment will allow the technical task of the actual laboratory work to be completed more effectively and in a shorter time. It will also reinforce that a combination of technical and managerial skills is necessary to complete a task effectively and efficiently.

In the second year, students could investigate a particular problem with a number of acceptable solutions. They must decide which solution they would recommend with the appropriate justification. The recommendation may vary between groups based on their results and the factors that the group members see to be important. In this situation the outcome is again certain based on their chosen solution. However, the choice of solution is open to discussion.

In the third and fourth years the students would design two experiments as a group, conduct them and formally report their results in a written and oral presentation. A significant component of the assessment of each practical experiment would be the generation of the experiment including the processes used to achieve the result.

The integration of interpersonal components into technical subjects will reinforce the concept that management is an integral part of technical situations.

As with the case with Recommendation 1, this integration of interpersonal skills with technical skills will not dilute the technical content of the subject since at least the same amount of technical material can be covered. In some cases this group work may improve a students' understanding of the technical aspects since it may result in a greater understanding of the content of the material they are presenting. The sharing of tasks may also allow a greater technical coverage.

Again, presentation of the solution has passed from tutor to student group. Each group must coordinate their overall written submission of the experiment as well as the individual presentation of each group member.

As noted in Recommendation 1, a poorly coordinated and/or presented activity would result in a lower assessment result. The advantage of this experience is the development of the notion that interdependence on other group members is important to the overall success of the individual group members.

The logistics of practical work indicates the oral presentation be done at the start of the practical session since it may be difficult to stop the experiment early if some students have not finished. It is possible that other member of the class may not pay attention and try to start the current experiment. Alternative seating arrangements may be necessary for this short time to ensure the class gives due attention to the presenting group.

Whilst students would perform and submit written reports as a group on 4 or 5 experiments, they would only have a single presentation each semester.

The assessment component would be 10 per cent of the practical component in the first year increasing to 30 per cent in the final year. This reflects the increasing emphasis on interpersonal skills over the period of the degree.

**Recommendation 3**

*Undergraduate engineers need to be involved with professional engineers and their representative bodies and industry associations.*

The purpose of this recommendation is to encourage students to develop networks with their professional colleagues from an early stage in their training.

Adopting this feature of the RMIT double degree course requires students to join an appropriate professional body as a student member at the commencement of their second year, attend meetings, workshops and seminars and establish professional contact with at least two full members on an ongoing basis.

There is no technical dilution of subject content in this recommendation since it will be performed outside the formal class time. The undergraduate will experience the subordinate role in a situation since he/she will be communicating with graduate engineers who have had the opportunity to expand their theoretical knowledge into practical situations. This would be less threatening if a 'buddy system' was adopted with a third or fourth year undergraduate assisting the second year student. Not only would this buddy system reduce apprehension in the second year student, but it gives the higher student an opportunity to assist in the development of a less experienced person.

Assessment will be annually and based on:

- Attendance and participation at professional body meetings;
- Submission of reports of meetings; and
- Reports of contact with professional engineers.

This network development would be continued throughout their degree course with at least one oral presentation to the association. This professional contact may also have the additional benefit of assisting the students in gaining employment at the end of their degree.

**Recommendation 4**

*Students need to demonstrate knowledge of literature relevant to their area of specialisation.*

The purpose of this recommendation is to encourage students to become familiar with relevant published literature and encourage students to improve their investigative skills and keep up to date with developments within the profession.

Again, there is absolutely no dilution of the technical content of the course. It is likely to broaden their understanding of their chosen profession. It is possible that this recommendation combined with Recommendation 3 may assist in the choice of practical experiments (according to Recommendation 2) in the later years.

Assessment would be based on:

- The depth, range and quality of a folio of relevant articles from a range of journals; and
- A written report on the folio.

A minimum number of articles would be required for satisfactory completion of this requirement. It may be appropriate to combine Recommendations 3 and 4 for assessment purposes.

**Recommendation 5**

*Two six month industry placements would occur with different organisations.*

The six month component of this recommendation is to give students a significant time in industry to tackle meaningful projects and see the results of their efforts.

The requirement of different organisations is to give a broader base of experience than would be likely if this experience was gained in just one organisation. This experience would comprise more than just technical projects, since it would allow the student would see how different organisations are managed.

The Sandwich approach adopted by Swinburne University would be instituted after students had passed their second year. A six month industry experience would be undertaken with payment at 60 per cent of the recommended rate of a graduate engineer. A second six month placement would occur in the second semester of their fourth year at another organisation. Students would be encouraged to use their own initiative for industry placements, although the University must approve the placement and would have overall control during the placement. The development of their networks started in their second year may assist in these endeavours.

For this recommendation to be successful, there needs to be a commitment from both academia and industry to provide a positive environment for the student.
As with all previous recommendations, this does not dilute in any way the technical component of the undergraduate degree. It does require, however, recognition of two additional factors:

- engineers with industrial experience are more likely to perform better on graduation than those without industrial experience, and
- timetabling would need to be reorganised.

Surely the first factor is unquestionable. The second factor is a matter of funding and organisation.

Assessment will comprise three parts:
- A written report of their industry experience to the management of their employing organisation and also to the University;
- An oral presentation of their industry experience to a panel consisting of academics, engineers and managers of their employing organisation; and
- An assessment provided by the employing organisation.

Students would graduate with twelve months experience working in industry and a not insignificant financial income over the latter part of their degree.

**Recommendation 6**

*Four individual management subjects are integrated into the engineering undergraduate engineering degree, one subject in each year level.*

This recommendation is based on the experiential learning techniques introduced at the Victoria University of Technology in 1994 and the author's industry and academic experience. Whilst management is an integral part of engineering and should pervade throughout most of the subjects some formal management elements need to be taught as separate subjects. The following subjects should be included.

The subject **Introduction to Engineering Management** should be taught in the first year. This will encompass management theories such as Scientific Management, Human Relations Management and Welfarism. Students will appreciate that each of these theories have strengths and weaknesses and that the best management practice is a combination of the strengths of all these theories in each particular context. The theories of motivation will demonstrate that people are motivated by different factors at different times and that there is no single motivating aspect that is always absolute or precise. Group theory will demonstrate how individuals will behave when are in groups.

The subject **Engineers as People** should be taught in the second year and will focus on students developing interpersonal skills through experiential exercises. A major focus will be on communication and interview skills that were shown from the survey to be deficient and in great need on graduation. Students will develop their curriculum vitae and then be interviewed for positions. There will be an interview panel of three students and three or four students will be interviewed as candidates for the position. Feedback will be an integral part of this subject. By the end of the semester, students should have been on three interviewing panels and have been interviewed at least three times. The lateral thinking skills of the undergraduates should become more highly developed during this subject. This should enhance their chances of obtaining industrial experience at the end of the second year since they will have developed their curriculum vitae and have gained some experience at interviewing and being interviewed.

The subject **Labour Engineering** should be taught in the third year and involves case studies of labour relations and the study of major industrial disputes. At this stage of their training students will have had six months experience in industry and should have some (albeit small) appreciation of labour relations in the workplace. Role plays of industrial situations involving union/management negotiations will give students some experience in this area.

The subject **Commercial Engineering** studied in the fourth year would relate to the financial/accounting aspects of industry. It will reinforce that an effective engineer needs to be mindful of the economic effect of his/her decisions whether these be in design, construction, operation or maintenance of plant and equipment. The cost of labour in differing scenarios - skilled vs unskilled, overtime vs additional people, shift vs non shift options will be studied. This is technically aligned to engineering undergraduates since a knowledge of spreadsheets is required to assess the 'what-if' analysis of their decisions.

It is absolutely vital that these management subjects be focussed towards engineers and not be a unit merely removed from a business or accounting degree. Engineering undergraduates will need to be able to relate to these management subjects as part of their overall effectiveness as a practising engineer.

