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An Analysis of the Career Span, Patterns, and Retention Rates of Alberta Engineers

by

Donald Kennedy

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Department of Mechanical Engineering

Edmonton, Alberta
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To my wife, Marina, who married me anyway at a hectic point in my career and studies.

ABSTRACT

This study used multi-method research techniques to examine the value organizations place on the experience engineers gain through their careers. Studies over the past fifty years suggest that engineers may leave their field at an earlier age compared against university graduates of other professions. Analysis of the literature was complicated by the lack of concise definitions for 'engineer' and 'engineering'. An initial study was conducted to test the validity of the published data to the present situation. A sample of 270 past engineering graduates was obtained and traced to the present. The findings supported the trends observed in the published data. No indication was found for a large group of engineers whose retirement would cause an imminent shortage of engineers. Instead, an available pool of freelance and retired engineers could potentially be tapped, if required. A second study was conducted to gain an insight into both the perception of a shortage of engineers and a large group of under-utilized fully trained engineers. Fourteen in-depth interviews were conducted. The results provide insights into the high attrition rates from salaried engineering positions. The work of most engineers was found to have a low correlation with the university engineering programs. Many of the engineers duties were found to not require much technical training. The ability to function in a corporate environment appeared to be of greater value to organizations than technical expertise. There appears to be a barrier to communication between those dealing with the practical side of running organizations and management that deals with control and allocating resources. As engineers gain experience, many expressed a conflict between the assigned performance measures and effective organizational performance. Conformity to established processes appears to have a higher value to these organizations than economic factors. There appears to be little value placed on the experience of mature engineers.

ACKNOWLEDGEMENTS

I hope everyone that has helped me with this work knows that I am truly grateful for their support. I would like to single out Dr. Whittaker by name because I doubt very much that I would have gone this far without his special perspective on engineering management. I hope I have helped him to go out a winner.

I am greatly appreciative of the guidance that all of you have given me.

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CHAPTER 1

DEVELOPING THE RESEARCH QUESTION

1.1 Introduction

In 1971, engineer Gene Dalton was 42 years old and Paul Thompson was 32 (Dalton and Thompson 1971). Their *Harvard Business Review* article reported on their results from studying 2500 engineers in research and development firms. They suggested that Thompson may have been at his peak of productivity as an engineer and Dalton was already ten years past his peak. They expressed concern that their findings "are likely to be quite depressing" (p. 63). Also, the trends over the previous 13 years (1958 to 1971) indicated that the obsolescence of engineers may have been accelerating so that they were peaking at an ever younger age. They noted that the salary of engineers did not peak until their early 40's, but one consequence of this was that the younger, more productive engineers were cheaper and would logically be selected ahead of the older engineers when the opportunity was available. Dalton and Thompson found that in regards to training to maintain competency, "in all age groups, the courses did not seem to help" (p. 64). Many of the engineers they interviewed felt that one "becomes bored after doing the same work for 15 or 20 years" (p. 65) but that moving jobs was not likely when younger engineers were more hireable. The younger engineers also maintained a positive attitude from a promise of reward for good work. However, the older engineers felt there was a significant gap between actual performance and management's assessment to the point that the impact of hard work was likely to be "nothing" (p. 63). Overall, these factors resulted in the older engineers becoming "simultaneously angry and afraid" (p. 60). It should also be noted that Dalton and Thompson concluded that a potential solution for the older

engineers to move into general management is only available to a select few. This is due to a lack of available management positions for everyone and because "engineers are often not prepared mentally or emotionally for this role" (p. 66).

1.2 Current Situation

Over thirty years have passed since Dalton and Thompson published their paper. It makes one wonder if the situation they report is only applicable to the R&D firms they studied at that time or if there is a wider application to engineers in general. Has the obsolescence of engineers accelerated since the early 1970's? Do engineers reach a maximum in usefulness to organizations in their early 30's (or even earlier if the prediction of accelerated obsolescence was accurate)? Is there evidence elsewhere for the decrease in cost effectiveness of engineers as their salaries rise and their usefulness does not? If so, what is the consequence of this to the career of the average engineer?

If the trends Dalton and Thompson observed in 1971 are applicable to a wider scope of organizations that employ engineers, there would be important consequences to current practices involving the engineering profession. Some of these would be on a personal level for the engineers in the system. Better understanding of the nature of engineers' careers would help the individual engineer be better prepared for making long term decisions. However, other more global efforts could be executed more effectively if they were based on a clearer understanding of the factors impacting the results of decisions made.

There is a trend in most of the highly industrialized nations towards an aging population. One of the consequences of this trend is that a major portion of the workforce is reaching retirement age. Many papers have been published over the last few decades calling for preemptive action to mitigate the impact of any impending shortage of engineering talent (for example, see Finn 1991; Stuart and Graham 2003). If the observation by Dalton and Thompson is valid that engineering is a profession for the young, then any impact of baby boomers advancing in age may have already happened in

the engineering field. If engineers in their 50's are significantly less productive than their young counterparts, a shortage of talent in engineering may have already occurred and may have been addressed by industry. Such a scenario would lessen the importance of programs designed to enhance the supply of engineers.

In sharp contrast to the situation of a great number of mature engineers reaching retirement, there is also a perception that there are proportionally lower numbers of senior engineers in large organizations. This has been noted by some engineers in the field (for example, see Smith 2005). Are these observations simply due to chance occurrences at a few organizations that these engineers happen to be in, or is it indicative of the population of working engineers as a whole? In a review of policies over the past two decades, Teitelbaum (2003) states that most of the assertions of current or impending shortages of engineers and scientists have originated from four sources: university administrators, government agencies that finance research, corporate employers of engineers and scientists, and immigration lawyers. These are bodies that gain from the implementation of programs geared to prevent any impending shortage. Teitelbaum notes that most economic indicators suggest that there is no current shortage of engineers and starting salaries have shown a downward trend for these groups over the 40 year time period he investigated.

Other newspaper and journal articles (for examples, see Read 2004; Gray 2005) acknowledge that the Canadian establishment foretells the impending shortage in the engineering (and other knowledge worker) labour supply, but that there is much evidence to refute that claim. One such indicator given in these articles is that mature immigrant engineers are taking low skilled positions. A frequent example given is the recent immigrant who has an M.Sc. in Chemical Engineering but works as a Calgary taxi driver. This is because he is unable to get hired as a professional. Once these highly experienced people arrive in Canada they find the demand for their skills is dramatically lower than their expectations (Vu 2004), but their immigration is still encouraged by the authorities (Brown 2005). The Government of Alberta provided the Bredin Institute with $1.8 million

in the third quarter of 2003 for the purpose of supporting more than 1000 newcomers with professional designations in their efforts to find relevant employment (Government of Alberta 2004). Genai McLeod is employed by the Center for Foreign Trained Professionals in Edmonton Alberta, which is a part of the Bredin Institute. During a conversation with McLeod, she revealed that approximately 80% of these experienced engineers that pass through their coaching program are still not able to find suitable engineering positions, or even jobs relating to engineering functions such as drafting. A potential solution offered in the articles to this problem of under utilization is for the corporate employers to work with the regulators to streamline the professional registration process and to lower the expectations of the hiring reviewers including lowering the requirements for domestic experience. If the situation of a preference by employers for younger engineers as outlined in the introduction is valid, however, these mature immigrant engineers will still have the same problems in getting and keeping engineering work as do the Canadian-born mature engineers whose departure from the system is a potential contributing factor to an impending shortage. Perhaps the skills and experience of these mature immigrants are not even valued by the organizations that hire engineers.

The Canadian system is structured so that the practice of engineering is more highly regulated compared to some other countries such as the United States (Collins et al. 2004). The American model, however, is moving towards an increasing requirement to demonstrate continuing competency in their engineers. Regarding engineers in the United States, Humphreys (2003) states that the registration process should be started while the engineer is still in school because "while still a student the candidate has the greatest possible chance of being successful on the examination" (p.10). Although the salaries of engineers increase with experience early in their careers (Hedden 2004), it seems the engineers are most knowledgeable of the items they need to know to demonstrate competency while they are still in school. Also, once they are practicing in the field they should be gaining skills that are more relevant to their work than many of the concepts

that would be taught in short seminars. The view that direct work is a major source of gaining valuable knowledge is held by many managers and professionals as suggested by Koch (2003). The increasing difficulty that practicing professionals have in demonstrating competence suggests that the tests are not accurately reflecting the skills that engineers actually use. A move towards increased requirements to demonstrate competency as defined by the regulating authorities will increase the pressure on maintaining the supply of available engineers in the workforce since some engineers currently in the system may be unwilling to maintain their competency requirements.

The review of the current situation shows that there are programs in place whose goals have conflicting effects in terms of either increasing or decreasing the supply of engineers in the system. There is one view that there is an impending shortage of engineers that will result from the most experienced engineers leaving the system in large numbers in the very near future. In contrast to this is evidence that there is no shortage of mature engineers and many of these already cannot find work related to their field of expertise. Some other evidence suggests that some of the mature engineers may not possess the levels of competency required to either maintain professional registration or demonstrate the skills desired by employers.

1.3 Research Question

In light of the conflicting views of the situation regarding the current and desired levels of the supply and demand of engineering experience, an important question emerges around the value that employers place on the abilities of the mature engineer. Therefore the research question of this dissertation is:

> "What is the economic value of the experience engineers gain after qualification?"

Specific questions that relate to the situation outlined above or were developed as the study progressed are as follows:

- Of the knowledge gained from experience, what types are more valued by the organizations that employ engineers?
- Should an engineer yield to the pressures to move into management positions or stay on a technical track?
- Do engineers leave the profession at a faster rate than other knowledge workers?
- Is a move to freelance consulting worth the loss of the security promised by a salaried position?
- What roles do engineers perform at work?
- What is the rate at which the knowledge learned at University becomes obsolete?
- Should immigration policy be modified to only encourage young engineers to come in the expectation of working in their field?
- Is there evidence of a large number of practicing engineers nearing retirement that will cause a subsequent shortage?
- Will an injection of money in the form of higher salaries mitigate this potential problem of a shortage of engineers?
- Do continuing competency requirements for engineers simply aggravate the problem of retaining the skilled workforce?
- What type of training will help engineers maintain their competency?
- Will extending the age of retirement beyond 65 help mitigate a potential shortage?

1.4 Significance of the Research Question

The questions raised above are important to engineers who are approaching the midway point of their careers (as reflected by the concerns of Dalton and Thompson when they were at that stage). In addition, gaining an insight to the present situation of the engineering community will have applications for policy makers and managers of engineers. The approach and research methodologies developed here may help future researchers in directing resources for increasing the effectiveness of their studies.

CHAPTER 2

LITERATURE SURVEY

2.1 Introduction

A review of the literature on engineers in organizations provides many insights into the nature of engineers, the work they do and the value placed on the knowledge they accumulate over their career. No study was found however, that focuses on all these factors and the overall impact they have on the profession. By looking at the relevant aspects of each of many studies, indicators can be found that support a number of conclusions. In addition, the literature provided thorough examples of the range of research methods used and their particular applicability to different research questions.

In *To Engineer is Human*, Henry Petroski (1992) relates the anxiety he faced as a student in engineering. He recognized that his understanding of the concepts was not complete and he seldom managed to complete assignments without some error. The responsibility of not endangering the public with a faulty design was troublesome to Petroski. He states that he postponed that anxiety by delaying working and attending graduate school. If the situation is valid that the less experienced engineer may actually be the one preferentially selected for engineering work, it would seem that such a system would only increase the anxiety as expressed by Petroski.

2.2 Previous Work

In the late 1950's, Pelz and Andrews (1976) performed their classic study on the factors that influence productivity in knowledge workers. Part of their work involved researching the relationship between age and performance in a variety of research intensive

organizations. They used a variety of techniques but the bulk of their data collection was based on answers to questionnaires. Their participants were generally classified as Ph.D. scientists, assistant scientists and engineers. For the engineers, they noted that productivity appeared to drop off sharply when they reached their late 40's. However Pelz and Andrews also noted in passing that "because of the very few persons aged 50 and up among engineers and assistant scientists, correlations in these subgroups will be unstable" (p. 203). This was despite the fact that engineers of all ages represented about half of the 1300 participants. They reported no information on the reasons for the lack of mature engineers in the organization other than to note that "it would have been necessary to compare ...[those] who had left with those who stayed; and we had almost no information on the former" (p. 193).

Combining these observations by Pelz and Andrews with the study on obsolescence by Dalton and Thompson, one can wonder if the lack of older engineers in the one case may be related to the acknowledged lower cost effectiveness of that same group as stated in the other case. Also, was the acceleration in the age of obsolescence predicted by Dalton and Thompson realized in 2005, and if so what are the observable indications of the current status either way? Were Dalton and Thompson correct in their observation that there are not enough management positions in these organizations to accept all the engineers that are leaving the technical area, or are the engineers simply being promoted to better paying positions where they are more hidden from the younger engineers' view?

Frederick Herzberg was a psychologist who contributed to the body of knowledge in management by performing work studies (Merit 1995). Herzberg et al. (1959) present their important findings on the dual nature of motivators and demotivators in *The Motivation to Work.* It is interesting that a major portion of their earliest studies was performed on engineers. Interviewing engineers proved to be particularly effective for data collection. As they state,

> *In our first study we talked with clerical and production workers as well as professional and managerial people. We discovered that the professional and managerial groups were more verbal, showed a quicker grasp of the technique, and gave more and better delineated sequences of events than the clerical and production groups.* (p.32)

plus,

> *The second pilot study was restricted to managerial and professional people. On the basis of our experiences in this work, we decided to concentrate in the major sample on engineers and accountants. It was apparent in the results of this second pilot that engineers were able to give exceptionally vivid accounts of their work experience. Since our study was still in the nature of an exploratory project, it was vital to us that we mine where the metal was richest.* (p.32)

and finally,

> *Last, by covering accountants and engineers, we examined the job attitudes of two of the most important staff groups in modern industry.* (p.32)

Herzberg et al. consider in-depth interviewing to be a preferred method of data collection. This was in part because taking one person at a time out for an interview of about an hour in duration was seen to have a much lower organizational impact than long-term direct observation of the group. Since the research group under Herzberg was not clear at the outset on what they would find or what exactly they should focus on, it was felt that semi-structured interviews would provide the flexibility and depth required to properly study motivation. Semi-structured interviews continue to be widely used in Engineering Management research, as will be developed further in the section on methodology.

Herzberg developed the two-factor theory, whereby the factors that create job satisfaction and motivation are not related to the factors that create dissatisfaction. Based on follow-up works, the two-factor theory presented in *The Motivation to Work* created

considerable interest (both positive and negative) in the fields of management studies and psychology. Herzberg (1976) indicates that this includes a hostile reaction to his study from a small but "very vocal and persistent" (p. 245) circle of critics. Herzberg (1966) also states that the 1959 work was incorrectly seen by some as a potential for unlimited benefit to organizations. As Herzberg points out:

> *The fact is that the increase in profits that the psychologists can effect at any one time is slight in comparison with the effects of the engineers, marketing experts and sales department.* (p. viii)

Herzberg is acknowledging that the economic impact of morale may be too insignificant to be measured when compared against the fundamentals of the business such as the design of the facilities, the skill of the sales personnel and the market campaigns promoting the product. Still, Herzberg felt the morale of employees was paramount for more ethical than economic reasons.