**Recommendation 7**

*Management subjects are taught by people who are able to effectively communicate to engineers the need for effective interpersonal skills.*

This recommendation can be achieved in a number of ways.

(i) *Use sessional lectures/tutors who are lateral thinking engineers with a significant management component in their professional working lives and who are able to and prepared to teach undergraduate engineers.*

This would be the ideal situation whereby students would be able to relate to the engineering discipline of the lecturer/tutor and learn from their knowledge and experiences. Such people may not always be available on a continuing basis.

The choice of how *laterally thinking* a prospective lecturer/tutor is very subjective. Ideally this would be decided by a panel with skills in engineering, social sciences and academia. This selection panel may seem excessive for a sessional lecturer/tutor.

The *significant management component* is the easiest of the four criteria.

To be *able to* teach would most likely require some educational training or at least extensive industrial experience at teaching young professionals in a formal situation.

To be *prepared to* teach requires the lecturer/tutor to want to undertake this extra activity in combination with their employment commitments and their own personal life outside the workplace. Since most full time engineering degrees hold classes between the normal business hours of 9 am - 5 pm, this person would most likely need to come from either an organisation who is strongly committed to the management training of engineers, or a person who is able to obtain a regular leave of absence from the workplace.

(ii) *Use laterally thinking engineering academics with management experience in industrial settings.*

This option removes some of the restrictions from the ideal situation. It still provides students with a mentor figure of an engineering manager to whom they can relate. Using an academic presumably removes the *able to* and *prepared to* restrictions. Again, such people may not always be available.

(iii) *Use management academics with significant industry experience.*

One example would be a former Accountant or Personnel Manager who has worked in a manufacturing organisation. Such a person would have knowledge of some of the requirements of industry.

(iv) *Use Social Science academics with significant management experience.*

Social scientists are more likely to be lateral thinkers than engineers and therefore better able to handle the multiplicity of outcomes from a given situation. They may however, have greater difficulty relating to the more linear thinking of engineers.

One suitable combination might be a social scientist using guest engineers from industry for part of the course. One example could be interviewing an engineering manager in front of the students regarding interview techniques or resolution of an industrial conflict. This concept has the benefits in that a number of engineering managers could be interviewed, exposing the students to a variety of engineering attitudes. In addition, engineering managers are more likely to be available for a single session rather than the thirteen weeks of a semester. This also reduces the requirement for a lateral thinking engineer since exposure to a linearly thinking engineer would not necessarily be a bad experience, particularly late in the semester when students would have a basis for comparison between different types of thinking of engineers.

This option has the benefit of exposing students to people other than engineers - a situation they will be involved in early in their professional career. Care must be taken to ensure that the presentation of lectures and tutorials do not alienate students. It is important they see these classes as a core part of their engineering training and not some 'add-on' component just to fulfil a curriculum requirement.

The best mix of lecturers/tutors for these subjects could be a combination of all the above range of people.

## 5.3 Summary

After consideration of the results of the literature review, survey and investigation of three university courses a number of recommendations are proposed as a basis for an undergraduate engineering course. These recommendations combine the positive features of the courses investigated together with the author's industrial experience as an engineer, manager and academic.

The model is proposed as another step towards reducing the deficiency of management skills existing in engineers whilst preserving the technical integrity of engineering courses.

# Chapter Six Future Research

Not only should academia be pro-active and look outward to industry for guidance, but it should also look inwardly at itself to determine why it is taking so long to effectively address the problems of management education that have been raised by a number of researchers over many years.

One way in which this could be achieved is to survey academics in engineering faculties and other academics who are involved with teaching management to engineers. Areas to investigate include:

- the level of management training in their undergraduate degree;
- the manner in which it is taught;
- whether they consider this to be an appropriate amount;
- whether teaching methods are relevant to engineers;
- their view of the positive and negative aspects of the management curricula of engineering;
- the importance they place on the management components of undergraduate engineering curricula;
- their knowledge of the management content and teaching methods of other institutions; and
- their degree of collaboration with industry and with other educational institutions.

This should give some guidance of the extent individual academics favour management teaching and how informed they are of trends in other places. It should also highlight any negative sentiments, individuals, or groups of individuals, may have about management training as part of an undergraduate engineering degree.

Another area of research worthy of investigation is that group of engineers identified in this research who undertook further postgraduate study in management. This research should focus on the benefits these engineers gained from their additional study and the impact this had on their professional and personal lives.

## 6.1 Conclusions

The industry perception of a graduating engineer is that they need management skills early in their career and that current undergraduate courses do not provide sufficient training for engineers to become World Competitive Managers. This reinforces the views of earlier researchers that there is a significant disparity between academic outcomes and industry requirements and that this has been occurring for some time. It also confirmed that this disparity must be addressed and remedied as a matter of urgency. There is still much work to be done!

Not only is this view being expressed by engineers with much experience who graduated many years ago, but it is also being expressed by relatively young engineers who have recently graduated.

The questionnaire method of researching industry proved to be a valuable tool and provided a source of valuable and current information from industry to academia. The high response rate indicates that engineering managers did not see this method as being too intrusive into their time. It therefore provides an important and effective communication link between academia and industry. This link should be developed by more frequent replication of this work by other academics.

The general response by industry to academics concerned with the lack of effective management training in undergraduate degree courses is positive. In addition, a large number of respondents indicated that they are willing to be involved in further research and this provides another meeting point between academia and industry. Industry wants to give their input to help academia to solve the problem.

It is vital that academia recognise and accept that industry is the major 'customer' of the output from engineering degrees. It is essential for all organisations to monitor the level of 'customer satisfaction' so that the positive aspects can be enhanced and that any negative aspects can be reduced and eventually eliminated. Periodic replication of this work will allow improvements to the management education of engineers to be monitored and provide another vehicle to assess the effectiveness of engineering courses.

Further, academics should be encouraged to spend a significant time working as an engineer and/or manager in industry so that they can better understand the needs of their customer. The time release period must be sufficiently long (say 6 - 12 months) for them to experience events in industrial situations and maintain a current knowledge of industry expectations. This means the major focus of their work would be as a practising engineer/manager rather than as a consultant or researcher.

A number of Melbourne universities are already addressing this question in a variety of ways. When the positive aspects of their courses are collated into an overall common curriculum another step will have been taken to resolving the difference between academic outcomes and industry requirements. This collation of ideas should be extended nationally and incorporate other universities to take advantages of their innovations.

In conclusion, there is a need for constant reappraisal of the recommendations of this research towards making continuous improvement. This will require ongoing change. Management education of engineers must become a dynamic, pro-active and progressive evolution towards the 'perfect' model.

This research is only the beginning of a need for change that has become urgent. In the global environment of the 1990's, Australia is under increasing competition from her Asian neighbours. The problem of the lack of effective management education of undergraduate engineers needs to addressed quickly!

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## Appendix 1: Questionnaire

VICTORIA UNIVERSITY OF TECHNOLOGY

**A SURVEY ON THE MANAGEMENT SKILLS OF ENGINEERS**

**Mr. Trevor Rosan**
**Department of Management (Werribee Campus)**
**Faculty of Business**
**Victoria University of Technology**
**P O Box 14428**
**MMC Melbourne**
**Victoria 3000**

**May 1994**

*The answers to this survey will be kept in strict confidence.*
*The names of participating companies and individuals will not be released.*

**1.** **What is your current position/title?**

______________________________________________________

**2.** **How long have you been in this position?**

______________________________________________________

**3.** **From which institution, and in what year, did you acquire your undergraduate engineering degree?**

Institution __________________________ Year 19__

**4.** **As a practising engineer, to what extent in your first <u>two years</u> were the following management/people skills required?**

(Please circle the most appropriate response for each item)

| | Not Applicable | Not Important | | | | Most Important |
|---|---|---|---|---|---|---|
| **a. Planning** | | | | | | |
| Defining goals for non technical people | 0 | 1 | 2 | 3 | 4 | 5 |
| Defining goals for technical people | 0 | 1 | 2 | 3 | 4 | 5 |
| Establishing strategies | 0 | 1 | 2 | 3 | 4 | 5 |
| Developing plans to coordinate activities | 0 | 1 | 2 | 3 | 4 | 5 |
| **b. Organising** | | | | | | |
| Work routines of non technical people | 0 | 1 | 2 | 3 | 4 | 5 |
| Work routines of technical people | 0 | 1 | 2 | 3 | 4 | 5 |
| Grouping of work tasks | 0 | 1 | 2 | 3 | 4 | 5 |
| Reporting relationships | 0 | 1 | 2 | 3 | 4 | 5 |
| **c. Controlling** | | | | | | |
| Monitoring people activities | 0 | 1 | 2 | 3 | 4 | 5 |
| Correcting deviations of behaviour | 0 | 1 | 2 | 3 | 4 | 5 |

| | Not Applicable | Not Important | | | | Most Important |
|---|---|---|---|---|---|---|
| **d. Leading** | | | | | | |
| Motivating others | 0 | 1 | 2 | 3 | 4 | 5 |
| Directing others | 0 | 1 | 2 | 3 | 4 | 5 |
| Resolving conflicts | 0 | 1 | 2 | 3 | 4 | 5 |
| Negotiating with superior levels | 0 | 1 | 2 | 3 | 4 | 5 |
| Negotiating with peer level | 0 | 1 | 2 | 3 | 4 | 5 |
| Negotiating with subordinate levels | 0 | 1 | 2 | 3 | 4 | 5 |
| Negotiating with unions | 0 | 1 | 2 | 3 | 4 | 5 |

**5. When you completed your undergraduate degree, were you equipped with those skills you identified as important?**

☐ YES ☐ NO

If NO, which skills were not addressed?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Did you subsequently acquire these skills?**

☐ YES ☐ NO

If YES, how did you acquire these skills?

(Please specify Title and Year)

Another degree ______________________

Post graduate study ______________________

Professional Short Course/s ______________________

______________________

______________________

Experience (please specify types) ______________________

______________________

**6. Do you believe that the current undergraduate engineering degrees have adequate management training?**

☐ YES ☐ NO

If NO, which skills are not being addressed?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**7. In your opinion, what recommendations would you make for the training and development in management skills for future engineers?**

______________________________________________

______________________________________________

______________________________________________

______________________________________________

***Thank you for your assistance in completing this questionnaire.***

*********

Please indicate if you would be willing to participate in follow up research which would be completely confidential.

☐ YES ☐ NO

If you would be interested in receiving a summary report of the findings, please complete the following details.

Name: ______________________________

Company: ______________________________

Address: ______________________________

______________________________

Phone: ______________ Fax: ______________

## Appendix 2: Covering Letter

**Victoria University of Technology**
McKechnie Street
St Albans
PO Box 14428
M.M.C.
Melbourne
Victoria 3000
Australia
Telephone
(03) 365 2111
Facsimile
(03) 366 4852

**St Albans Campus**

**VICTORIA UNIVERSITY OF TECHNOLOGY**

Attention: The Manufacturing Manager

May 3rd, 1994

Dear Manager,

I am conducting a survey on Engineering graduates and how well their undergraduate degree studies prepare them for management roles. A questionnaire is enclosed for the purposes of canvassing your views in this area.

It would be greatly appreciated if you would take 15 minutes or so to complete this questionnaire, insert it in the enclosed postage paid envelope and return it to me as soon as possible.

I would also be grateful if you could be available for a follow up case study research but if you wish to remain anonymous that will be respected.

If you have any queries regarding this research, please phone me on (03) 216 8269 during office hours.

If you do not hold a degree in Engineering, please pass this questionnaire to someone who has such a degree, or return the questionnaire to me unanswered.

Thank you in anticipation of your co-operation in completing this questionnaire.

Yours Sincerely,

[redacted]

Trevor L. Rosan

## Appendix 3: Reminder Letter

**Victoria University of Technology**
McKechnie Street
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Telephone
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**St Albans Campus**

VICTORIA UNIVERSITY OF TECHNOLOGY

Attention: The Manufacturing Manager

May 17th, 1994

**REMINDER**

Dear Manager,

Recently you were sent a questionnaire regarding undergraduate engineering studies and their suitability for management preparation.

If you have already returned the questionnaire to me, thank for your assistance and please disregard this reminder.

If you have not yet returned it, please would you do so as soon as possible. In order for the study to be valid, a response rate of 50% at least is required. I am sure that you will agree that if engineering studies are to be relevant to the workplace, feedback from the workplace is essential. Hence I need your support.

Should you require a second questionnaire then you are welcome to phone me at (03) 216 8269 and one will be mailed to you with a postage paid return envelope.

Your Sincerely,

[redacted]

Trevor L. Rosan

# Appendix 4: Raw Analysis of Survey

Importance Ranking by Respondent Number and Category

| | Institution | Grad Year | Non Tech Goals | Tech goals | Strategies |
|---|---|---|---|---|---|
| | | $X_1$ | $X_2$ | $X_3$ | $X_4$ |
| 1 | Melb | 1 | 3 | 4 | 3 |
| 2 | UK | 1 | 0 | 4 | 1 |
| 3 | Yorkshire | 3 | 1 | 1 | 1 |
| 4 | RMIT | • | 4 | 1 | 4 |
| 5 | GIAE | 3 | 3 | 4 | 4 |
| 6 | RMIT | 2 | 3 | 3 | 2 |
| 7 | Monash | 5 | 0 | 2 | 4 |
| 8 | Monash | 3 | 2 | 3 | 0 |
| 9 | Gordon | 0 | 0 | 2 | 0 |
| 10 | Monash | 3 | 1 | 1 | 1 |
| 11 | Monash | 3 | 2 | 0 | 0 |
| 12 | Aukland | 3 | 4 | 3 | 1 |
| 13 | O/S | 4 | 0 | 3 | 3 |
| 14 | Monash | 5 | 4 | 3 | 3 |
| 15 | Swinburne | 4 | 1 | 1 | 3 |
| 16 | Melb | 0 | 3 | 4 | 2 |
| 17 | Swinburne | 1 | 5 | 5 | 4 |
| 18 | Preston | 3 | 4 | 3 | 4 |
| 19 | Swinburne | 5 | 3 | 4 | 5 |
| 20 | Melb | 5 | 3 | 4 | 4 |
| 21 | Paisley | 0 | 1 | 1 | 0 |
| 22 | Swinburne | 2 | 0 | 0 | 0 |
| 23 | RMIT | 5 | 5 | 5 | 1 |
| 24 | RMIT | 1 | 3 | 0 | 2 |
| 25 | RMIT | 4 | 2 | 3 | 3 |
| 26 | Swinburne | 4 | 2 | 5 | 2 |
| 27 | Swinburne | 2 | 4 | 3 | 4 |
| 28 | Melb | 3 | 2 | 2 | 2 |
| 29 | x | • | 3 | 2 | 4 |
| 30 | FIT | 3 | 1 | 1 | 0 |
| 31 | Melb | 0 | 0 | 3 | 2 |
| 32 | UNSW | 1 | 1 | 1 | 3 |
| 33 | RMIT | 2 | 0 | 0 | 3 |
| 34 | Melb | 5 | 0 | 3 | 0 |