Although the morale of the worker may not be an important factor for achieving profits, Herzberg states that, even in 1966, there was a recognized shortage of talent. Advertising mogul David Ogilvy (1966) expresses the concern that the shortage of talent can be due more to management action than an actual shortage of supply:

> *The business community wants remarkable advertising, but it turns a cold shoulder to the kind of people who can produce it.* (p. 27)

Although Ogilvy is addressing specifically the advertising business, the idea that management actions may actually contribute to the problems they identify is a recurring theme in a variety of works such as those of W. Edwards Deming (Gabor 1992) or Tom Peters (Barker 1994). Herzberg (1966) restates the problem identified by Ogilvy by noting that any shortage of talent is likely actually due to the under-utilization of the available talent. Herzberg views the history of work careers as a "history of human waste" (p. 176).

This waste is stated to result from the scientific design of job tasks to accommodate the lowest skill level of any employee expected to be encountered in that position.

Parkinson (1960) argues that organizational directed attempts to reduce waste are counterproductive, and the development of procedures to address productivity actually leads to a level of bureaucracy greater than the original inefficiency. The difference between the expected and realized levels of improved performance in engineers through the development of procedures manuals is dealt with in detail by Kennedy and Whittaker (2000). These documents are often written in response to a desire by organizations to lessen their dependency on the tacit knowledge of a few experts. The procedures manuals typically deal with the detailed aspects of how the engineer is expected to perform their tasks. An example of a typical section is one that deals with how to prepare a procurement document, who should sign it, what factors need to be considered and how many copies are required and where they are sent. Using semi-structured interviews of engineers in industry, Kennedy and Whittaker discovered that procedures manuals are often deemed to be highly valued by management and can cost the organization in excess of $200,000 to produce. However, they are often not written, or even influenced, by the people that actually know how to do the work. Further, the benefit of such documents is largely under-realized because the manuals are seldom looked at by the intended audience after distribution. There are many factors that contribute to the low usage of the documents, including organizational or procedural changes that may occur between writing and distribution. If the experience of the engineer is captured in a document that is not looked at again, the newly created explicit knowledge must actually be of limited realized value to the organization.

By 1976, Herzberg recognized a growing dissatisfaction within the ranks of employees. The drive towards more standardization within the workforce continues and therefore there is a resulting decrease in the ability to express individuality. This has produced an increase in the rate of rejection of certain jobs as being unacceptable. It is

possible that a highly proceduralized job description may be responsible for producing a job that is seen to be boring to engineers who are expecting the anxiety (as expressed by Petroski) from the potential consequences of their errors. Whereas there may have once been a strong sense of duty towards the organization, this was seen by Herzberg to be eroding even 30 years ago. A greater erosion was then seen to be one of the results of the re-engineering movement (Ciulla 2000).

The study that is now referred to as the Hawthorne Experiment covered a span of about 6 years at the Western Electric Hawthorne Works in Cicero, Illinois (Roesthlisberger and Dickson 1964). After a refinement of the participating members in the famous Relay Assembly group, the Hawthorne researchers were able to get a 16-month period during the boom of the late 1920's where the workers' productivity increased, apparently independent of the controlled experimental conditions. In the case of this Relay Assembly test, the varying experimental conditions related to the length of the workweek and the introduction and duration of breaks. It must be noted that subsequent trials conducted by the same research team, performed with a highly skilled Mica Splitting group and a second Relay Assembly group, did not produce favorable increases in production. The researchers did recognize that the negative impact on morale from the onset of the Great Depression likely overshadowed anything they were doing in the test rooms. They did not, however, note any potential for the opposite impact of the economic boom during their earlier experiment. The 6 years of the Hawthorne experiments are usually refined down by modern writers to reflect a simplified conclusion based on one part of the experiment and, in particular, the earlier Relay Assembly test. For example, Frederick (2001) defines the Hawthorne effect as the following:

> *Workers improve their productivity when they believe management is concerned about their welfare and assign them particular attention.* (p. 36)

Comments made by the first Relay Assembly test participants, however, indicate that they attributed their increased productivity to their freedom from constraint and supervision.

One of the workers, who replaced a less cooperative one and became an informal leader of the group, explained their successes by boasting, "We don't have any boss" (Roesthlisberger and Dickson 1964 p. 86).

The management of engineers appears to be more successful when the engineer is recognized as belonging to a distinct group of knowledge worker. In the original studies performed by Herzberg et al. (1959), they found that the dissatisfiers they identified were equally effective at producing low morale across all sectors of the work force. Still, Badawy (1978) notes that there are many factors in the management of organizations that are particularly demotivating for engineers. First is management's general failure to acknowledge either the distinction between engineers and skilled labourers or between engineers and other technical professionals. Badawy states that the engineers' salary impacts the self-esteem of the junior engineers who may be paid less than the labourers they direct. A finding in the Hawthorne experiments was that the absolute salary level is not demotivating on its own, but is so only when compared in relation to others' salaries coupled with a perception of lack of fairness (Roesthlisberger and Dickson 1964). Badawy states that unlike engineers, scientists are often motivated by the ability to contribute to the public body of knowledge in their field. Management's perception of engineers as scientists may cause a lack of opportunity for the engineer to achieve their more common goals of financial and organizational achievement. Badawy also notes that a potential source of dissatisfaction in engineers is when management techniques are applied to them that are more suitable for controlling scientists. (For further evidence of confusing scientists and engineers see Page (1998); Keller (1997); Schriesheim (1977); and Badawy (1971)). It may be possible that the confusing of engineers with scientists is contributing to the conclusions that lead to misinterpretation of statistics such as age distribution within the workforce and the potential for the impending shortage outlined earlier.

A second area Badawy sees as demotivating to engineers is the general lack of competency in the management of that group. The promotion of someone to management

based on their technical skills is a typical move in keeping with the Peter Principle (Peter and Hill 1970). This principle holds that a promotion is generally based upon the skill and ability the worker displays in their current job, not upon any valuation of the worker's potential for their new job. This continues until the worker is incompetent in their current job and their career stalls. Although it is generally recognized that many engineering careers end up with roles in management, Badawy states that the evidence suggests that engineers, as a group, are ill equipped for such moves. This is consistent with other authors cited earlier. Engineers expect the manager to be as competent at management as the technical professionals are in their fields. Badawy explains that engineers were found to also resent reporting to non-professionals who may have better management skills than an ill-prepared professional. Both types of managers can "turn-off" (p. 39) some engineers by implementing controls aimed at measuring engineering productivity. The work of Zhou (1998) would tend to indicate that, given the multi-faceted nature of the tasks engineers perform and the often short durations (measured in minutes) of their activities, even a meaningful measure of the definition of engineering productivity would be difficult to develop.

Badawy states that the greatest demotivator of engineers is in the area of the tasks that make up the actual work. It is very typical for the engineer to perform many duties which could be equally well handled by someone with fewer technical qualifications. Engineers also often fail to see where their tasks contribute to the overall success of the organization. Engineers turn to their direct supervisors for personal recognition of achievement as opposed to seeking any recognition of compliance to the wishes of management. There appears to be a strong indication that engineers are "underemployed, underutilized and misutilized" (p. 40) which echoes Herzberg's comments. Badawy states that the dual career path between technical and managerial positions has been usually offered to engineers, but that these have never effectively eliminated the bias towards the management roles. Moravec (1991) states that an organization's focus on the managerial

career track often leaves the technical track with a low ceiling. The higher status of the managerial track tends to pressure the technical workers to either take a position they may not want, accept that their careers have stalled, or simply choose to leave the company. Moravec adds that the emphasis on management over individual contribution tends to diminish the entrepreneurial spirit within the company. Although they offer a multiple path scenario as a possible solution, Leibowitz et al. (1992) note that attempts to promote the dual career path as a viable strategy have generally failed to achieve the intended outcomes. Problems occur because the managerial positions typically come with higher pay, the technical positions serve as a dumping ground for ineffectual managers, and the technical positions lack the mechanism, authority or power to adequately influence company strategic decision making.

Some researchers have reported a sharp decline in employee loyalty following lay-offs. An example of increased termination levels is one consequence of the re-engineering craze that peaked around the early 1990's (Lee 1997). Spreitzer and Mishra (2002) found that the impact of downsizing is not very significant on the motivation of those surviving employees who were less committed to the organization to begin with. More importantly, those surviving employees who were highly committed to the organization prior to the downsizing can respond in very dysfunctional ways. Spreitzer and Mishra emphasize that this decrease in commitment occurs at a time when the organization has the most need to benefit from these people's leadership. Ciulla (2000) observes that Scientific Management may have produced a feeling in workers that they are being treated like replaceable parts, but reengineering instilled a feeling that they may now be obsolete parts. Butyn (2003) notes that some organizations can become aware of the potential difficulties that may follow from the loss of knowledge capital when their workers choose or are asked to leave at an earlier age. In one particular case reported by Butyn, the organization implemented a formal mentoring program as a way to transfer the tacit knowledge contained in the mature workers. The company did not notice any significant benefit from increased

knowledge in the younger workers, but the goal of knowledge retention was achieved through the greatly reduced attrition rates of the mature workers who now felt more useful and recognized. In a study of setting up a trial mentoring program with university students and industry, Dutton (2003) states that quantifiable benefits to the organizations were difficult to determine. Most interest by the participants focused on cultural norms and fitting in, rather than knowledge transfer of valuable insights.

McGuire (1982) notes that most of the managerial theories promoted by the behaviorists have had no noticeable negative effect on the economic health of organizations and "have probably made the work environment more pleasant, at least" (p. 35). Having a fulfilling and enjoyable second half of a career is of utmost importance to an engineer entering that stage of life. It is important to the motivation and happiness of the engineer to know that there is value in the contributions to be made based on the experience they have gained. It is possible that few studies have been conducted on the nature of an engineer's career because of a low utilization of qualitative research techniques within the engineering management field. In 1973, Henry Mintzberg published *The Nature of Managerial Work.* This is now considered a groundbreaking work (Merriden 1998) because Mintzberg demonstrated that managers do not follow the practices that the management textbooks state they do. In a follow-up article, Mintzberg (1990) expressed concern that his work did not lead to a new area of study to build on what he considered his preliminary findings:

> *Perhaps my greatest disappointment about the research reported here is that it did not stimulate new efforts. In a world so concerned with management, much of the popular literature is superficial and the academic research pedestrian. Certainly, many studies have been carried out over the last 15 years, but the vast majority sought to replicate earlier research. In particular, we remain grossly ignorant about the fundamental content of the manager's job and have barely addressed the major issues and dilemmas in its practice.* (p. 175)

Galbraith (1974) notes that although management gets much of the attention in the research, it is a small part of the driving force within a modern organization. Engineers play a large role in the group that contains the knowledge that ultimately directs the formation of the decisions that truly run the organization. Galbraith referred to this larger group as the technostructure. A better understanding of key players of this technostructure would lead to a better understanding of business as a whole. Both Mintzberg and Galbraith note the lack of information on the fundamental elements of modern organizations at a formal level.

Finn and Baker (1993) report that long term shortages or surpluses in skilled workers are difficult to predict and most models look at changes in university enrollments and simply assume a constant demand. They state that the best indicator of a shortage in a particular discipline is the starting salary of the graduate in that field. They claim that over the past 40 years, the system of supply and demand has been shown to work and that people entering college will be influenced in their career choice by the starting salaries at the time of entry. However, this does create a 4 year lag in the response to a shortage of fields such as engineering, so that upon graduating, the students may enter a very different market than when they started school.

2.3 Summary

The review of the literature did not yield any studies that were specifically concerned with the value employers put on the experience an engineer gains. However, the review does lead to the following concepts that helped guide the methodology of this dissertation:

- Engineers are a distinct sector of the labour force with their own characteristics. Therefore, they need to be understood as a distinct group in order to effectively manage them.

- Engineers generally possess a high awareness of their employment situation and how they relate to their working environment. A study of engineers can be conducted successfully by directly asking them for insights.
- Semi-structured interviews have proven to be effective for building the basic concepts used in engineering management.
- Human systems are complex. In order to obtain a broad understanding of situations, in-depth analysis is required to augment quantitative studies in the area.
- Morale may not be of significant importance to the profitable operation of an organization. Morale of engineers is significant to the engineers on a personal level. Workplace ethics suggests improving employee happiness may still be a justifiable basis for conducting research.
- Management shares in the responsibility for creating and maintaining circumstances that produce results they may actually not be satisfied with. Their intended outcomes may be very different than the situations they create.
- Many engineers may have low morale in part because of the methods used to directly supervise them.
- There has been a downward shift in the loyalty from individuals in organizations following the programs implemented by management over the past decade.

If there is a shortage of engineers, it may be simply a shortage of engineers that are willing to receive much less in salary than a more mature person would demand. Is the shortage of engineers due to a progression into management resulting in gaps to be filled from below, or is it due to the more expensive workers leaving the system to be replaced by the more cost effective younger people? If the engineer reaches the peak of performance around 30 years of age, there is little economic sense to paying more for someone that is older, but equal at best. If this is the case, any shortage of engineers may potentially be resolved by

prolonging the careers of those currently working or returning those experienced workers back into the system. This may simply involve putting more money into wages but could potentially require satisfying needs for authority, loyalty, and fulfillment.

CHAPTER 3

APPROACH TO THE RESEARCH QUESTION

3.1 Research Goals and Methodologies

In order to properly study the question of "What is the economic value of the experience engineers gain after qualification?" and the more specific follow-up questions that were outlined earlier, a systematic approach was developed. In the study of complex systems, many studies have found that a multi-method approach was successful for examining the different facets under investigation. Davey and Arnold (2000) used a combination of quantitative and qualitative methods to study the impact of change on graduates entering the workforce. Ghoshal and Bartlett (1988) also used multiple methods to study the adoption of innovations in multi-national organizations. For this type of research, the output is not a single quantity that defines the system being studied, but rather a depth of knowledge that accounts for the complexity of social systems. The findings of such studies are often generalizations that apply to certain sectors of the study population, but may not be universally applicable given the diverse preferences of the individuals that make up organizations. For this dissertation, the first step was establishing the context and definitions of terms. Then, in order to establish the current situation and determine the relevance of the Dalton and Thompson findings to today, more recent publicly available data was analyzed. Next, available data relating to the career paths of engineers was reviewed to determine if engineers are significantly different from other groups of knowledge workers and if engineers experience an employer bias towards younger members, as was suggested by Pelz and Andrews forty years ago. Then, a field study was designed and conducted to validate the findings of the data analysis (the 'What' Study). Finally, a

second field study was developed to study the factors contributing to the observed trends (the 'Why' Study). From this, the value of an engineer's experience was determined along with its impact on the career paths an engineer may experience.

3.2 Definition and Discussion of Terms

The definitions of terms used in this study are as follows:

Study Population: The population under consideration is engineers in the Province of Alberta, Canada.

Engineer: The definition of an engineer shall be the one promoted by the Panel on Infrastructure Diagraming and Modeling (Commission on Engineering and Technical Systems 1986) (hereafter referred to as the CETS Panel) which is as follows:

> *[An] engineer [is] a person having at least one of the following qualifications: college / university B.S. or advanced degree in an accredited engineering program; membership in a recognized engineering society at a professional level; registered or licensed as an engineer by a government agency; current or recent employment in a job classification requiring engineering work at a professional level. (p. 11)*

In 1986, the U.S. Commission on Engineering and Technical Systems issued a report on engineering infrastructure dynamics in the United States. The report was the work of a group called the Panel on Infrastructure Diagraming and Modeling. According to the report, the group encountered considerable difficulty in the early stages, largely due to the controversy and emotionalism they encountered over attempts to define the term engineer. Every engineer has their own definition of 'engineer' but it may not be consistent with that of the

next engineer. The panel members felt that a major accomplishment derived from their work was simply reaching a consensus on a working definition of an engineer. The definition was reviewed and accepted by members of the National Research Council, the Committee on the Education and Utilization of the Engineer, and the National Society of Professional Engineers. The panel recommended that the definition they agreed upon should be used by all future researchers studying the engineering community. Since the report recounted considerable difficulty in reaching consensus on the above definition, further refinement would likely require resources beyond the scope of this project. Therefore, the population for this dissertation consists of people that meet the definition of engineer as outlined above. Under this definition, it holds that a person with an engineering degree is an engineer, regardless of their current employment status or job duties.