Importance Ranking by Respondent Number and Category

| | Plans | Non Tech Work | Tech Work | Groups | R/ships | Monitoring |
|---|---|---|---|---|---|---|
| | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ | $X_{10}$ |
| 1 | 5 | 4 | 4 | 5 | 4 | 5 |
| 2 | 4 | 0 | 4 | 5 | 1 | 4 |
| 3 | 5 | 1 | 1 | 3 | 3 | 0 |
| 4 | 4 | • | • | 4 | 2 | 3 |
| 5 | 4 | 3 | 4 | 4 | 4 | 4 |
| 6 | 3 | 2 | 2 | 1 | 0 | 1 |
| 7 | 4 | 2 | 0 | 0 | 0 | 0 |
| 8 | 4 | 1 | 2 | 2 | 1 | 2 |
| 9 | 2 | 0 | 3 | 3 | 2 | 2 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 0 | 0 | 0 | 1 | 1 | 0 |
| 12 | 2 | 4 | 3 | 3 | 2 | 3 |
| 13 | 4 | 0 | 3 | 4 | 4 | 4 |
| 14 | 4 | 4 | 3 | 2 | 0 | 4 |
| 15 | 4 | 5 | 2 | 5 | 3 | 3 |
| 16 | 3 | 1 | 2 | 2 | 1 | 1 |
| 17 | 4 | 3 | 3 | 3 | 5 | 1 |
| 18 | 5 | 4 | 3 | 4 | 3 | 4 |
| 19 | 5 | 4 | 3 | 4 | 5 | 4 |
| 20 | 5 | 4 | 4 | 4 | 3 | 3 |
| 21 | 1 | 0 | 0 | 3 | 3 | 2 |
| 22 | 2 | 5 | 5 | 4 | 4 | 5 |
| 23 | 5 | 3 | 5 | 3 | 4 | 5 |
| 24 | 4 | 3 | 0 | 1 | 1 | 0 |
| 25 | 3 | 2 | 4 | 3 | 3 | 4 |
| 26 | 4 | 2 | 5 | 5 | 3 | 5 |
| 27 | 5 | 3 | 4 | 4 | 4 | 4 |
| 28 | 2 | 3 | 2 | 2 | 2 | 3 |
| 29 | 4 | 3 | 2 | 2 | 2 | 3 |
| 30 | 4 | 2 | 2 | 3 | 1 | 1 |
| 31 | 4 | 2 | 3 | 4 | 3 | 4 |
| 32 | 5 | 5 | 5 | 5 | 5 | 5 |
| 33 | 3 | 0 | 0 | 0 | 0 | 0 |
| 34 | 5 | 5 | 3 | 2 | 4 | 5 |

Importance Ranking by Respondent Number and Category

| | Correcting | Motivating | Directing | Resolving | Neg Sup |
|---|---|---|---|---|---|
| | $X_{11}$ | $X_{12}$ | $X_{13}$ | $X_{14}$ | $X_{15}$ |
| 1 | 5 | 3 | 4 | 4 | 4 |
| 2 | 4 | 3 | 3 | 1 | 5 |
| 3 | 0 | 1 | 1 | 2 | 4 |
| 4 | 1 | • | • | • | 4 |
| 5 | 4 | 3 | 4 | 3 | 3 |
| 6 | 0 | 3 | 2 | 1 | 3 |
| 7 | 1 | 1 | 2 | 1 | 2 |
| 8 | 1 | 1 | 1 | 1 | 3 |
| 9 | 0 | 4 | 4 | 2 | 4 |
| 10 | 1 | 1 | 1 | 1 | 1 |
| 11 | 0 | 0 | 2 | 0 | 2 |
| 12 | 4 | 2 | 3 | 3 | 2 |
| 13 | 4 | 3 | 3 | 3 | 4 |
| 14 | 1 | 4 | 3 | 4 | 1 |
| 15 | 2 | 2 | 3 | 2 | 2 |
| 16 | 0 | 4 | 3 | 2 | 3 |
| 17 | 2 | 4 | 4 | 1 | 4 |
| 18 | 4 | 4 | 4 | 4 | 4 |
| 19 | 3 | 4 | 4 | 5 | 5 |
| 20 | 2 | 3 | 5 | 4 | 4 |
| 21 | 1 | 3 | 2 | 1 | 5 |
| 22 | 5 | 5 | 5 | 5 | 5 |
| 23 | 5 | 4 | 5 | 4 | 3 |
| 24 | 0 | 2 | 3 | 1 | 2 |
| 25 | 3 | 4 | 4 | 4 | 4 |
| 26 | 5 | 5 | 4 | 4 | 4 |
| 27 | 4 | 3 | 4 | 4 | 4 |
| 28 | 5 | 2 | 4 | 4 | 3 |
| 29 | 3 | 3 | 3 | 2 | 4 |
| 30 | 0 | 3 | 4 | 3 | 3 |
| 31 | 2 | 3 | 3 | 2 | 4 |
| 32 | 5 | 5 | 5 | 3 | 0 |
| 33 | 0 | 4 | 3 | 3 | 4 |
| 34 | 3 | 3 | 3 | 4 | 4 |

Importance Ranking by Respondent Number and Category

| | Neg Peers | Neg Sub | Neg Unions |
|---|---|---|---|
| | $X_{16}$ | $X_{17}$ | $X_{18}$ |
| 1 | 3 | 2 | 2 |
| 2 | 5 | 5 | 1 |
| 3 | 4 | 2 | 0 |
| 4 | 5 | 5 | 1 |
| 5 | 4 | 4 | 3 |
| 6 | 3 | 3 | 0 |
| 7 | 3 | 3 | 1 |
| 8 | 4 | 1 | 0 |
| 9 | 3 | 3 | 0 |
| 10 | 1 | 1 | 1 |
| 11 | 2 | 3 | 0 |
| 12 | 4 | 3 | 2 |
| 13 | 4 | 3 | 1 |
| 14 | 0 | 0 | 0 |
| 15 | 2 | 3 | 1 |
| 16 | 3 | 1 | 0 |
| 17 | 5 | 5 | 0 |
| 18 | 4 | 4 | 4 |
| 19 | 3 | 4 | 1 |
| 20 | 5 | 5 | 3 |
| 21 | 4 | 2 | 0 |
| 22 | 5 | 5 | 5 |
| 23 | 3 | 5 | 1 |
| 24 | 0 | 1 | 0 |
| 25 | 4 | 4 | 0 |
| 26 | 4 | 4 | 5 |
| 27 | 4 | 4 | 4 |
| 28 | 4 | 2 | 3 |
| 29 | 4 | 5 | 1 |
| 30 | 4 | 3 | 0 |
| 31 | 3 | 2 | 0 |
| 32 | 3 | 5 | 0 |
| 33 | 4 | 4 | 0 |
| 34 | 4 | 4 | 0 |

## Mean and Standard Deviation by Category

### $X_1$: Grad Year

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.688 | 1.655 | .293 | 2.738 | 61.569 | 32 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 86 | 316 | 2 |

1

### $X_2$: Non Tech Goals

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.059 | 1.594 | .273 | 2.542 | 77.439 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 70 | 228 | 0 |

2

### $X_3$: Tech goals

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.471 | 1.522 | .261 | 2.317 | 61.615 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 84 | 284 | 0 |

3

### $X_4$: Strategies

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.206 | 1.553 | .266 | 2.411 | 70.389 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 75 | 245 | 0 |

4

### $X_5$: Plans

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 3.618 | 1.326 | .227 | 1.758 | 36.656 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 123 | 503 | 0 |

5

# Mean and Standard Deviation by Category

### $X_6$: Non Tech Work

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.455 | 1.66 | .289 | 2.756 | 67.631 | 33 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 81 | 287 | 1 |

6

### $X_7$: Tech Work

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.636 | 1.558 | .271 | 2.426 | 59.082 | 33 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 87 | 307 | 1 |

7

### $X_8$: Groups

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.971 | 1.446 | .248 | 2.09 | 48.667 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 101 | 369 | 0 |

8

### $X_9$: R/ships

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.471 | 1.542 | .264 | 2.378 | 62.416 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 84 | 286 | 0 |

9

### $X_{10}$: Monitoring

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.794 | 1.737 | .298 | 3.017 | 62.164 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 95 | 365 | 0 |

10

# Mean and Standard Deviation by Category

### $X_{11}$: Correcting

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.353 | 1.873 | .321 | 3.508 | 79.601 | 34 |

| Minimum: | Maximum: | Range: | Sum: | Sum Squared: | # Missing: |
|---|---|---|---|---|---|
| 0 | 5 | 5 | 80 | 304 | 0 |

11

### $X_{12}$: Motivating

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 3 | 1.25 | .218 | 1.562 | 41.667 | 33 |

| Minimum: | Maximum: | Range: | Sum: | Sum Squared: | # Missing: |
|---|---|---|---|---|---|
| 0 | 5 | 5 | 99 | 347 | 1 |

12

### $X_{13}$: Directing

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 3.273 | 1.126 | .196 | 1.267 | 34.394 | 33 |

| Minimum: | Maximum: | Range: | Sum: | Sum Squared: | # Missing: |
|---|---|---|---|---|---|
| 1 | 5 | 4 | 108 | 394 | 1 |

13

### $X_{14}$: Resolving

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 2.667 | 1.384 | .241 | 1.917 | 51.916 | 33 |

| Minimum: | Maximum: | Range: | Sum: | Sum Squared: | # Missing: |
|---|---|---|---|---|---|
| 0 | 5 | 5 | 88 | 296 | 1 |

14

### $X_{15}$: Neg Sup

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 3.324 | 1.224 | .21 | 1.498 | 36.829 | 34 |

| Minimum: | Maximum: | Range: | Sum: | Sum Squared: | # Missing: |
|---|---|---|---|---|---|
| 0 | 5 | 5 | 113 | 425 | 0 |

15

# Mean and Standard Deviation by Category

**$X_{16}$: Neg Peers**

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 3.441 | 1.26 | .216 | 1.587 | 36.612 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 117 | 455 | 0 |

16

**$X_{17}$: Neg Sub**

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 3.235 | 1.437 | .246 | 2.064 | 44.408 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 110 | 424 | 0 |

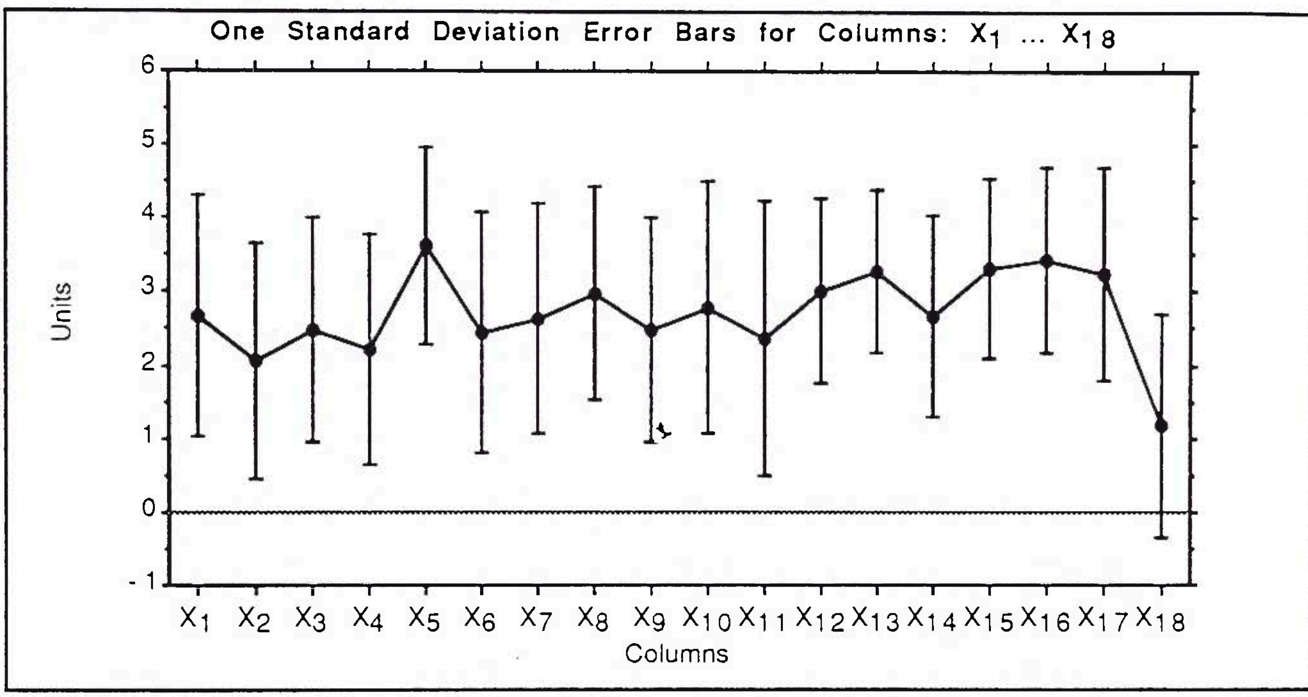
17

**$X_{18}$: Neg Unions**

| Mean: | Std. Dev.: | Std. Error: | Variance: | Coef. Var.: | Count: |
|---|---|---|---|---|---|
| 1.176 | 1.547 | .265 | 2.392 | 131.466 | 34 |
| **Minimum:** | **Maximum:** | **Range:** | **Sum:** | **Sum Squared:** | **# Missing:** |
| 0 | 5 | 5 | 40 | 126 | 0 |

18

## Standard Deviation Error Bars



# Frequency Distribution by Category

**$X_1$: Grad Year**

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 4 | 12.5 | |
| 2 | 1 | 2 | 5 | 15.625 | |
| 3 | 2 | 3 | 4 | 12.5 | |
| 4 | 3 | 4 | 9 | 28.125 | -Mode |
| 5 | 4 | 5 | 4 | 12.5 | |
| 6 | 5 | 6 | 6 | 18.75 | |

1

**$X_2$: Non Tech Goals**

| Bar: | From: (≥) | To: (<) | Count: | Percent: |
|---|---|---|---|---|
| 1 | 0 | 1 | 8 | 23.529 |
| 2 | 1 | 2 | 6 | 17.647 |
| 3 | 2 | 3 | 5 | 14.706 |
| 4 | 3 | 4 | 8 | 23.529 |
| 5 | 4 | 5 | 5 | 14.706 |
| 6 | 5 | 6 | 2 | 5.882 |

2

**$X_3$: Tech goals**

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 4 | 11.765 | |
| 2 | 1 | 2 | 7 | 20.588 | |
| 3 | 2 | 3 | 4 | 11.765 | |
| 4 | 3 | 4 | 10 | 29.412 | -Mode |
| 5 | 4 | 5 | 6 | 17.647 | |
| 6 | 5 | 6 | 3 | 8.824 | |

3

# Frequency Distribution by Category

**$X_4$: Strategies**

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 7 | 20.588 | |
| 2 | 1 | 2 | 5 | 14.706 | |
| 3 | 2 | 3 | 6 | 17.647 | |
| 4 | 3 | 4 | 7 | 20.588 | |
| 5 | 4 | 5 | 8 | 23.529 | -Mode |
| 6 | 5 | 6 | 1 | 2.941 | |

4

**$X_5$: Plans**

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 2.941 | |
| 2 | 1 | 2 | 2 | 5.882 | |
| 3 | 2 | 3 | 4 | 11.765 | |
| 4 | 3 | 4 | 4 | 11.765 | |
| 5 | 4 | 5 | 14 | 41.176 | -Mode |
| 6 | 5 | 6 | 9 | 26.471 | |