It will also be noted at this time that the definition of an engineer as presented above was indeed successfully used by researchers such as Florman (1987), Zhou (1998) and Whittaker (1999). It should further be noted that there were instances during the development of this dissertation when proposals were forwarded by stakeholders concerning the need to further refine the definition of engineer. Observations made during meetings on the development of this dissertation indicated that when the definition of engineer was discussed, there was a potential for considerable expenditure of resources on the topic without any indication of resolution. Concerning only North American engineers, Meiksins states in the book *Engineering Labour: Technical Workers in Comparative Perspective* (1996) that "the term 'engineer' covers so wide a range of experiences as to be virtually meaningless" (p. 92). The potential problem of discussing the definition of engineer without reaching a consensus highly mirrors the one the U.S. Commission on Engineering and Technical

Systems found themselves in. This is the type of situation this commission strongly recommended against pursuing without the understanding that it will be a difficult and complicated undertaking. Instead, they recommend that their definitions "be accepted by the engineering community" (CETS 1986 p. 4) and be used by all organizations involved in research activities.

Engineering: The 1986 report by the CETS Panel also defined engineering. The panel concluded that there was less contention over what engineering work entailed than there was over who was entitled to be classified as an engineer. The definition they proposed is as follows:

> *Engineering: Business, government, academic or individual efforts in which knowledge of mathematical, physical and / or natural sciences is employed in research, development, design, manufacturing, systems engineering, or technical operations with the objective of creating and / or delivering systems, products, processes and / or services of a technical nature and content intended for use (p. 11).*
> *The functions of engineering extend from research through technical operations and include direct management of technical or engineering activity but do not include general management or such support functions as purchasing or sales (p. 9).*

It should be noted here for further clarification, that by assuming the working definitions provided, people can be defined as engineers and simultaneously be doing work that is defined as not being engineering. This is directly appropriate from the definitions provided by the Commission on Engineering and Technical Systems and was understood by them to be the case. A number of examples of jobs were flagged by this project's committee as being uncertain whether they were indeed engineering positions or not. A panel of five engineers from

industry, each with more than thirty years experience performing engineering as defined above, was convened. Without being provided with the working definition of engineering developed by the Commission on Engineering and Technical Systems, the panel of five engineers were asked if the people in these positions were doing engineering. There was surprisingly little discussion on the examples before answers were provided. The consensus of the panel was in agreement with the working definition in every instance.

APEGGA: The Association of Professional Engineers Geologists and Geophysicists of Alberta (APEGGA) is the body that regulates the practice of engineering in the Province of Alberta. Individuals practicing engineering within the jurisdiction of Alberta must maintain their membership with APEGGA. By law, APEGGA has the exclusive use of the term 'engineer' (Government of Alberta, 2000). A review of the association's website shows that in the late 1990's a program was being developed to demonstrate that the membership was maintaining their competency throughout their careers. The movement was seen as a pro-active measure to prevent direct legislative changes, which were seen to be less preferred than keeping the issue within the control of APEGGA. In conversations with board members of APEGGA committees, it was stated that the issue of evaluating competency of an engineer would be very difficult to address. For this reason, the association adopted a mandatory Continuing Professional Development (CPD) program, whereby the members were required to demonstrate that they were engaging in activities that would lead to continuous learning. Engaging in life-long learning was seen by the profession to be a surrogate indicator that the member was maintaining their competency. A member that is employed full time fulfills over 60% of the minimum annual CPD activities simply by working in an engineering area.

Career: The career of an engineer will be defined by the sequence of work duties the engineer performed at different stages of life, following meeting the criteria of being defined as an engineer using the above definition. Under these definitions as selected, the experiences of a farmer who holds an engineering degree would be included as data.

Experience: According to Davenport and Prusak (2000), experience refers to what we have done and what has happened to us in the past. The value in modern organizations is contained within the knowledge of the employees that has been obtained through experience. In knowledge intensive organizations, the value is less contained in the data and information available explicitly, and more entrenched in the experience based insights contained within the minds of the workers. Experts are people with a deep knowledge of a subject that is strengthened through experience.

Leaving engineering: Due to the potential controversy and confusion over what constitutes engineering, a distinction was made on the aspects of what constitutes leaving engineering. The results of this study were differentiated between those engineers that leave the profession because they no longer work at any job, those that are promoted out of engineering as an expected consequence of their career, and those that choose to pursue other opportunities in external organizations that are clearly not engineering.

Freelance engineer: In this paper, the term 'freelance' shall be used to distinguish those engineers who are members of the contingent workforce but do not have an employer / employee relationship with any organization. Without the qualifier 'freelance,' the term 'consultant' will be used to denote those engineers who provide temporary services but may be employees of a service company. This second relationship is common where operating companies enter alliances with Engineering Procurement and Construction (EPC) firms to alleviate the

cyclic nature of seasonal demands on their own employees (Zhang and Flynn 2003).

3.3 Implications of the Definitions Used

The confusion around the definition of the term engineer creates problems in comparing the results of different studies because it may be unclear who exactly is being studied. In Canada, the professional associations continue to try to limit the practice of engineering to registered members of the provincial associations. They are often not successful, but other times practitioners continue performing the same duties, but change the title on their business card to exchange the word engineer to another similar word, such as design specialist, or process consultant (Piper 2000). Within the employer company, such people will likely maintain their jobs in the engineering department and be performing duties indistinguishable from the engineers. They may even be called engineers by others within the company. In studying the careers of engineers, the confusion over who is an engineer and what constitutes engineering was accommodated for in the methods used in the field studies of this dissertation.

Pelz and Andrews (1976) noted that their methods of distributing questionnaires to the engineers within the research and development organizations prevented them from finding out any useful information on the engineers that had left these organizations. Drucker (2003) comments on the failure of many researchers in missing many of the important aspects of their topic by only studying the individuals that are within the organization. Drucker feels that it is often more important to find out why the majority of individuals are not within a system, than to continually refine the characteristics of the minority of ones that are already better known.

One of the challenges of the Knowledge Management initiatives is to democratize knowledge so that less skilled (lower cost) people can perform the tasks that previously required (higher cost) experts (Davenport and Prusak 2000). One of the ways this is

attempted is to formalize and document the knowledge contained within the mind of the experienced individual and make it available to all. The advance of the internet has already made some professions like law and medicine less dependent on the memorization of details that can instead be searched quickly, but this also allows the untrained to access the same information (Lewis 2001). One of the roles of an engineer is to act as collector and historian for the organization (Whittaker 1999). The easy access of information through an electronic distribution system may further reduce the importance of the experience of a mature engineer.

Engineering (as well as many other fields that deal in the more abstract) involves the use of some terms that are used on a daily basis but do not have clear and universally accepted meanings. As an example, one of the participants in the study for this dissertation was developing a work plan for a $100 million project. For one step of the work plan, he had to assign the responsibilities for preparing the P&ID's. These are standard drawings used in a variety of industries to describe the process flow and control of facilities (Ingebrigtsen 2004). This engineer had 33 years experience directly dealing with project management and design work that often began with the production of a P&ID for any given assignment or project. When the engineer began to draft the current planning document, he realized he did not know what to put for the full wording represented by the initialization P&ID. According to one article in *Mechanical Engineering* (Dyche 2000), P&ID stands for 'Piping and Instrumentation Diagram.' According to another article in a different issue of the same journal (Deitz 1997), P&ID represents 'Process and Instrumentation Diagram.' Further, Gips (2003) refers to"process and instrument drawings" (p.62) and Withered and Hahn (2000) refer to "piping and instrument drawings" (p. 139) The participant in this study stated that any attempt by him to pick one definition of P&ID and incorporate it within his document would lead to negative comments by those engineers that believed a different definition was appropriate. This would then evolve into unproductive discussions over which definition should be used. He

also stated that perhaps a consensus would eventually be reached but it would last only until the next time such a document was produced. He stated that engineers are able to move beyond unimportant items such as the definition of P&ID and focus on the work at hand, the actual production of the P&ID. In the end, he just used the term P&ID in his plan without further clarification since everyone receiving the document had their own working definition of the term and knew what to do with the instructions once received, anyway. The important message was communicating who was doing what, not how to do it or to explain the concepts involved. All definitions are similar enough to not require further clarification to avoid undesired consequences through misinterpretation.

In his highly successful book, *The Structure of Scientific Revolutions*, Kuhn (1970) states that scientists, and the scientific methods they use for research, are well suited for solving problems that are of interest only to other scientists at a more academic level. He notes that fields with more complex and practical systems, such as engineering, medicine and theology, are driven to solve problems that are more needed but may have solutions that are difficult to reach. For this study, the assumption has been made that engineers are able to deal with complex ideas and can work with results that may cause scientists or other more academically oriented professionals to become paralyzed over the initial definitional matters. The results of this study are aimed at increasing the knowledge of the practicing engineer and those that may influence the management of engineers. Therefore, the focus is on the important consequences of the study and less on simple replication of previously published work. The definitions used in this study were developed in a manner that allowed the research to be focused and consistent. It is accepted that another study at another time could use definitions that may differ.

CHAPTER 4

ANALYSIS OF AVAILABLE DATA

4.1 Salaries

The October 2001 edition of the PEGG, the newsletter for the Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA) contains a detailed salary survey of its members. The association obtained this information from the Human Relations or other central departments of 83 companies in Alberta that hire the engineers. In 2001, these companies submitted information on 6,030 employees they consider engineers. This is 1/5th of 32,500, which is the number of registered engineers in the province for 2001. For the data submitted, 3,314 responses (slightly more than half) included information on the year of graduation as part of the data. This then represents approximately 10% of the total engineering population of Alberta. The numbers of people in the surveys submitted by the firms are relatively consistent year over year, but in 2001 APEGGA made more details publicly available than in other years. The 2001 data included numbers of engineers by year of graduation, for the employers that submitted that information. The published data was amalgamated with similar surveys conducted between 1997 and 2004. The overall trend in salaries was then compared with the results presented in the Dalton and Thompson (1971) article. The salaries were adjusted to allow for inflation using the Consumer Price Index as provided by Statistics Canada workers Logan and Pearl (1996). The age of the APEGGA members was taken to be 22 years of age at the time of graduation. (This assumption will be shown to have an acceptable tolerance of error in later sections.) The comparison is presented in Figure 4.1. Dalton and Thompson reported their salaries as averages, so this statistic was used for the APEGGA data as well.

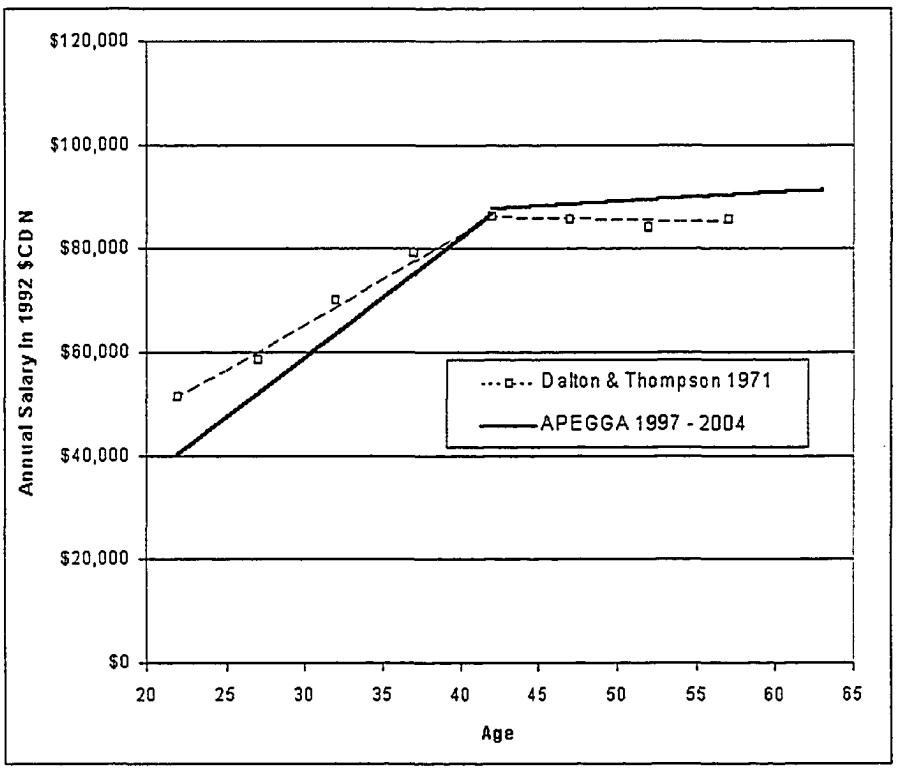

Figure 4.1: Comparison of average salaries reported in Dalton and Thompson (1971) and the APEGGA salary surveys.

A review of the distributions of salaries as presented from the APEGGA data showed that the median salaries and average salaries for any group did not differ by more than +/-2%. Therefore no significant difference in trends would be obtained by using either the average or median salaries for the groups presented. Given the snapshot shown in Figure 4.1, it appears that the salary of the professional members increases more or less steadily at a rate of about $2,000 (in 1992 CDN dollars) a year for about the first half of their careers.After that, the increase is much slower (less than $1,000 a year) and there appears to be an actual decrease in salary for the engineers in the Dalton and Thompson study. It should be noted that the trend is approximately the same for the two studies with the plateau in salaries occurring at around 43 years of age. This implies that the increase in the rate of obsolescence predicted by Dalton and Thompson is not noticeable in the

salaries paid 30 years after their work. It is however, interesting to note that the beginning salaries of the engineers in the newer data are lower than that of the older study and that the final salaries of the mature engineers are higher under the newer data. This was also reported over the 40 years investigated by Teitelbaum. The implication is that the effects noted by Dalton and Thompson of younger engineers being seen as equal in ability to the more mature engineers and being cheaper at the same time would be even more significant now than 30 years ago.

4.2 Age Distribution of Knowledge Workers

4.2.1 SESTAT Data - College Graduates

As noted earlier, it is widely held that the current general population of North America is undergoing an increase in the average age and that this trend will have a beneficial impact on the demand side for employees in the workforce (again see Stuart and Graham 2003). SESTAT (2004), a division of the American National Science Foundation, performed 148,932 interviews of college graduates identified in the 1990 American federal census. The interviews represent about 0.7% of the total population of 21,000,000 workers with college degrees in the United States in 1990. From their interviews, SESTAT developed tables of data that contains information relating to the age of this workforce. The total list of all types of degrees considered by SESTAT and their relative proportion of the total appears in Appendix A. A graph was developed from the SESTAT data to illustrate the distribution by age of 100 representative college degree holders working full time in 1990. The result is shown in Figure 4.2. As can be seen, there is a peak that resembles a wave of workers, dropping off drastically at the age of 45. This represents the leading edge of the baby boomers in 1990. The same analysis comparing the 12,975 elementary school teachers reported by SESTAT against the age profile of all degree holders, is shown in Figure 4.3. The elementary school teachers were selected for this discussion because they represent a workforce of similar size to that of engineers, namely 12,975 teachers compared with 11,329

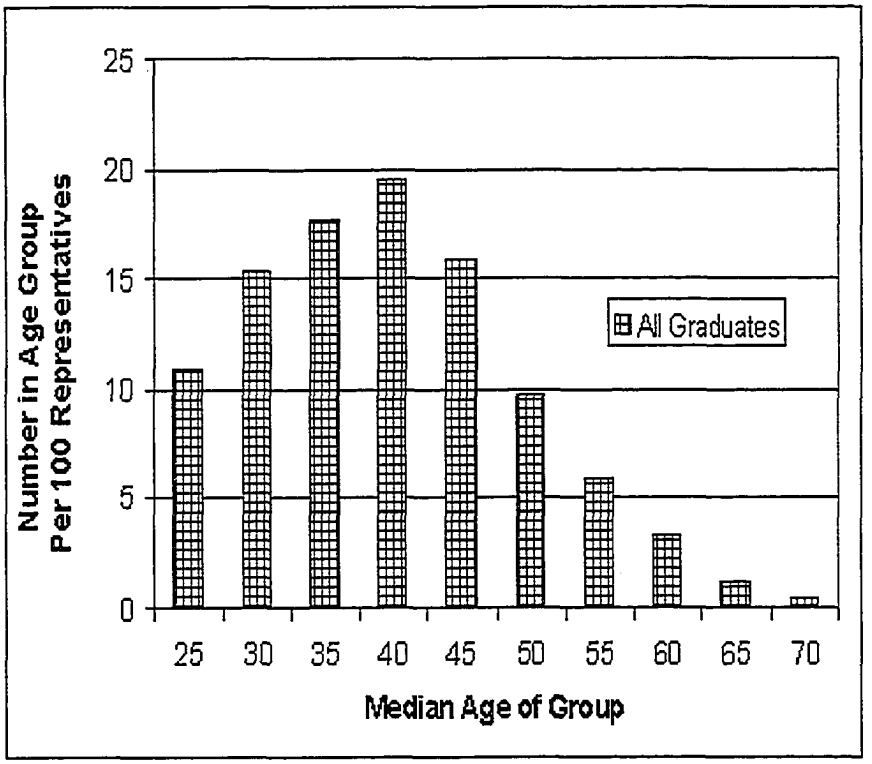

Figure 4.2: Summary of the SESTAT data for all American full time workers with college degrees in 1990.

engineers, according to the SESTAT data. For these teachers, a constant demand would create a serious shortage in the near future, as the sharp peak seen in Figure 4.3 will be reaching retirement age in 2005 and beyond. It must be noted, however, that the age at which the two populations in Figure 4.3 peak is around the same value and the two distributions have a similar overall shape, with the teachers being more pronounced in the variation.

4.2.2 SESTAT Data - Engineers

A logical progression from the general trend of an aging population is the assumption of an impending shortage of engineers in North America driven by the large numbers of mature people reaching retirement age. The need for corrective action has been touted for many

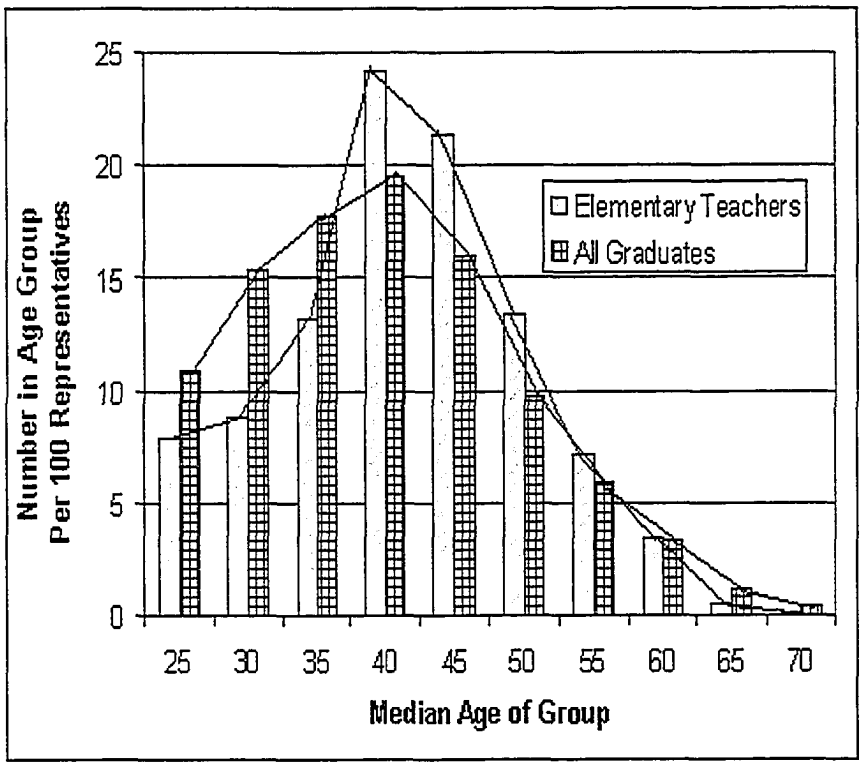

Figure 4.3: Comparison of elementary school teachers and all workers with college degrees, from the 1990 data compiled by SESTAT.

years with Somers (1991) being an example from more than a decade ago. The popular view is that the numbers of current graduates in engineering is insufficient to replace those that will leave the system shortly. As noted, the bases for these beliefs are often derived from looking at the population at large, similar to the situation with teachers and other college graduates demonstrated above. A consequence of this development could be that the educational and professional organizations should be acting proactively in order to promote engineering and the applied sciences in an attempt to fill the upcoming gap. Somers notes that starting salaries are a significant driver for enrollment choices by undergraduate students entering universities. Another alternative, under this scenario, would be to extend the age of retirement beyond 65 and implement programs to encourage people to remain in the workforce longer (Simmons 2001). The SESTAT data was also

analyzed to determine the distribution by age of 100 representative engineers working full time in 1990. The results for the 11,329 engineers interviewed were compared against those for all graduates and this is displayed in Figure 4.4. As can be seen, the peak in numbers for the engineers occurs at an age approximately 10 years younger than that for the group of all workers with college degrees. This would not be expected for a situation resulting from the baby boom wave phenomenon. As suggested by Dalton and Thompson, if engineering is a young person's profession, the decrease in numbers by age forty may be due to effects different from simple population demographics. It may be that the observed trend towards young engineers in the workforce is not indicative of a passing circumstance, such as the baby boom phenomenon, but instead, it may have been fairly consistent over the past several decades.

SESTAT (2004) also presents data for fully employed degree holders in the United States as of 1999. Full time employed scientists outnumbered engineers from just over six million to just under two million in that year. The data presented above shows that the potential shortage from the baby boom was more likely with scientists than engineers. Grouping engineers in with this population will lead to the wrong conclusions.

4.2.3 APEGGA Membership

The APEGGA website contains the registry data of all professional engineers, geologists and geophysicists practicing in the Province of Alberta. This information is available to the public. A random number generator was developed in Microsoft Excel to generate a number between 1 and 40,447, which represented the total number of APEGGA members at the time of this study. The random number was used to select the corresponding member in the APEGGA database. If the member was registered in a field other than engineering (e.g. a geologist), the next engineering member was selected. The database was randomly sampled 1000 times to determine a profile of the membership by age. The distribution produced was compared with the SESTAT data for engineers. The results are

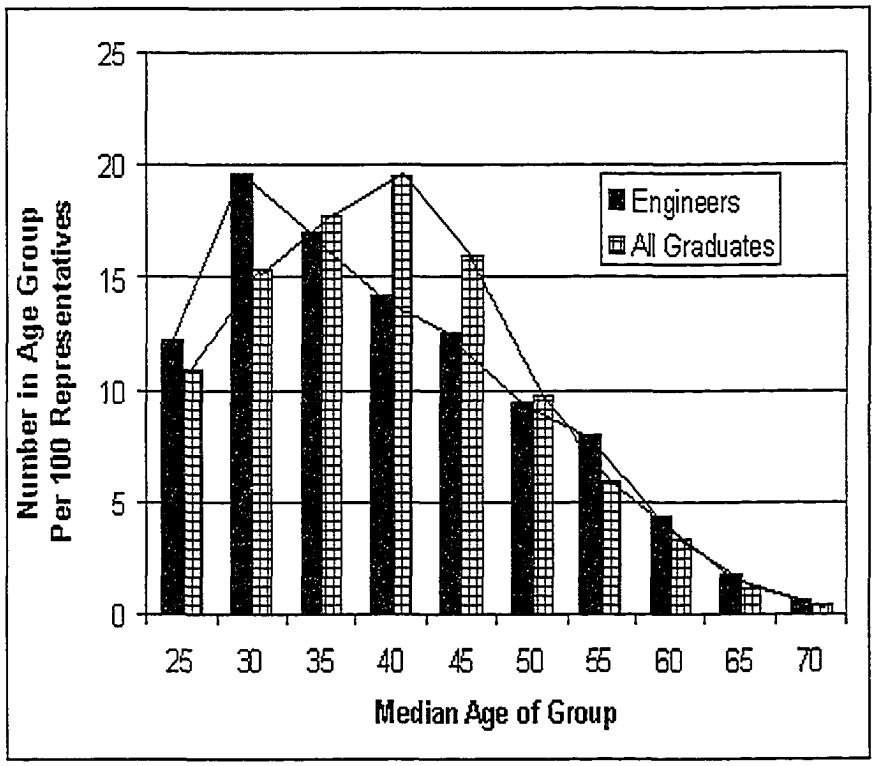

Figure 4.4: A comparison between the age distribution of the engineers and all workers with college degrees, from the 1990 data compiled by SESTAT.

presented in Figure 4.5. Although the current membership of APEGGA is more uniform in distribution by age than the SESTAT engineers, the profiles shown in Figure 4.5 are more similar than when comparing the engineering and non-engineering SESTAT distributions. This point will be demonstrated further during the statistical analysis of this data. The highest level of the age distribution of the APEGGA membership occurs for the group with the median age of 25, compared with 30 for the SESTAT data. A possible explanation will not be offered at this juncture, except to state that it is in holding with a trend towards younger engineers as predicted by Dalton and Thompson. The higher levels for APEGGA membership at the older end of the scale can be explained by the requirement for the engineers in the SESTAT to be employed full time, whereas APEGGA membership does not have that stipulation, except where it impacts the on-going requirement to

demonstrate continuing professional development. Retired engineers can maintain special membership without the competency requirements. Therefore, the higher levels at the older end of the scale could possibly be explained by engineers that maintain their membership after retirement, but these same people would not be counted under the SESTAT qualification of being employed full time.

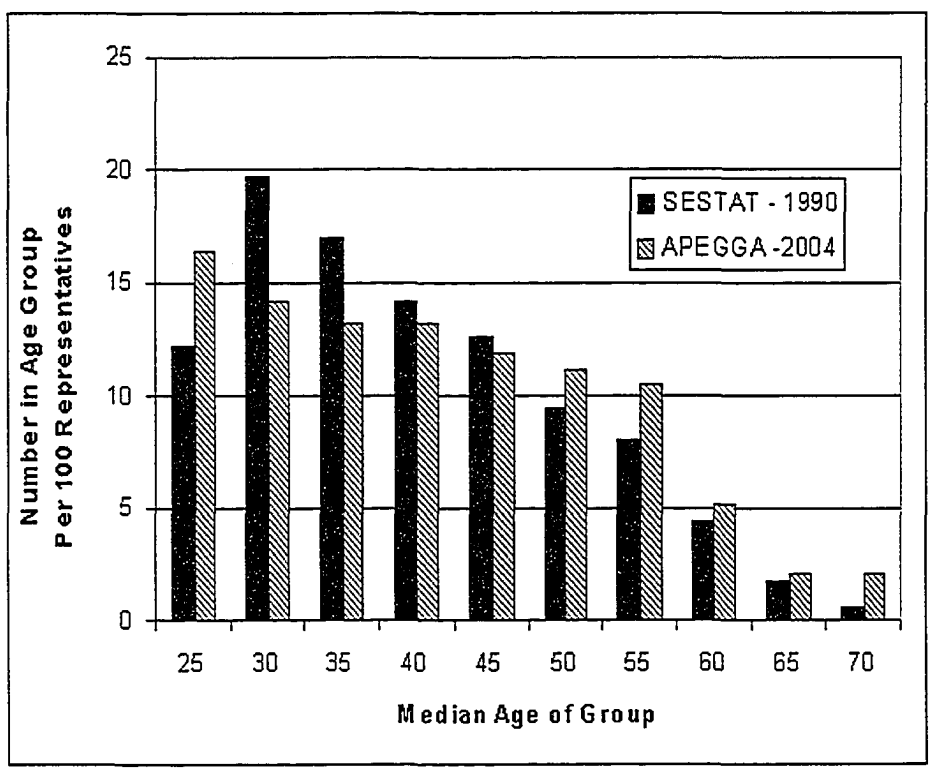

Figure 4.5: Age distribution of the 2004 APEGGA general membership and the engineers in the 1990 SESTAT database.

4.2.4 APEGGA Salary Survey

As noted earlier, APEGGA requests data, including salaries, from the employers of engineers. The background of the people completing the surveys (for example, the general manager or a human resources clerk) will vary between organizations depending upon the circumstances of the companies involved. The information they chose to provide and who

they include in the surveys is also not consistent among organizations. APEGGA only controls for obvious inconsistencies in the responses, such as receiving reports that indicate a much larger number of participants than the number of engineers the company employs. The companies that fill out the surveys are required as employers of engineers to hold government regulated permits to practice engineering and they must have at least one registered engineer on staff. As noted in the section outlining the definitions for this study, the term engineer may vary between organizations and even between people within the same organizations. It is acknowledged that people could be counted in the APEGGA salary survey that may be considered engineers by the person completing the survey but that these same people may not be considered engineers by another person. As well, employees considered to be engineers by some people within the organization (including the workers themselves) may not be included by the person completing the survey. Therefore, any conclusions based solely on this data would be suspect as to their validity in representing all engineers and should be used only as general indications of trends, and providing supporting evidence for other conclusions reached. It must be also noted, however, that the inclusion in this study of the APEGGA survey data was considered to be appropriate because, as stated, the number of participants represents close to 10% of the total number of engineers registered in the province at the time of the survey. It would reflect less than due diligence to ignore this data outright. Further, the relevance of arguments against inclusion of this data will be shown to be unfounded in the section containing the discussion of the results of the field research. Also, the rejection of the usefulness of the data should be contingent upon showing that the people that were deemed to be incorrectly selected as engineers for inclusion or those that were deemed to be incorrectly missed by the companies' representatives were significantly different in age profile than the rest of the sample group. This would require a demonstration that the selection process significantly altered the resulting profile to the point of misrepresenting the actual population being sampled. As the procedures of data collection are determined

individually by the companies surveyed, a considerable effort would be required to establish the relevance of the potential issues with the data. It was felt that individual biases of all the people independently completing the surveys should tend to balance out. The determination of the magnitude of these uncertainties was not included in the scope of research at this juncture.