5

**$X_6$: Non Tech Work**

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 6 | 18.182 | |
| 2 | 1 | 2 | 4 | 12.121 | |
| 3 | 2 | 3 | 6 | 18.182 | |
| 4 | 3 | 4 | 7 | 21.212 | -Mode |
| 5 | 4 | 5 | 6 | 18.182 | |
| 6 | 5 | 6 | 4 | 12.121 | |

6

# Frequency Distribution by Category

### $X_7$: Tech Work

| Bar: | From: (≥) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 5 | 15.152 | |
| 2 | 1 | 2 | 2 | 6.061 | |
| 3 | 2 | 3 | 7 | 21.212 | |
| 4 | 3 | 4 | 9 | 27.273 | -Mode |
| 5 | 4 | 5 | 6 | 18.182 | |
| 6 | 5 | 6 | 4 | 12.121 | |

7

### $X_8$: Groups

| Bar: | From: (≥) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 2 | 5.882 | |
| 2 | 1 | 2 | 4 | 11.765 | |
| 3 | 2 | 3 | 6 | 17.647 | |
| 4 | 3 | 4 | 8 | 23.529 | |
| 5 | 4 | 5 | 9 | 26.471 | -Mode |
| 6 | 5 | 6 | 5 | 14.706 | |

8

### $X_9$: R/ships

| Bar: | From: (≥) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 4 | 11.765 | |
| 2 | 1 | 2 | 7 | 20.588 | |
| 3 | 2 | 3 | 5 | 14.706 | |
| 4 | 3 | 4 | 8 | 23.529 | -Mode |
| 5 | 4 | 5 | 7 | 20.588 | |
| 6 | 5 | 6 | 3 | 8.824 | |

9

# Frequency Distribution by Category

### $X_{10}$: Monitoring

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 5 | 14.706 | |
| 2 | 1 | 2 | 5 | 14.706 | |
| 3 | 2 | 3 | 3 | 8.824 | |
| 4 | 3 | 4 | 6 | 17.647 | |
| 5 | 4 | 5 | 9 | 26.471 | -Mode |
| 6 | 5 | 6 | 6 | 17.647 | |

10

### $X_{11}$: Correcting

| Bar: | From: (≥) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 8 | 23.529 | -Mode |
| 2 | 1 | 2 | 6 | 17.647 | |
| 3 | 2 | 3 | 4 | 11.765 | |
| 4 | 3 | 4 | 4 | 11.765 | |
| 5 | 4 | 5 | 6 | 17.647 | |
| 6 | 5 | 6 | 6 | 17.647 | |

11

### $X_{12}$. Motivating

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 3.03 | |
| 2 | 1 | 2 | 4 | 12.121 | |
| 3 | 2 | 3 | 4 | 12.121 | |
| 4 | 3 | 4 | 12 | 36.364 | -Mode |
| 5 | 4 | 5 | 9 | 27.273 | |
| 6 | 5 | 6 | 3 | 9.091 | |

12

# Frequency Distribution by Category

### $X_{13}$: Directing

| Bar: | From: (≥) | To: (<) | Count: | Percent: |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 |
| 2 | 1 | 2 | 3 | 9.091 |
| 3 | 2 | 3 | 4 | 12.121 |
| 4 | 3 | 4 | 11 | 33.333 |
| 5 | 4 | 5 | 11 | 33.333 |
| 6 | 5 | 6 | 4 | 12.121 |

13

### $X_{14}$: Resolving

| Bar: | From: (≥) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 3.03 | |
| 2 | 1 | 2 | 8 | 24.242 | |
| 3 | 2 | 3 | 6 | 18.182 | |
| 4 | 3 | 4 | 6 | 18.182 | |
| 5 | 4 | 5 | 10 | 30.303 | -Mode |
| 6 | 5 | 6 | 2 | 6.061 | |

14

### $X_{15}$: Neg Sup

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 2.941 | |
| 2 | 1 | 2 | 2 | 5.882 | |
| 3 | 2 | 3 | 5 | 14.706 | |
| 4 | 3 | 4 | 7 | 20.588 | |
| 5 | 4 | 5 | 15 | 44.118 | -Mode |
| 6 | 5 | 6 | 4 | 11.765 | |

15

**$X_{16}$: Neg Peers**

| Bar: | From: (≥) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 2 | 5.882 | |
| 2 | 1 | 2 | 1 | 2.941 | |
| 3 | 2 | 3 | 2 | 5.882 | |
| 4 | 3 | 4 | 9 | 26.471 | |
| 5 | 4 | 5 | 15 | 44.118 | -Mode |
| 6 | 5 | 6 | 5 | 14.706 | |

16

**$X_{17}$: Neg Sub**

| Bar: | From: (≥) | To: (<) | Count: | Percent: |
|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 2.941 |
| 2 | 1 | 2 | 4 | 11.765 |
| 3 | 2 | 3 | 5 | 14.706 |
| 4 | 3 | 4 | 8 | 23.529 |
| 5 | 4 | 5 | 8 | 23.529 |
| 6 | 5 | 6 | 8 | 23.529 |

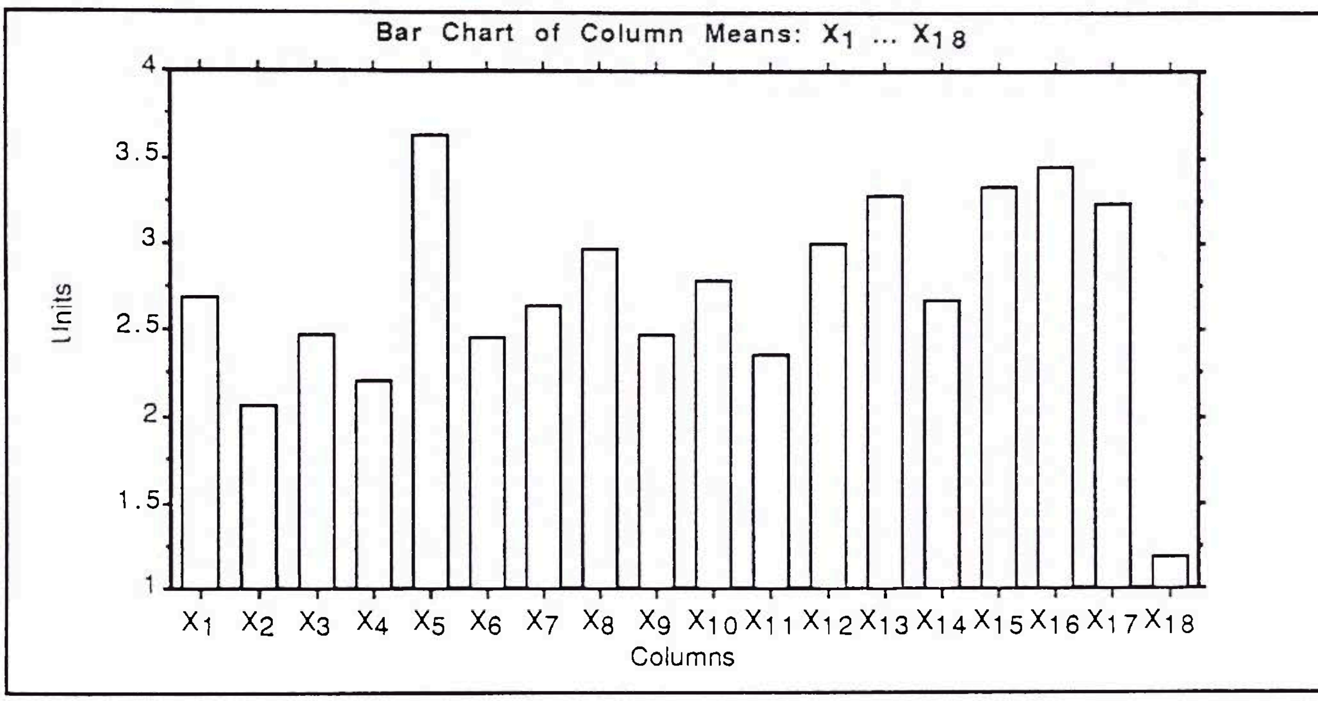
17

**$X_{18}$. Neg Unions**

| Bar: | From: (>) | To: (<) | Count: | Percent: | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 16 | 47.059 | -Mode |
| 2 | 1 | 2 | 9 | 26.471 | |
| 3 | 2 | 3 | 2 | 5.882 | |
| 4 | 3 | 4 | 3 | 8.824 | |
| 5 | 4 | 5 | 2 | 5.882 | |
| 6 | 5 | 6 | 2 | 5.882 | |