Giving due respect to the limitations of the APEGGA salary survey, the data was analyzed and compared with the membership data that was developed by sampling the registry. The results appear in Figure 4.6. It can be seen that for the median age of 55, there is a sharper drop in the numbers of engineers being reported by the employers that

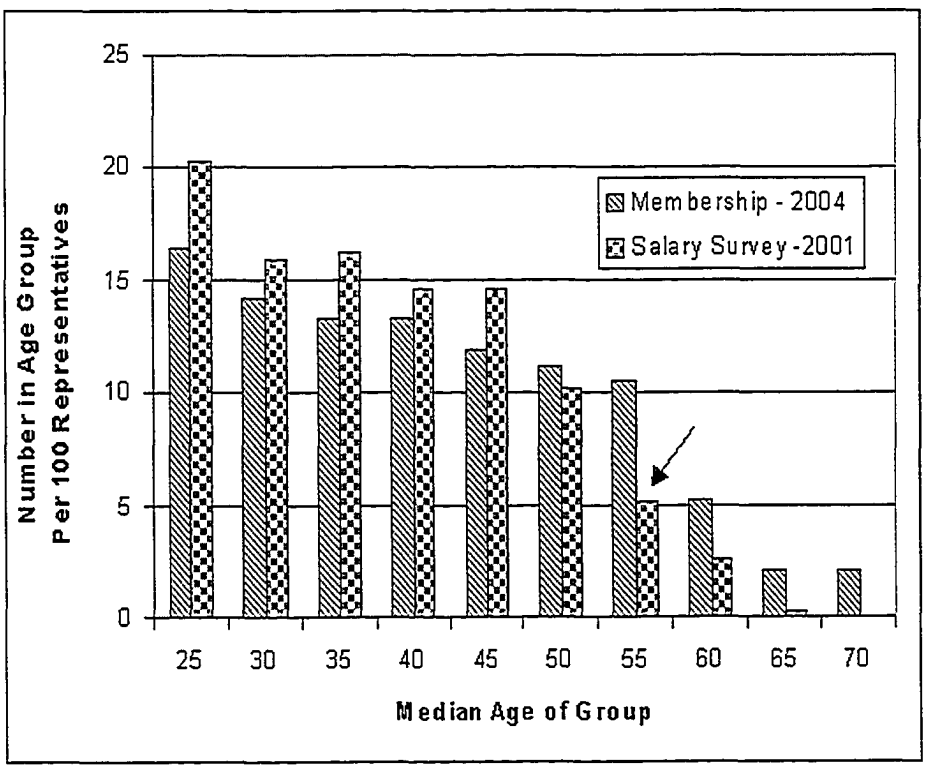

Figure 4.6: Comparison of company workforce reported by the 2001 salary survey and the 2004 general APEGGA membership

complete the salary surveys compared with the membership at large. The first plausible explanation is that the engineers no longer work for these companies shortly after they

reach the age that many of these companies offer early retirement. A second plausible explanation is that the engineers move within the companies to positions, such as general management, where they are no longer counted as engineers in the survey. To expect the companies to miss the counting of these particular positions at one particular age, however, while the engineers themselves maintain their professional membership, seems less likely than the first possible explanation. The nature of this observation is dealt with in detail in the research portion of this thesis.

Further evidence that the observation of a lack of engineers over 55 years of age is not due to any special circumstances of the current economic situation is provided by comparing the distribution by age of the APEGGA salary survey data to the distribution by age of the engineers in the Pelz and Andrews study. Pelz and Andrews reported their data based on different median ages than have been presented above, so the data from the APEGGA salary survey was adjusted accordingly. The results of the comparison is shown in Figure 4.7. As can be seen, in all three sets of data, there is a large drop in the numbers of engineers reported to still be in the organizations after the age of 45. For the recent data, the peak for engineers occurs below 30 years of age. For the Pelz and Andrews data for engineers employed by the government, the peak occurs between 35 and 39. The proportion of government employed engineers over 55 is around 5% of the total and this is similar to the APEGGA salary survey results for the over 55 group. For the Pelz and Andrews data for engineers employed in private industry, a majority of 63% was in the narrow age band of between 30 and 34 years of age. The number of engineers over 55 years old in the organizations examined by Pelz and Andrews represented less than 0.5% of the total. This low number is for those engineers who would be only in the final quarter of a potential career that could span 42 years. One unusual circumstance of the times, however, was the impact of World War II. The peak of engineers in industry for the Pelz and Andrews data between 35 and 39 years of age would be the people who were still too young to serve in the second World War. People who were 20 in 1939 would have been 40 by

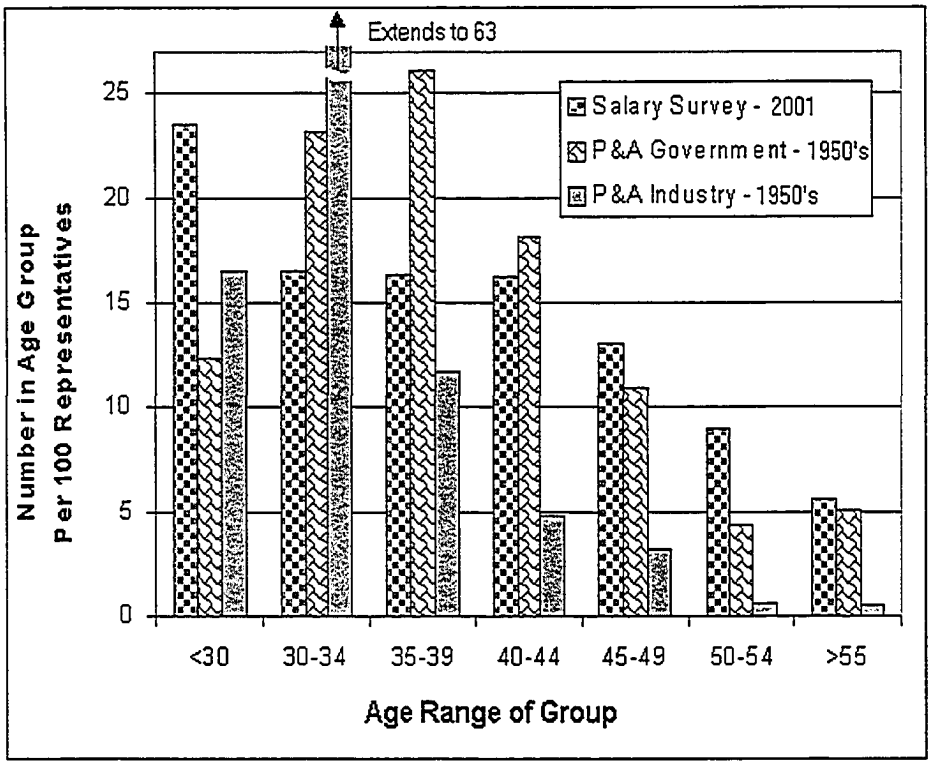

Figure 4.7: Comparison of the Pelz and Andrews data for engineers from the late 1950's with the 2001 APEGGA salary survey data.

1959, which was the year at the end of the Pelz and Andrews study. The loss of engineers to the war effort could be a contributing factor to the very sharp drop in numbers for those over 40 in the Pelz and Andrews study. As well, even older engineers would have been entering the work force during the Great Depression (Khol 2004). However, to show that this is not necessarily due totally to a general phenomenon of the time of the Pelz and Andrews study, Figure 4.8 shows a comparison of the engineers against the scientists in the same organizations. Figure 4.8 represents the combined numbers of industry and government workers for the three groups presented. Because the Ph.D. scientists would enter the workforce later than the other groups, Pelz and Andrews did not provide data for Ph.D. scientists under 30 years of age. Therefore the data for the assistant scientists and engineers were excluded for that age group. As can be seen, both the assistant scientists

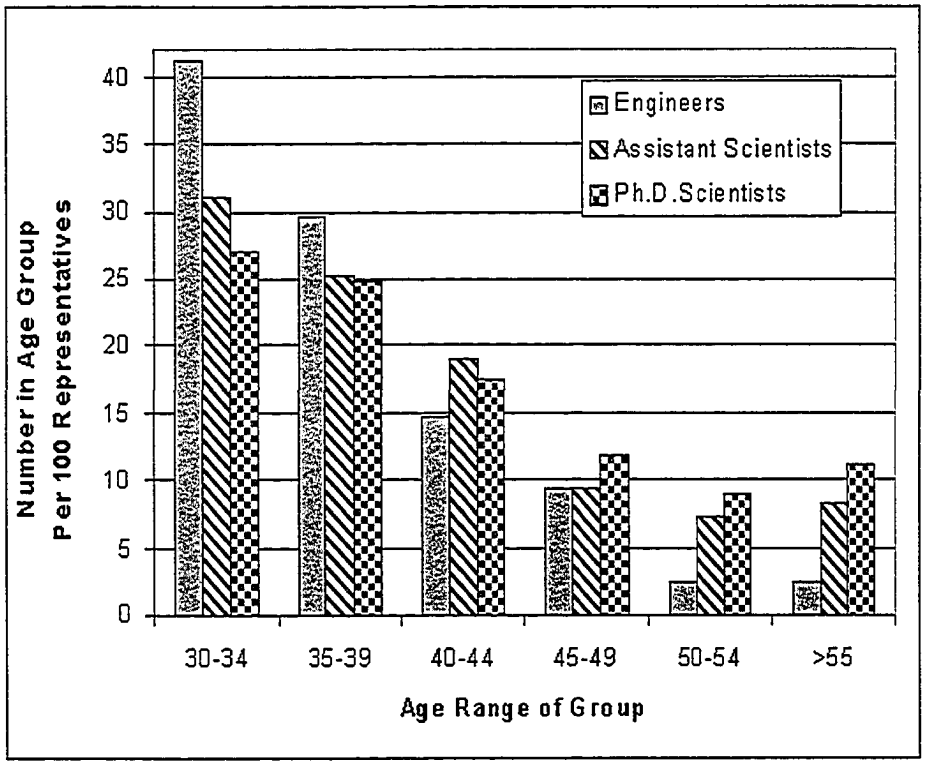

Figure 4.8: Comparison of the categories of workers investigated by Pelz and Andrews across all employers studied in late 1950's.

and the Ph.D.'s had distributions by age that were much more evenly distributed than the engineers. It would appear that although the private companies in the Pelz and Andrews study had their engineering done by people that were in a narrow age range, this was not totally a function of the engineering pool that was available to draw from. Pelz and Andrews stated that when they looked at the turnover rates in industry and government, they were surprised to find the larger numbers of mature engineers in the government organization were attributable more to hiring practices than to turnover rate differences between the organizations. The evidence they presented included the fact that the older engineers that were still in industry had been with their organization a long time. Some engineers with the government were still entering the organizations after 40 years of age. In comparing government to industry they state: "For our group of engineers... before age 35,

	Engineers		All University Degrees	
Census Year	Under 45	Over 45	Under 45	Over 45
2001	17,310	6,835	701,798	520,405
1996	15,995	4,395	687,410	411,160
1991	12,250	2,315	644,730	310,375
Totals	45,555	13,545	2,033,938	1,241,940
	77.1%	22.9%	62.1%	37.9%

Table 4.1: Canadian Census data comparing Engineers (including Applied Scientists) with the general population of all workers with university degrees.

those in government on the average had longer tenure; but after 40, those in industry had increasingly longer service. In other words, the government labs were ... recruiting more older employees" (p.194)

4.2.5 Statistics Canada

Statistics Canada (2004) provides the numbers of workers with advanced Engineering or Applied Science degrees by age group for the census years 1991, 1996 and 2001. This data was collected from the Canadian Census detailed surveys that are stated to represent a 20% sample of the entire Canadian population. The census group of Engineering or Applied Science represents a population for which the engineers would be a majority subset. A comparison was also made with the Canada Census data for the general population of workers with university degrees from all fields of study. Table 4.1 represents a summary of the data contained in the Statistics Canada study for 1991, 1996, and 2001. The large numbers of participants would lead one to suspect that the differences between the two groups are significant and this was proven to be the case, as will be shown in the statistical analysis of the available data.

4.3 Engineers in Management

As noted by Dalton and Thompson, it may not be possible for all the engineers that appear to be leaving the profession to find management positions within these

organizations to move into. Eight companies were randomly selected from the list of participating companies that supplied data for the APEGGA salary survey. Since the companies were selected from those that have permits to practice engineering in Alberta, it would be expected by the legal requirements that they would have greater numbers of engineers in their employment than the general private sector. The companies selected were researched using sources such as annual reports, company websites and the names provided on the registration data for their respective permits to practice engineering. It was found that one of the eight companies had a professional engineer as the CEO. Also a large majority of the executives listed in the sources were holders of non-engineering degrees, with Science, Law, Arts and Business being the most common. This is in keeping with a number of studies of career advancement into upper management. Useem (1985) recounts a study that found that over a 20 year period at AT&T, the engineering graduates were more able to get into the lower ranks of the organization than holders of non-career specific degrees. However, the engineers were only half as likely to be promoted into middle management positions than were their coworkers with liberal arts degrees (humanities and social science). It must be noted that the sources used in this study to investigate the background of the executives, such as annual reports, may not identify all the senior management personnel and these documents are not controlled over such specific contents. Therefore this information again should not be used to directly draw conclusions from, but is provided as supporting evidence for the general trends observed. The field research on this project was developed to also address the issue of engineers in management from other approaches. This matter will be dealt with further below.

4.4 Engineers in Consulting Services

Beyer and Beaton (1998) performed a detailed analysis of the 1991 Canadian Census pertaining to the technical services industries. Their work included a breakdown by age for the Engineering Consulting Services industry, which would represent a subset of the entire

engineering population. Their data, however, also includes engineering technologists and support staff that would be hired by these firms. It is also not clear what the make-up of the engineering consulting industry would be in terms of proportions of service providers that would be working as freelance contractors versus employees of large Engineering, Procurement and Construction (EPC) firms. At any rate, the data provided by Beyer and Beaton suggests that the distribution by age of their data closely mirrors that of the general population. Since the Beyer and Beaton data is from the consulting industry only, it is possible that this area does not experience the same depletion as other sectors, or is a sector for which mature engineers move into at a later stage of their career. It is also possible, however that the non-engineering component of their target population skews the data to more resemble the general population. When looking at suggestions for managers to improve the performance of engineers over 40 years of age, Pelz and Andrews noted that many of the subordinates would resist the move to a more administrative role. They suggested that these people be encouraged to "continue in the role of consultant rather than investigator; in general the curves for usefulness remained high" (p. 198). The term 'consultant' in this instance was meant more as an intra-company position rather than to suggest a change in employer, but the effect should be similar in either instance.

4.5 Observations and Other Evidence

In startling contrast to the expectation of a baby boomer wave reaching the retirement age, each result of the analysis of the available data (with the noted exception of the subset of the consulting industry studied by Beyer and Beaton) commonly suggests that there is no pending shortage due to any large number of mature engineers ready to retire. In fact, it appears that most engineers in the system are still in the first half of their careers. Before engineers can be registered in Alberta, they must complete 4 years of work supervised under a professional. From the reports on membership issued by the association, the numbers of these Engineers in Training (EIT's) represent about 17% of the total

membership and this level has stayed reasonably consistent over the past 4 years. This figure for younger members is about 50% higher than would be expected if the engineers in the system were evenly distributed by age. It is also certainly much higher than would be expected for a situation where the age distribution was higher for people nearing retirement age. It is notable that there also appears to be a distinct break in the characteristics of the population of engineers by year of graduation around the same point as the plateau in salaries. It raises the question of the possibility of a relationship between the two phenomena.

4.6 Statistical Analysis of the Available Data

The general trends observed during the review of the previously published data were tested for any statistical significance. Cross-tabular, multivariate ANOVA tests were performed on the data using the MINITAB statistical analysis software. The procedures were in accordance with generally accepted statistical methodologies as presented by Miller and Freund (2003), Hines and Montgomery (1990) and Steel et al. (1997). The general procedures for doing the statistical analysis and experimental design were also discussed with Dr. Bob Hardin, Professor Emeritus, University of Alberta. Dr. Hardin had a lengthy career in teaching statistical analysis and experimental design at the graduate student level. One of the first items that should be addressed in preparing for quantitative testing is that the probability of Type II acceptance error of an invalid conclusion increases with the number of statistical tests performed. Therefore, it was considered prudent to limit the number of tests on hypotheses to those chosen in advance and not go searching for statistically significant results from the data as a whole (McDonald et al. 2002). In testing the SESTAT data during the first statistical analysis, cells were developed for the numbers of college graduates in the workforce for each year of age. The sources of variation chosen for the cross tabular ANOVA test were age and profession. The data was sorted into rows for each age from 21 to 73. The columns were selected to be the numbers of engineers, the

numbers of elementary school teachers and the general population of college graduates with the other two groups (i.e. engineers and teachers) subtracted out.

4.6.1 Statistical Test 1

Null Hypothesis: Given the SESTAT survey data from the 148,932 interviews performed, there is no difference in the distribution by age between the population of 11,329 Engineers, 12,975 Elementary School Teachers and the 124,628 other workers with college degrees.

$$H_0 : \mu_1 = \mu_2 = \mu_3 \tag{4.1}$$

$$H_1 : H_0 \textit{ is not true.}$$

where: μ_1 = the distribution of Engineers in the SESTAT data.

μ_2 = the distribution of the Elementary School Teachers in the SESTAT data.

μ_3 = the distribution of all other workers with college degrees in the SESTAT data not included in μ_1 or μ_2.

Result: The Pearson chi square test of association yielded a p-value result of 0.000, or less than the three decimal place output resolution of the software. The likelihood-ratio chi square test of association also yields a p-value of 0.000, which again is below the lowest level of the three decimal place output as well. One can then conclude that the confidence level for rejecting the null hypothesis on a statistical basis is greater than 99.9%.

4.6.2 Statistical Test 2

Null Hypothesis: Given the SESTAT survey data from the 148,932 interviews performed, there is no difference in the age distribution of the 11,329 Engineers and the 137,594 workers with non-engineering college degrees (elementary school teachers now included with the other graduates).

$$H_0 : \mu_1 = \mu_4 \tag{4.2}$$

$$H_1 : \mu_1 \neq \mu_4.$$

where: μ_1 = the distribution of Engineers in the SESTAT data.

μ_4 = the distribution of all other workers with college degrees in the SESTAT data not included in μ_1.

Result: The Pearson chi square test of association again yields a p-value result of 0.000. The p-value of the likelihood-ratio chi square test of association is again also 0.000. Hence, the conclusion can be reached that the confidence level for rejecting the hypothesis that the age profile of the engineers in the SESTAT data is the same as the larger population of all other graduates is also greater than 99.9%.

4.6.3 Statistical Test 3

Since the SESTAT data originated in 1990, the people that were interviewed are 14 years older in 2004 than they were at the time of the census. To test the populations, 14 years was added to the ages of the participants of the SESTAT data in order to compare them against the two sources of APEGGA data (i.e. the survey results and the random sampling of the membership directory). The ages of the people in the 2001 APEGGA salary survey results were similarly advanced by 3 years for the same reason. Cross-tabular, multivariate ANOVA tests were also performed on this data using the MINITAB statistical analysis software in a format similar to that outlined above. The test could not be performed for the age group younger than 36 due to the age of the SESTAT data. That is, graduates who were 22 in 1990 would be 36 years old in 2004. There is no SESTAT data to compare against the members of APEGGA that are currently less than 36 years old. The data for SESTAT participants older than 46 in 1990 were also not included in the statistical analysis because of the expectation that retirements would dramatically decrease the numbers of workers after the age of 60. For example, the number of people who would now be 80 years old and still be employed as engineers is likely to be insignificant. This is supported by visual inspection of the graphs presented above, and was not pursued further. Due to the

desire to reduce the probability of Type II statistical errors, the exact point of discrepancy between the two populations due to the effect of reaching old age was not explored.
Null Hypothesis: The 1000 name sample taken from the APEGGA database for the ages 37 to 59 is not different than the SESTAT data population for engineers from the same year of birth.

$$H_0 : \mu_5 = \mu_6 \tag{4.3}$$

$$H_1 : \mu_5 \neq \mu_6.$$

where: μ_5 = the distribution of Engineers in the APEGGA database between the ages of 37 to 59.

μ_6 = the distribution of Engineers in the SESTAT data born in the same years as μ_5.
Result: The Pearson chi square test of association yields a p-value of 0.477. The likelihood-ratio chi square test of association gives a p-value of 0.514. These values show that the null hypothesis cannot be rejected. Hence, the age characteristics of the two groups are clearly not statistically different.

4.6.4 Statistical Test 4

Null Hypothesis: The population represented by the 1000 name sample taken from the APEGGA database for the ages 37 to 59 is not different than the SESTAT data population for all college graduates from the same year of birth.

$$H_0 : \mu_5 = \mu_7 \tag{4.4}$$

$$H_1 : \mu_5 \neq \mu_7.$$

where: μ_5 = the distribution of Engineers in the APEGGA database between the ages of 37 to 59.

μ_7 = the distribution of all college graduates in the SESTAT data born in the same years as μ_5.

Result: The Pearson chi square test of association yields a p-value of 0.046. The likelihood-ratio chi square test of association yields a p-value of 0.047. These values show that the null hypothesis can be rejected at a confidence level of 95%. Hence, the age characteristics of the two groups are statistically different.

4.6.5 Statistical Test 5

Null Hypothesis: The population represented by the 2001 APEGGA salary survey is not different than that represented by the engineers in the SESTAT data for the birth years that would give the present ages of 37 to 59.

$$H_0 : \mu_8 = \mu_6 \tag{4.5}$$

$$H_1 : \mu_8 \neq \mu_6.$$

where: μ_8 = the distribution of Engineers in the APEGGA 2001 salary survey with current ages between 37 and 59.

μ_6 = the distribution of Engineers in the SESTAT data born in the same years as μ_8.

Result: The Pearson chi square test of association yields a p-value of 0.000. The likelihood-ratio chi square test of association also yields a p-value of 0.000. These values show that the null hypothesis can be rejected at a confidence level of 99.9%. Hence the age characteristics of the two groups are also statistically different.

4.6.6 Statistical Test 6

Null Hypothesis: For the approximately 3.3 million census surveys analyzed by Statistics Canada, the age distribution of the engineers was not significantly different from the

population of all University graduates.

$$H_0 : \mu_9 = \mu_{10} \tag{4.6}$$

$$H_1 : \mu_9 \neq \mu_{10}.$$

where: μ_9 = the distribution of Engineers in the Canada census data.

μ_{10} = the distribution of all university graduates in the Canada census data.

Result: Because of the large number of data points, it should not be surprising to those familiar with statistical analysis that the Pearson chi square test of association yields a p-value of 0.000. The likelihood-ratio chi square test of association also yields a p-value of 0.000. These values lead to the conclusion that the null hypothesis can be rejected with a confidence level of more than 99.9%.

4.6.7 Summary of the Statistical Tests

Table 4.2 represents a summary of the statistical analysis of the preliminary work done prior to the commencement of the field research. By presenting the summary in a tabular format, it should be clear as to what was considered, what data was analyzed and what conclusions can be drawn from the tests conducted.

A summary of the useful conclusions that can be drawn from Table 4.2 are as follows:

- The trends observed suggest that engineers in the workforce have a different age profile from other degree holders.
- The population of workers represented by the companies that respond to the APEGGA salary surveys has a different age profile than the general population of engineers. That is, the engineers that work for these companies are not representative of the general pool of engineers. (The engineers that work in these organizations appear to be younger than the general membership).

Test	Total size of sample tested.	Smallest population within total	Null Hypothesis	Conclusion	Confidence Level
1	148,932	11,329 where:	$\mu_1 = \mu_2 = \mu_3$ μ_1 = the distribution of Engineers in the SESTAT data. μ_2 = the distribution of the Elementary School Teachers in the SESTAT data. μ_3 = the distribution of all other workers with college degrees in the SESTAT data not included in μ_1 or μ_2.	Reject	99.9%
2	148,932	11,329 where:	$\mu_1 = \mu_4$ μ_1 = the distribution of Engineers in the SESTAT data. μ_4 = the distribution of all other workers with college degrees in the SESTAT data not included in μ_1.	Reject	99.9%
3	8,776	518 where:	$\mu_5 = \mu_6$ μ_5 = the distribution of Engineers in the APEGGA database between the ages of 37 to 59. μ_6 = the distribution of Engineers in the SESTAT data born in the same years as μ_5.	Cannot reject	n/a
4	107,607	518 where:	$\mu_5 = \mu_7$ μ_5 = the distribution of Engineers in the APEGGA database between the ages of 37 to 59. μ_7 = the distribution of all college graduates in the SESTAT data born in the same years as μ_5.	Reject	95%
5	10,340	2,082 where:	$\mu_8 = \mu_6$ μ_8 = the distribution of Engineers in the APEGGA 2001 salary survey with current ages between 37 and 59. μ_6 = the distribution of Engineers in the SESTAT data born in the same years as μ_5.	Reject	99.9%
6	3,275,878	2,315 where:	$\mu_9 = \mu_{10}$ μ_9 = the distribution of Engineers in the Canada census data. μ_{10} = the distribution of all university graduates in the Canada census data.	Reject	99.9%

Table 4.2: Summary of the statistical tests performed on the previously published age distribution data.

- Working engineers over 45 years of age represent a smaller proportion of the total number of engineers than workers with other degrees over 45 years of age do for the general population of working University degree holders.
- The trends suggest that working engineers are younger than the general population of university educated workers.

The evidence is quite compelling to support the conclusions suggested by the data analysis. However, it was felt that there are sufficient numbers of assumptions made in the development of the data presented that may lead to some incorrect interpretation of the results based on an alternate but unconsidered situation. For example, the trends observed could be explained by a situation where engineers are repeatedly being promoted into positions where they deal less with their former associates, are not considered engineers by the company at large, but still maintain their professional registration for a number of years until they conclude they are permanently placed in their new field at which time they then stop renewing their professional membership. In order to exclude the possibility of such alternate explanations, further field research was conducted and is explained in later chapters.

CHAPTER 5

FIELD STUDY 1 - THE WHAT STUDY

5.1 Research Design and Methodology - The What Study

As noted in the analysis of the available data, there were some general assumptions made on the interpretation of the results obtained. One shortcoming of the data, as was also identified by Pelz and Andrews for their work, is that by studying those within a particular subset it is difficult to learn about those outside that subset. Although the proportions of a particular group of engineers are reported to decrease with age, for example, this information does not tell enough about whether the decrease is a function of the population or the counting methods. It was determined that an study focused on the existing population of engineers as a whole was required to confirm the conclusions suggested by the data already examined. The study was developed to show that if there is a change in the numbers of one subset, there should be an increase in another subset. In particular, the first study was designed to answer the following specific questions:

- Do engineers in Alberta leave the system at a rate suggested by the data examined?
- Are engineers promoted into management or staff positions around the age of 55 at a rate that explains the drastic drop in engineers in organizations observed in the data?
- Are there specific types of organizations that retain their engineers longer than others?
- As noted during the defining of the term 'engineering', due to the potential controversy and confusion over what constitutes engineering, the distinction must be made on the aspects of what constitutes leaving engineering. The study must

differentiate between those engineers that leave the profession because they no longer work at any job, those that are promoted out of engineering as an expected consequence of their career, and those that choose to pursue other opportunities in external organizations that are clearly not engineering.

5.2 A review of Research Methodologies

The general approach outlined earlier was to conduct two studies to study different aspects of the research question. Study 1 deals with the validation of the observed trends or the 'What' of the current situation in the status of engineers in the workforce. Study 2 deals with potential reasons or 'Why' these situations may exist. A review of methods for studying the research question was conducted with the view of studying both of these aspects of the value of experience. The results of the review of research methods will be presented here, demonstrating the background to the design of the two studies.

Petroski (1992) notes that although engineers often feel more comfortable with the quantitative methods of research and calculation, the discipline is very much rooted in the qualitative end of scientific endeavours. He specifically states that Engineering is done inductively. Regarding the failure of two skywalks in the Kansas City Hyatt Regency in1981, he states:

> *The example of the poorly conceived skywalks emphasizes the view of design as the obviation of failure. While the initial structural requirement of bridging a space may be seen as a positive goal to be reached through induction, the success of a designer's paper plan, which amounts to a hypothesis, can never be proven by deduction. The goal of the designer is to recognize any counter examples to a structurally inadequate hypothesis that he makes.* (p. 104)

In *Research Methods for Managers*, Gill and Johnson (2002) provide a guide to aid in selecting a research strategy for any management research project. They note that there

is no ideal solution to the problem of research choice, but only a series of compromises leading the researcher to the strategy they feel best suits their particular project. Not only do all research strategies have some benefits to offer, but Gill and Johnson conclude there also appears to be no way to evaluate their relative suitability in any absolute terms. Concerning the nature of the research question, there appears to be little prior work in the area to rely upon for building a foundation or starting theory from the literature. An experiment in the form of an industrial project based on the introduction of a management program to change the work environment of the engineers or a traditional laboratory experiment both appear ill suited for the topic at hand. Likewise a deductively thought through approach would seem to be problematic for similar reasons. Marketing researcher and academic, Evert Gummesson (1991) states that in business related research, access to "real-world data" (p. 11) is the most vital challenge facing the researcher. Whether qualitative or quantitative methods are employed, the validity of the data depends upon the researcher gaining an open and informed relationship with the participants. Gummesson considers it to be a frequent occurrence where the senior executives of a firm make decisions based on information gathered in part during brief stops at the facilities under their command. Interaction is typically between the outsider (in this case even the executive is seen as an outsider) and a gatekeeper (for example, a shop foreman). The gatekeeper may supply data designed to minimize the amount of disruption caused by the inquiry. One effective way to achieve the least disruption is to understand the background of the person asking the questions and provide data that supports the perceived schema of this outsider. The intentional shielding of information protects the interests of the gatekeeper but it also produces a sense of validation of the executive's or researcher's original hypotheses. Gummesson relates that a common misconception of the nature of information gathering in business is that it follows the Pareto principle, whereby 80% of the relevant information would be obtained within the first 20% of the effort expended. In order to dig deeper, the principle of diminishing returns would result in considerable

resource usage for little benefit. As noted by Kerssens-van Drongelen and Fisscher (2003), corporations are often environments that promote mistrust, personal agendas differing from those stated, distortions of facts, conflicting goals, and apathy. These complications result in a more accurate view of the ability to access information to be one similar to that presented by Gummesson. This access to information is a more step-wise function in relation to the effort expended (i.e. the first 20% of the effort may result in almost no reliable information). Gummesson states that good data will be obtained only after sufficient time is spent determining the nature of the interactions at play.

As will be further developed below, Mintzberg (1973) states that in contrast to the scenario presented by Gummesson, many forms of information gathering is highly influenced by the agendas of the person soliciting the information. Surveys measure answer rates to predetermined questions, for example. Mintzberg considers the ability to phrase questions of interest to be indicative of an assumption of a high level of understanding of the situation being measured. The personal agendas of the researcher are typically assumed to be in-line with the stated goals, but this is not always the case, as stated by Gibson et al. (2001). Argyris (1994) states that many of the familiar tools developed in the past, such as employee surveys, may actually inhibit a manager's ability to obtain key information about their organization. Management's emphasis on positive attitudes, for example, will likely produce employees that display cheerfulness, even if it is false.