18

## Bar Chart of Category Means



Correlation between Categories

| | Name | Grad Year | Non Tech Goals | Tech goals | Strategies |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Grad ... | 1.000 | .143 | .193 | .241 |
| 2 | Non T... | .143 | 1.000 | .517 | .384 |
| 3 | Tech g... | .193 | .517 | 1.000 | .374 |
| 4 | Strate... | .241 | .384 | .374 | 1.000 |
| 5 | Plans | .285 | .231 | .473 | .513 |
| 6 | Non T... | .329 | .353 | .143 | .346 |
| 7 | Tech ... | .118 | .239 | .593 | .187 |
| 8 | Groups | -.084 | .055 | .391 | .202 |
| 9 | R/ships | .037 | .172 | .336 | .285 |
| 10 | Monit... | .205 | .099 | .475 | .161 |
| 11 | Corre... | .181 | .173 | .422 | .241 |
| 12 | Motiv... | -.138 | .127 | .345 | .249 |
| 13 | Direct... | .048 | .270 | .315 | .335 |
| 14 | Resol... | .416 | .197 | .288 | .315 |
| 15 | Neg Sup | -.143 | -.141 | .288 | -.014 |
| 16 | Neg P... | -.050 | -.122 | .308 | -.002 |
| 17 | Neg Sub | .156 | .016 | .250 | .234 |
| 18 | Neg U... | .194 | .192 | .220 | .243 |

Correlation between Categories

| | Name | Grad Year | Non Tech Goals | Tech goals | Strategies |
|---|---|---|---|---|---|
| 1 | Grad ... | 1.000 | .143 | .193 | .241 |
| 2 | Non T... | .143 | 1.000 | .517 | .384 |
| 3 | Tech g... | .193 | .517 | 1.000 | .374 |
| 4 | Strate... | .241 | .384 | .374 | 1.000 |
| 5 | Plans | .285 | .231 | .473 | .513 |
| 6 | Non T... | .329 | .353 | .143 | .346 |
| 7 | Tech ... | .118 | .239 | .593 | .187 |
| 8 | Groups | -.084 | .055 | .391 | .202 |
| 9 | R/ships | .037 | .172 | .336 | .285 |
| 10 | Monit... | .205 | .099 | .475 | .161 |
| 11 | Corre... | .181 | .173 | .422 | .241 |
| 12 | Motiv... | -.138 | .127 | .345 | .249 |
| 13 | Direct... | .048 | .270 | .315 | .335 |
| 14 | Resol... | .416 | .197 | .288 | .315 |
| 15 | Neg Sup | -.143 | -.141 | .288 | -.014 |
| 16 | Neg P... | -.050 | -.122 | .308 | -.002 |
| 17 | Neg Sub | .156 | .016 | .250 | .234 |
| 18 | Neg U... | .194 | .192 | .220 | .243 |

Correlation between Categories

| | Plans | Non Tech Work | Tech Work | Groups | R/ships | Monitoring |
|---|---|---|---|---|---|---|
| 1 | .285 | .329 | .118 | -.084 | .037 | .205 |
| 2 | .231 | .353 | .239 | .055 | .172 | .099 |
| 3 | .473 | .143 | .593 | .391 | .336 | .475 |
| 4 | .513 | .346 | .187 | .202 | .285 | .161 |
| 5 | 1.000 | .459 | .442 | .428 | .410 | .398 |
| 6 | .459 | 1.000 | .483 | .358 | .471 | .535 |
| 7 | .442 | .483 | 1.000 | .746 | .612 | .863 |
| 8 | .428 | .358 | .746 | 1.000 | .699 | .732 |
| 9 | .410 | .471 | .612 | .699 | 1.000 | .630 |
| 10 | .398 | .535 | .863 | .732 | .630 | 1.000 |
| 11 | .307 | .498 | .770 | .658 | .648 | .853 |
| 12 | .298 | .302 | .660 | .449 | .416 | .567 |
| 13 | .345 | .538 | .735 | .543 | .561 | .614 |
| 14 | .421 | .593 | .650 | .434 | .493 | .717 |
| 15 | .126 | -.198 | .198 | .321 | .333 | .216 |
| 16 | .147 | -.049 | .374 | .371 | .386 | .237 |
| 17 | .279 | .262 | .557 | .423 | .534 | .395 |
| 18 | .110 | .377 | .501 | .443 | .319 | .48[illegible] |

Correlation between Categories

| | Correcting | Motivating | Directing | Resolving | Neg Sup |
|---|---|---|---|---|---|
| 1 | .181 | -.138 | .048 | .416 | -.143 |
| 2 | .173 | .127 | .270 | .197 | -.141 |
| 3 | .422 | .345 | .315 | .288 | .288 |
| 4 | .241 | .249 | .335 | .315 | -.014 |
| 5 | .307 | .298 | .345 | .421 | .126 |
| 6 | .498 | .302 | .538 | .593 | -.198 |
| 7 | .770 | .660 | .735 | .650 | .198 |
| 8 | .658 | .449 | .543 | .434 | .321 |
| 9 | .648 | .416 | .561 | .493 | .333 |
| 10 | .853 | .567 | .614 | .717 | .216 |
| 11 | 1.000 | .412 | .614 | .635 | .170 |
| 12 | .412 | 1.000 | .734 | .598 | .305 |
| 13 | .614 | .734 | 1.000 | .701 | .191 |
| 14 | .635 | .598 | .701 | 1.000 | .273 |
| 15 | .170 | .305 | .191 | .273 | 1.000 |
| 16 | .380 | .261 | .304 | .250 | .666 |
| 17 | .509 | .469 | .639 | .347 | .364 |
| 18 | .663 | .255 | .466 | .561 | .264 |

Correlation between Categories

| | Neg Peers | Neg Sub | Neg Unions |
|---|---|---|---|
| 1 | -.050 | .156 | .194 |
| 2 | -.122 | .016 | .192 |
| 3 | .308 | .250 | .220 |
| 4 | -.002 | .234 | .243 |
| 5 | .147 | .279 | .110 |
| 6 | -.049 | .262 | .377 |
| 7 | .374 | .557 | .501 |
| 8 | .371 | .423 | .443 |
| 9 | .386 | .534 | .319 |
| 10 | .237 | .395 | .489 |
| 11 | .380 | .509 | .663 |
| 12 | .261 | .469 | .255 |
| 13 | .304 | .639 | .466 |
| 14 | .250 | .347 | .561 |
| 15 | .666 | .364 | .264 |
| 16 | 1.000 | .643 | .364 |
| 17 | .643 | 1.000 | .363 |
| 18 | .364 | .363 | 1.000 |