In addition to the intentional barriers that may be in place, Gummesson also notes that the number of people within an organization that correctly understands the issues being examined by the researcher may be very limited. Sampling of the general population may distort the results and cloud the more meaningful information provided by what should be the target population. This concept is generally recognized in implementing quality programs where a standard principle is that the person closest to the work is generally regarded as the most knowledgeable (Cap 1996). Gummesson states that in a traditional organization those with the most authority to effect change may be

inadequately informed to make the proper decisions or to even be able to provide accurate information relating to the subject. One of the strengths of in-depth interviews is that the researcher may be able to determine the extent of the interviewee's knowledge and perhaps detect a sense of the bias that may be directing the information obtained. The ability of obtaining a better understanding through interviews is reflected in the work of Kvale (1996) and has been used increasingly in areas where quantitative methods have had limited success, such as political science (Dean 2004).

The use of qualitative methods in management research is nothing new and many of the most famous theories were developed from a qualitative approach. For example, Williams (2004) states that, in 1906, the New York Bureau of Municipal Research used qualitative methods, such as coded maps for revealing demographic information, to develop one of the earliest organizational performance measurement systems. Wren (1995) notes that beginning in 1860 with his graduation from engineering school, Henri Fayol, one of the founders of management as a discipline, relied heavily on field observation to develop his principles:

> *Qualitative data, such as reflections based on personal experiences, whether recorded during or after the experiences, are considered useful in generating data to be further tested systematically. For practitioners, such as Fayol, data collecting and theory building are ongoing and interdependent activities which can be subjected to further comparative analysis to improve generalizability. Fayol hoped that his experiences would make others start thinking about management and to that end he started his Centre for Administrative Studies. Here, and elsewhere, the experiences of non-academics provided the first insights into building a body of management knowledge. Without the contributions of these pioneers, such as Fayol, we would probably be teaching industrial engineering, sociology, economics, or perhaps ergonomics to those who aspire to*

> *manage. To be doing so would push us back to the nineteenth century when technical knowhow reigned supreme as a path to managerial responsibility.* (p. 6)

Most of the effort expended during the Hawthorne studies was not on the famous field experiments on productivity but rather on the more than 20,000 in-depth interviews performed on the population of workers (Roesthlisberger and Dickson 1964). One of the most clearly identified benefits of the Hawthorne experiments, as reported by the authors, was the knowledge gained in the area of interviewing and the improved skills of the interviewers (p. 270). As noted above, Herzberg developed his "two factor theory" by conducting semi-structured interviews in what appears to be very similar to a phenomenological framework (Herzberg et al. 1959). Chris Argyris is an important figure in the development of theories surrounding the psychology of management (Caulkin 1997). Argyris has written 32 books on management theory. The data Argyris used to formulate his theories was typically obtained by participant observation and included interviewing to follow up on survey results (Argyris 1994). Likewise in 1968, Henry Mintzberg, one of Canada's (and the world's) most prominent management researchers, chose a qualitative methodology for his Ph.D. dissertation on the development of a taxonomy of the work of managers (Taylor et al. 2002). Gill and Johnson note that Mintzberg developed the categories after his field observations of only five managers, in accordance with (what was at the time) a very recently published work by Glaser and Strauss (1967). The in-depth analysis of smaller sample sizes has proven to be effective a in wide range of research areas such as the food retailing business (Cox and Mowatt 2004) and real estate investment (de Bruin and Flint-Hartle 2003).

In many instances of the study of management in business, it is found that certain traditions are followed without sufficient reliance on examining the proof of the success of the processes. Quality researchers Leonard and McAdam (2002) state that grounded theory is one of the most developed inductive research methods useful for testing such situations. According to business and management researcher Christina Goulding (2002),

grounded theory is recognized as having been first codified by Barney Glaser and Anselm Strauss, culminating in the publication of their 1967 book *The Discovery of Grounded Theory.* Working as sociologists, Glaser and Strauss developed the standardization of this methodology while researching the experiences of chronically ill patients. A personal conversation regarding developing a methodology for this dissertation was held in May 2004 between Donald Kennedy and the famous ethnographer Michael Agar (e.g. Agar 1996). Agar related that the appearance of Glaser and Strauss's work was warmly welcomed and was seen as a great benefit to him and his fellow researchers. It was not so much that it altered any of the methods they were already using, but it greatly legitimized and categorized these methods. Prior to 1967, the methods used by the researchers were more informal, but over the past three decades the mutual understanding of the methodologies has become established. This may be seen as a parallel to the development of a paradigm as popularized by Kuhn (1970).

Glaser (1978) states that although grounded theory is well suited for fieldwork and qualitative data, it can be easily adapted for any form of data collection, including quantitative methods. Goulding notes that *The Discovery of Grounded Theory* is still used as the primary reference for students of the methodology. The basic principles of grounded theory can be drawn from the explanations provided by Strauss and Corbin (1998). Grounded theory refers to the process of deriving a theory directly from the data, which has been systematically collected and analyzed. The researcher does not begin with an hypothesis in mind, but rather lets the new theory emerge from the data. Goulding asserts that the theory development is a product of the continuous interplay between the analysis and new directions in data collection. Strauss and Corbin contend that the theory derived from the observation is more likely to resemble reality than one derived from remembering personal past experience or speculation.

Goulding states that once the theory emerges, it should provide clear enough categories to allow future verification and also enable prediction and explanation of

behavior. Due to the iterative nature of the process, an initial research question may be quite broad, but can become narrower as the researcher aims to develop an in-depth understanding (Roffey 2002). Goulding states that sampling in grounded theory studies is not purposive in the sense of defining a set of characteristics at the beginning of the study and selecting only participants that meet that criteria (for an example of purposive sampling see: Lu 2000). Instead, in grounded theory the analysis of the data continually directs the selection of the participants in accordance with what type of information is needed and where the best places to find it might be. This process of controlling the data collection by the emerging theory is called 'theoretical sampling.' With respect to the need to obtain consent to follow the entrenched ethical research principles, the validity of the 'randomness' of 'random' sampling from a group of pre-selected consenting participants is brought into question. For theoretical sampling, the choice of participants is often guided by selecting from those willing to consent to the study (see Pappu and Mundy 2002). In addition to the sampling being directed by the data collection, Glaser (1978) states that the researcher using grounded theory must also be prepared to change interview style, location, or anything else that may be necessary to follow and test emergent ideas.

The number of participants or sample size is determined in grounded theory by the objective of reaching saturation, as demonstrated by Information Technology (IT) researchers Sarker et al. (2001). The theory should only be considered developed when no new ideas or evidence emerge from further data collection. Henry Mintzberg (1973) determined that an inductive approach was the only reasonable choice to take for his groundbreaking Ph.D. thesis. He was able to build his theory on the nature of managerial work based on the data collected from shadowing 5 senior executives for one week each. Respectful of this, Goulding points out that a common mistake in grounded theory studies is to come to "closure" too soon. There is an importance to acknowledging variations and issues which do not fit the theory neatly. All schools of grounded theory also note the importance of using "memos throughout the research journey" (Goulding p. 65). These are

notes (a few words or up to several pages in length) that capture ideas that may strike at any point during the project, including during the researcher's free time. Following the advice of Glaser, Goulding notes that the memos should be kept and treated separately from the data.

It will be noted at this point that this project used many different sources of data for triangulating the results. The salary and age distribution data analyzed earlier are examples of this. Herzberg et al. (1959) recognized that quantitative measures relating to motivation are "subject to so may flaws" (p. 16) and that the worker providing a self report on the situation was typically the best source of information. In order to reduce the effect of giving answers to match the expectations of the researcher, Herzberg focused on reports of actual events and subsequent feelings resulting from the events, as opposed to requesting a response to hypothetical situations.

Other sources were also examined to obtain as many possible research methods for any type of research project. In addition to the sources mentioned above, these included the following: Ragin and Becker (1992), Creswell (1995), Marshall and Rossman (1995), Kvale (1996), Hoepfl (1997), Zhou (1998), de Guerre (2002), Mitchel (2002), Ojala (2002), Pappu and Mundy (2002), Towill et al. (2002), Bradford (2003), Cortvriend (2004), Duggan and Thachenkary (2004), McClellan (2004), and Whitehead (2004).

Table 5.1 presents all the methods uncovered from the sources referenced for conducting research and assesses their applicability to an study designed to answer the questions sought in the What Study.

Method	Example	Advantages	Disadvantages for use on the What Study
Laboratory Experiment (Note 1)	Duggan and Thachenkary (2004)	Controlled variables, highly repeatable methods.	Not feasible (Note 2)
Mail or Web-based Survey	Laws (2004)	Convenient, ease of statistical analysis, fast turnover of projects / papers	Typically low response (<10%), questionable reliability, unknown bias
Telephone or in Person Survey	Mitchel (2002)	Higher response rate (>50% on cold calls) than mail or web, convenient, immediate feedback on potential sources of error.	If the purpose was to explore any reasons, this method may not have the depth required (Note 3)
Secondary or published sources	Ojala (2002) (Note 4)	Convenient, draws on analysis of others	Data may not exist, be inappropriate or incomplete.
Critical Incident and Sequence of Events	Bradford (2003)	In-depth analysis of single factor, intense probing	Some factors not investigated, low transferability
Diary (Note 5)	Cortvriend (2004)	Efficient, many people collecting data	Not feasible, verisimilitude
Activity Sampling (Note 6)	Towill et al. (2002)	Efficient, recorded by researcher, ease of statistical analysis	Non-continuous, difficult, ineffective in gaining benefit above survey
Unstructured Observation and Participatory Action Research (PAR)	de Guerre (2002)	Researcher can develop new dimensions, effective at probing and exploring	Difficult to replicate without structure, inefficient, not feasible for long time horizons
Structured Observation	Mintzberg (1973)	Researcher can develop new dimensions, effective at probing, structured.	Not feasible, difficult to interpret some activities
In-depth Interviews	Whitehead (2004)	Flexible, in-depth, low impact, direct to source, feedback on analysis.	Ineffective in gaining benefit above survey

Table 5.1: Research methods considered for validating the observed trends in the previously published data, the What Study.

Notes to Table 5.1

Note 1. As expanded upon more fully in the review on methodologies, Kuhn's (1970) findings suggest that quantitative laboratory experiments may not be well suited for the types of complex problems engineers address.

Note 2. See the comments on the research by Gummesson (1991) outlined in the review on methodologies.

Note 3. See the comments outlined in the review on methodologies concerning Martinko and Gardner (1985), Mintzberg (1973), and Taylor et al. (2002).

Note 4. Mintzberg (1973) states that secondary sources, such as letters and interviews with connected informants are useful for studying subjects that are not available for approach directly, such as an important political figure. In typical managerial studies, the data is likely to be very limited and it is usually impossible to delve any deeper than the data as stated allows. Advances have occurred since 1973 and the internet is gaining usage as a means to collect data and search for material (for example see Rosenzweig 2001). Although access to information has been aided greatly by the development of the internet, it does not solve the problem of a lack of data when there are few secondary sources to be found (Hoppenstand 2004).

Note 5. McClellan (2004) demonstrated that more direct methods of observation produced dramatically different results from those obtained by relying on the self-reporting of the target population.

Note 6. Wilde (1994) observes that activity sampling can be misleading due to the participants willfully changing their behavior for the duration of the observation. Liao and Pape (1996) note that the effects of participants altering activities during the sampling period can be lessened by using a modified work sampling technique. Herzberg et al. (1959) noted that observation including

activity sampling may be disruptive and adversely affect the desired results. For this reason, Herzberg et. al chose interviewing as the least likely to bias the findings. According to Mintzberg (1973), the method works best when the material being studied is clearly understood at the outset due to the requirement for understanding what is being observed.

5.3 Research Method

Based on the analysis of all identified alternatives for conducting research as outlined in Table 5.1, it was determined that the most effective method to test the population's characteristics by age was through direct contact and the completion of a short survey. In order to conduct such a survey, an amendment was required to the project's application to the Faculty of Engineering Research Ethics Board. In order to demonstrate compliance with the Board's requirements for ethical research on human participants, the following procedure was established:

1. Locate the prospective participant through publicly available means.
2. Send a letter to the prospective participant outlining the request for participation.
3. After a one week waiting period, telephone the prospective participant and request participation.
4. If the prospective participant agrees, make a tape recording over the telephone of them providing informed consent to participate in the study.
5. Ask the participant the survey questions, if agreed consent is given.
6. Collect all the answers to the survey questions in a Microsoft Access database.
7. Present the results only in a summary format to prevent identification of the participants.

The participants were selected by choosing an experimental design guided by the same Dr. Hardin referenced earlier. The design consisted of randomly selecting 30 prospective participants from 9 different engineering graduating classes from the University of Alberta. The classes were chosen from the graduating years 1978, 1972, and 1967. It was felt that these years would give a good representation of mature engineers on either side of the potential transition period around 55 years of age observed for the engineering populations in the data presented earlier. For each graduating year, 30 graduates were randomly selected from each of the departments of Mechanical, Civil and Electrical Engineering. Seven graduate students were used to independently select the participants, with each student being assigned at least one of the nine classes. Methods used to collect the names of graduates from the class varied by the information each department and the University made available. The Mechanical and Electrical departments have pictures in the hallways of each graduating class including each graduate's name. The Civil department had their pictures removed during a relocation and were not readily available. All three of the 1967 classes had graduation lists available in a discontinued University yearbook. Convocation records were also consulted when other methods proved to be unavailable. This procedure resulted in 270 potential participants for the What Study. Other than the questions relating to proving that informed consent was being given, each willing participant was asked to supply the following information:

- Name.
- Year of graduation.
- Age.
- Current employer.
- Title of current position.
- Does the participant consider the work to be engineering?

- (If the answer to the above is no) What year did the participant last practice engineering?

It should be cautioned that this last question was largely irrelevant to most aspects of analyzing the data, with the exception of determining engineers' personal perceptions of their work status. The definition of engineering supplied under the definition of terms is independent of the personal definition held by the participants. It is useful, however in demonstrating that the engineer's view of their own job may be different than others' interpretions. Once the data was collected, the interpretation of the result for the engineer's status was determined according to one of the following categories:

1. Salaried Engineer. This category represented a salaried employee performing an engineering role as determined by applying the definition provided by the CETS Panel, with the exception of those that also qualified under the subset category 7.

2. General Management. This category was selected to determine the proportion of engineers that are in general management positions. As noted, there is the potential that moving into management positions is an expected progression of an engineer's career. Engineers that directly supervised front line engineers were included under category 1 as suggested by the definitions used.

3. Freelance consulting engineer. This person would get temporary contracts typically with firms that require engineers contingent on cyclical workloads that exceed their base resources.

4. Other. These engineers have jobs that are not related to engineering and do not fit in any of the other categories. The engineers would either be self-employed or work for companies that do not require engineering expertise. The engineers included in this category are not covered under a permit to practice engineering by the provincial engineering association where they work. Examples of such positions will be provided during the discussion of the results.

5. Retired. These engineers have no employer and do not do freelance work.

6. University professors. This category was selected to accommodate the classification of the academic members of this project's review committee. As noted in the definition section, a panel of five engineers from industry was convened to compare their definition of engineering with that of the CETS Panel. The assembled panel from industry strongly felt that engineering professors do not do engineering work. This is in direct contrast with the definition provided by APEGGA for its members as engineering professors are specifically stated as practicing engineering. As also noted in the definition section, the definition of engineering is highly susceptible to controversy and emotionalism. By first separating professors into a category of their own, the significance of the decision of whether they do engineering or not can first be determined. Once the significance of the decision can be quantified, it was then examined by the various parties to weigh the importance of professors' careers to the results of this study.