## Appendix 5: Survey Results Sorted

**Table Sorting by Most Important**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Developing plans to co-ordinate activities | 1 | 2 | 4 | 4 | 14 | 9 | 3.6 |
| Negotiating with subordinate levels | 1 | 4 | 5 | 8 | 8 | 8 | 3.2 |
| Monitoring people activities | 5 | 5 | 3 | 6 | 9 | 6 | 2.8 |
| Correcting deviations | 8 | 6 | 4 | 4 | 6 | 6 | 2.4 |
| Negotiating with peer level | 2 | 1 | 2 | 9 | 15 | 5 | 3.4 |
| Grouping of work tasks | 2 | 4 | 6 | 8 | 9 | 5 | 3.0 |
| Negotiating with superior levels | 1 | 2 | 5 | 7 | 15 | 4 | 3.3 |
| Directing others | 0 | 3 | 4 | 11 | 11 | 4 | 3.3 |
| Work routines of non technical people | 6 | 4 | 6 | 7 | 6 | 4 | 2.5 |
| Work routines of technical people | 5 | 2 | 7 | 9 | 6 | 4 | 2.6 |
| Reporting relationships | 4 | 7 | 5 | 8 | 7 | 3 | 2.5 |
| Defining goals for technical people | 4 | 7 | 4 | 10 | 6 | 3 | 2.5 |
| Resolving conflicts | 1 | 8 | 6 | 6 | 10 | 2 | 2.7 |
| Motivating others | 1 | 4 | 4 | 12 | 12 | 3 | 3.0 |
| Defining goals for non technical people | 8 | 6 | 5 | 8 | 5 | 2 | 2.1 |
| Negotiating with unions | 16 | 9 | 2 | 3 | 2 | 2 | 1.2 |
| Establishing strategies | 7 | 5 | 6 | 7 | 8 | 1 | 2.2 |

* Not Applicable + Not Important ~ Most Important

## Table Sorting by Mean

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Developing plans to co-ordinate activities | 1 | 2 | 4 | 4 | 14 | 9 | 3.6 |
| Negotiating with peer level | 2 | 1 | 2 | 9 | 15 | 5 | 3.4 |
| Negotiating with superior levels | 1 | 2 | 5 | 7 | 15 | 4 | 3.3 |
| Directing others | 0 | 3 | 4 | 11 | 11 | 4 | 3.3 |
| Negotiating with subordinate levels | 1 | 4 | 5 | 8 | 8 | 8 | 3.2 |
| Grouping of work tasks | 2 | 4 | 6 | 8 | 9 | 5 | 3.0 |
| Motivating others | 1 | 4 | 4 | 12 | 12 | 3 | 3.0 |
| Monitoring people activities | 5 | 5 | 3 | 6 | 9 | 6 | 2.8 |
| Resolving conflicts | 1 | 8 | 6 | 6 | 10 | 2 | 2.7 |
| Work routines of technical people | 5 | 2 | 7 | 9 | 6 | 4 | 2.6 |
| Work routines of non technical people | 6 | 4 | 6 | 7 | 6 | 4 | 2.5 |
| Reporting relationships | 4 | 7 | 5 | 8 | 7 | 3 | 2.5 |
| Defining goals for technical people | 4 | 7 | 4 | 10 | 6 | 3 | 2.5 |
| Correcting deviations | 8 | 6 | 4 | 4 | 6 | 6 | 2.4 |
| Establishing strategies | 7 | 5 | 6 | 7 | 8 | 1 | 2.2 |
| Defining goals for non technical people | 8 | 6 | 5 | 8 | 5 | 2 | 2.1 |
| Negotiating with unions | 16 | 9 | 2 | 3 | 2 | 2 | 1.2 |

* Not Applicable + Not Important ~ Most Important

**Table Sorting by Skills rated Not Applicable**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Directing others | 0 | 3 | 4 | 11 | 11 | 4 | 3.3 |
| Developing plans to co-ordinate activities | 1 | 2 | 4 | 4 | 14 | 9 | 3.6 |
| Motivating others | 1 | 4 | 4 | 12 | 12 | 3 | 3.0 |
| Resolving conflicts | 1 | 8 | 6 | 6 | 10 | 2 | 2.7 |
| Negotiating with superior levels | 1 | 2 | 5 | 7 | 15 | 4 | 3.3 |
| Negotiating with subordinate levels | 1 | 4 | 5 | 8 | 8 | 8 | 3.2 |
| Negotiating with peer level | 2 | 1 | 2 | 9 | 15 | 5 | 3.4 |
| Grouping of work tasks | 2 | 4 | 6 | 8 | 9 | 5 | 3.0 |
| Reporting relationships | 4 | 7 | 5 | 8 | 7 | 3 | 2.5 |
| Defining goals for technical people | 4 | 7 | 4 | 10 | 6 | 3 | 2.5 |
| Work routines of technical people | 5 | 2 | 7 | 9 | 6 | 4 | 2.6 |
| Monitoring people activities | 5 | 5 | 3 | 6 | 9 | 6 | 2.8 |
| Work routines of non technical people | 6 | 4 | 6 | 7 | 6 | 4 | 2.5 |
| Establishing strategies | 7 | 5 | 6 | 7 | 8 | I | 2.2 |
| Correcting deviations | 8 | 6 | 4 | 4 | 6 | 6 | 2.4 |
| Defining goals for non technical people | 8 | 6 | 5 | 8 | 5 | 2 | 2.1 |
| Negotiating with unions | 16 | 9 | 2 | 3 | 2 | 2 | 1.2 |

* Not Applicable + Not Important ~ Most Important

**Table Summary of Results from Question 4**

| Responses | Not App* 0 | Not Imp't+ 1 | 2 | 3 | 4 | Most Imp't~ 5 | Mean |
|---|---|---|---|---|---|---|---|
| Defining goals for non tech. people | 8 | 6 | 5 | 8 | 5 | 2 | 2.1 |
| Defining goals for technical people | 4 | 7 | 4 | 10 | 6 | 3 | 2.5 |
| Establishing strategies | 7 | 5 | 6 | 7 | 8 | 1 | 2.2 |
| Develop plans to co-ord. activities | 1 | 2 | 4 | 4 | 14 | 9 | 3.6 |
| **Mean of Planning** | **5.0** | **5.0** | **4.8** | **7.3** | **8.3** | **3.8** | **2.6** |
| Work routines of non tech people | 6 | 4 | 6 | 7 | 6 | 4 | 2.5 |
| Work routines of technical people | 5 | 2 | 7 | 9 | 6 | 4 | 2.6 |
| Grouping of work tasks | 4 | 4 | 6 | 8 | 9 | 5 | 3.0 |
| Reporting relationships | 2 | 7 | 5 | 8 | 7 | 3 | 2.5 |
| **Mean of Organising** | **4.3** | **4.3** | **6.0** | **8.0** | **7.0** | **4.0** | **2.6** |
| Monitoring people activities | 5 | 5 | 3 | 6 | 9 | 6 | 2.8 |
| Correcting deviations | 8 | 6 | 4 | 4 | 6 | 6 | 2.4 |
| **Mean of Controlling** | **6.5** | **5.5** | **3.5** | **5.0** | **7.5** | **6.0** | **2.6** |
| Motivating others | 1 | 4 | 4 | 12 | 12 | 3 | 3.0 |
| Directing others | 0 | 3 | 4 | 11 | 11 | 4 | 3.3 |
| Resolving conflicts | 1 | 8 | 6 | 6 | 10 | 2 | 2.7 |
| Negotiating with superior levels | 1 | 2 | 5 | 7 | 15 | 4 | 3.3 |
| Negotiating with peer level | 2 | 1 | 2 | 9 | 15 | 5 | 3.4 |
| Negotiating with subordinate levels | 1 | 4 | 5 | 8 | 8 | 8 | 3.2 |
| Negotiating with unions | 16 | 9 | 2 | 3 | 2 | 2 | 1.2 |
| **Mean of Leading** | **3.1** | **4.4** | **4.0** | **7.3** | **9.9** | **3.9** | **2.9** |

* Not Applicable + Not Important ~ Most Important