7. Engineer working for an EPC firm. This category was added to test the assertion that these firms are more likely to have mature engineers as suggested by Beyer and Beaton.

8. Non-engineering staff position at a company that has a permit to practice. This category was defined in this way to include engineers that may be promoted to non-engineering positions within their organizations.

9. Dead. Logically, this category was not determined through telephone interviews. Since 270 members of the graduating class were selected in the hopes that they will be representative of the population as a whole, the actuarial data for mortality will provide an accurate assessment of the appropriate levels of members that would be dead for each class. The calculation for mortality was performed by assuming all members of the graduating class would die at a rate similar to the general

population, with 100% alive at the age of 22. The number was reduced each year by the amount indicated in the actuarial tables provided by Statistics Canada (2000) (and confirmed through several other internet sources for validity). In this case, of the 90 graduates from each of the years, the expected number of deaths by 2005 are as follows: 1978 - 4 deaths would be expected out of the 90 names selected, 1972 - 7 deaths would be expected, and 1967 - 11 deaths would be expected. That is, for an example, approximately 12% of the graduating class of 1967 would be expected to have died by the year this study was completed.

A sample letter and the question guide for the What Study is included in Appendix D. The telephone interviews were conducted with those participants who granted informed consent to be a part of this study. For those that refused, and for those that could not be contacted by telephone, other sources of data were used when available. For each such graduate, searches began with the APEGGA membership directory to see if they were registered as an engineer in the province of Alberta. For those who could not be located through the telephone directories or the APEGGA database, other methods were tried to expand the search. A bound yearbook containing a directory of some graduates was published by the University in 1996. This book was used to locate a few of the people that were not found other ways. For these people, however, the data was too old to be used on its own and this yearbook was only helpful in leading to current information to be used to locate them.

Once the more reliable sources of tracking the graduates down, such as telephone directories, internet searches, University registries, and the APEGGA registry, were exhausted, other methods were tried to locate the remaining graduates. These other methods included directories of government employees and the directories of other provinces' professional associations. Because of the possibility of not being able to locate some members under any circumstances (for example if they are now dead), a reasonable limit was placed on the effort to locate the graduates. Eventually the rate of locating an additional graduate was reaching one success in more than 3 hours of trying the less

conventional methods of searching. At that point 225 of the 270 graduates were accounted for. The search was then stopped.

One of the 8 categories of engineer was designated for each person for whom data was found. The category assignments were checked for reliability by passing the same data to the panel of 5 engineers from industry. The categories assigned by the panel were the same as those assigned by the researcher for each individual case.

5.4 Results

5.4.1 Procedural Results

The tracking down of the potential participants required a variety of methods as outlined in the previous section. Despite the best efforts being expended, 67 of the 270 participants were not located as to their present status. As noted previously, the actuarial tables for Canada indicate that it would be expected that 22 of these 67 potential participants are now dead. If these levels are recognized as data, and included in the numbers that were tracked down, then information was obtained for 225 of the 270 engineers. Problems with tracking people down include unlisted telephone numbers, changes of names, and telephones that block unknown callers. Figure 5.1 shows the geographical location of the people found.

Of the engineers that were located, 25% refused to participate. Some of the people that answered the phone expressed anger at the intrusion. Some others stated that they were 'sick of the University calling all the time' and that they wanted to be left alone. Some also expressed annoyance or general distrust of the purpose of surveys. In both the What and the Why Studies, the only incentives for the engineer to participate were non-monetary. The contribution to knowledge is an activity that the engineer could use in demonstrating a part of their continuing professional development that is a requirement of registration with APEGGA. As will be shown in later sections, the participation of the

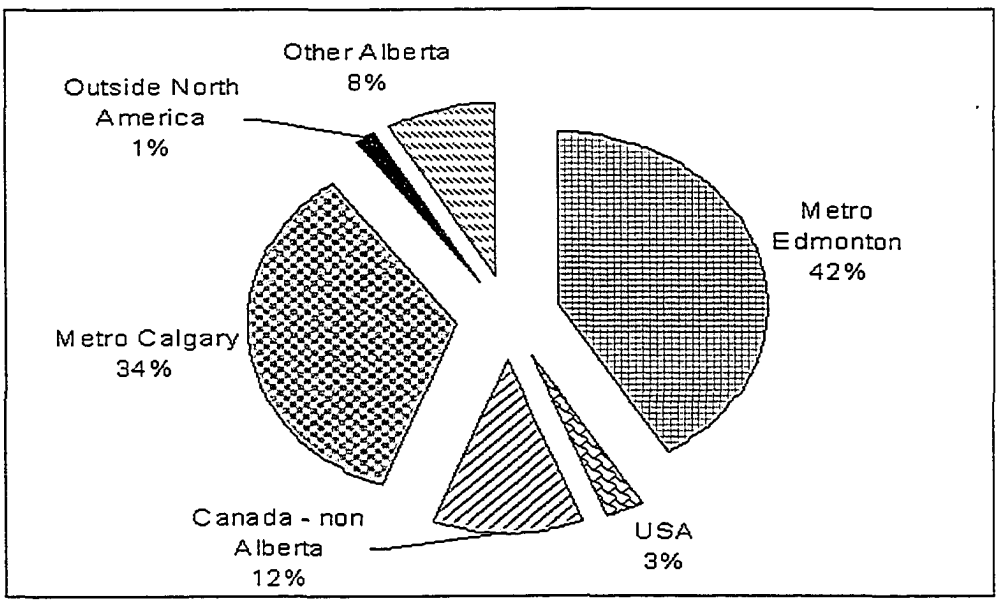

Figure 5.1: Break-out of the present geographical location of the 203 engineers tracked down in the What Study.

engineers was at a high enough level without monetary incentives, which may be a reflection of their sense of professional duty.

5.4.2 Sources of Data Used

Table 5.2 shows the sources of data used for compiling the results of the survey in the What Study. The term 'registry' includes the APEGGA membership registry and any other similar provincial association registries. For some of the cases, the engineer refused to participate during the telephone solicitation, but there was data available on that person in a membership directory. In 6 instances, the information in the registry included no useful information except for the member's name and whether or not the association considered them to be a practicing or non-practicing member. In such instances, the engineer was classified as 'no information' because there was no way to ascertain their work status.

The yearbook used was a special publication of 1996 by the University of Alberta as an offer to those students who wished to contribute. As the data was almost 10 years old,

Source of Data	Number	Notes
Phone only	8	
Phone and Registry	73	APEGGA or other province
Registry only	97	Includes 22 phone refusals
Email only	1	
Email and Registry	1	
Yearbook and Phone	4	
Yearbook and Registry	1	
Yearbook only	12	Data too old to include
Telephone directory	6	Refused, no other source
Not located	67	

Table 5.2: Sources of data used for the What Study.

it was only useful for providing a lead to establish the engineers' current location and as a cross-reference. The yearbook was typically only consulted after telephone and registry searches yielded no results, so the number of people indicated with yearbook as a source potentially is a lower number than the actual number of these people in the book.

5.4.3 Survey Results

Table 5.3 shows the age characteristics of the participants in the What Study. The mean for each group is equivalent to an age of 22 at the time of graduation. A visual inspection of the distribution revealed nothing unusual (such as a bimodal curve) and only a few participants were found in the extremes of age for each graduating class. There was also no noticeable difference between the discipline (Mechanical, Civil, and Electrical) and the career pattern. This was not tested statistically for the reasons previously provided regarding limiting the number of tests performed.

The companies that the engineers worked for were widely varied and very few companies had more than one engineer in the sample working for them. The largest single employer with 12 of the 270 engineers working for them is the government, including all federal, provincial and municipal levels. Colt Engineering employs 5 of the 9 engineers that work for EPC firms. Two of the 9 EPC Engineers work for AMEC. There were 23 operating companies found that employ 28 of the engineers. The operating companies

Grad Year	Statistic	Age
1967	Average	60
	Median	60
	Maximum	66
	Minimum	59
1972	Average	55
	Median	55
	Maximum	57
	Minimum	54
1978	Average	49
	Median	49
	Maximum	55
	Minimum	47

Table 5.3: Age Characteristics of the participants in the What Study.

employing more than one engineer from the 270 searched are Shell Canada and the ATCO group of companies. There are 22 service companies that employ 22 of the engineers. Examples of these companies are Lockerbie and Hole, IGL Canada, and Thurber Engineering. The University of Alberta employs 3 of the 4 professors plus an additional 1 engineer working as a researcher. The 145 engineers out of the 270 total that were found to be working were employed by 124 different companies. This would suggest a wide variety of experiences for the group.

The results for the survey regarding the present status of the engineers is shown in Figure 5.2. The number of individuals for which no usable data was obtained was relatively consistent at about 20 for each year.

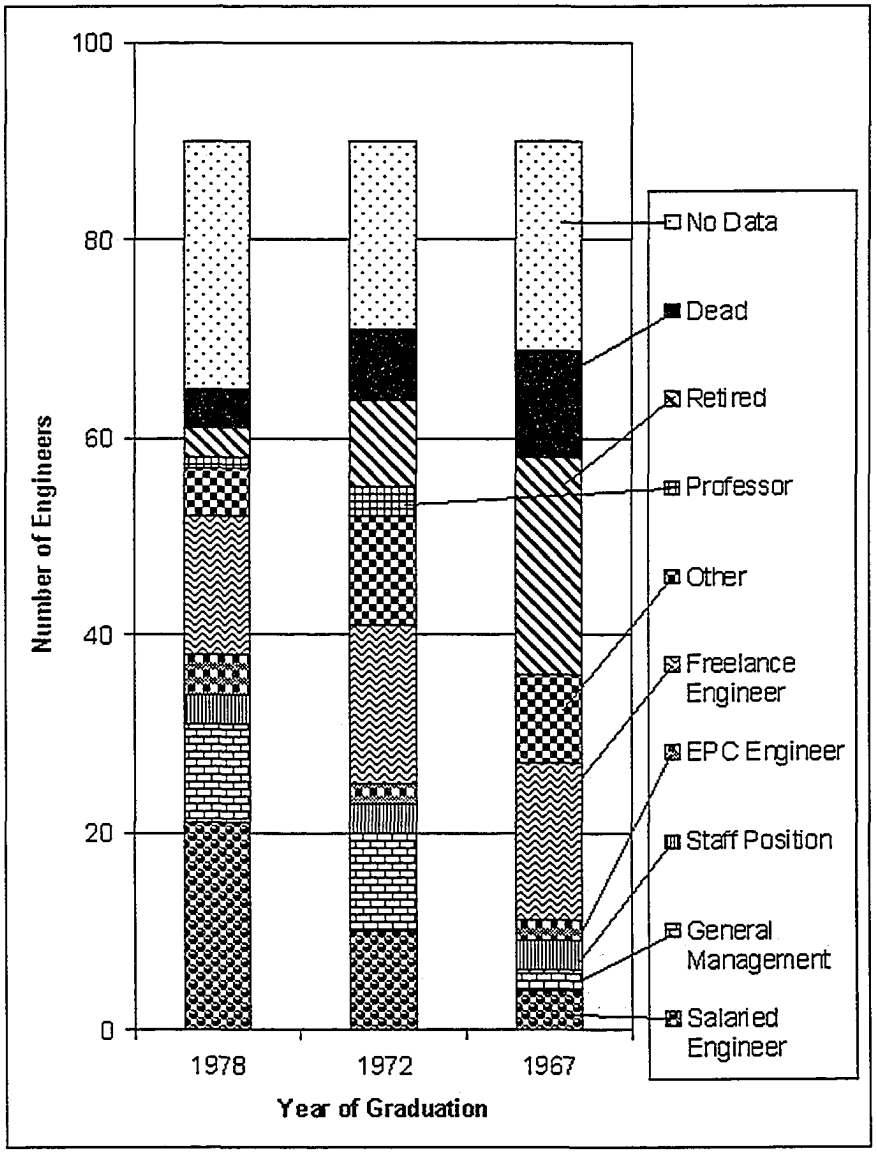

Figure 5.2: Results for all 270 engineers in the What Study.

5.5 Discussion of Results

5.5.1 Discussion of Procedural Difficulties

The employees of the University, including the Alumni Association, were generally hesitant to provide any assistance in the tracking down of the graduates. One Alumni Association employee suggested providing the letters to their office and them mailing them out. Under this proposal, the recipient would be relied upon to respond and the time frame to wait for responses would be more uncertain. Trussell and Lavrakas (2004) indicate that such a method would typically have a response rate of about 10% compared with the 75% participation rate for those that were contacted. At times, the University employee approached for help referred to FOIPP or the Freedom of Information and Privacy Protection Act (Tromp 2002) as the reason for not helping, including refusing to answer the question of where the graduation pictures were that were removed during an office relocation. It was up to the researcher to locate the pictures, or ask another employee with fewer reservations. Future researchers may find increasing problems in obtaining information such as that used in this study.

As noted in the section on methods, inquiries were made of the participants for locating a class representative that may have had a listing of the present whereabouts of the people that stayed in contact. It was disappointing that none of the people contacted by telephone indicated that they were aware of any designated class contact for any of the 9 graduating classes. Some people expressed a general lack of knowledge of any of the others they graduated with. It was originally hoped that an e-mail listing of a group of graduates would be obtained and this would greatly reduce the workload of doing the What Study. Advances in electronic communication did not significantly help this study, but they may help in the future as more households purchase computers. However, all the methods used to locate the graduates were considered likely to be more effective than they would be for many other professions or even newer graduating classes of engineers. This is

because of the overwhelming proportions of males in engineering for the years selected. The tradition of changing names upon marriage complicates the tracking down of the female members of such a study. A summary review of the classes indicated that males constituted approximately 98% of the graduates for all the years examined.

The negative reaction expressed by many participants is in line with that anticipated in the section on methods, but the 75% participation rate is clearly better than those for many studies that may experience participation rates below 30%, such as Lewis (2001) or Eby and Allen (2002). A follow-up call was initially considered to explain to the person that refused that the calls are not for the purpose of soliciting money. The suggestion of this call was rejected by the researcher, however, on the grounds that the approved ethics proposal clearly allows for the participant to refuse to participate and the assurance was made that no further calls would follow.

5.5.2 General Results

As was presented in Table 5.2, for 79 of the engineers multiple sources of data were available. Many of the participants of the telephone interviews were also listed in the APEGGA registry. These multiple sources provided a cross check on the reliability of the data for which there was only one source. For example, the data in the APEGGA registry could be compared with the answers provided by the willing participants. In no instance was there a conflict between the sources. It would be reasonable to assume that the information provided by only one source, either the membership directory or telephone answers, for example, are also reliable to an acceptable level. As noted earlier, there were 6 engineers that were not contacted but they were listed in the APEGGA database with only their names and no employment information available. These were categorized with those for whom no information was found. However, it is very possible that the lack of employment information suggests they may be unemployed or consider themselves retired.

The possibility that the people that were not located simply because they have moved geographically, is not totally explained by the findings. As Figure 5.1 demonstrated, the participants that were tracked down were from disperse locations. Figure 5.1 does show that many years after graduation, almost half of the engineers are currently in and around the Edmonton area and most are in Alberta.

It was assumed that the proportions belonging in each category for the people for whom data was not found would not be statistically different from the overall class year, so these were excluded from further analysis. In order to get a clearer understanding of the results, the data excluding these people is displayed again in Figure 5.3. Percentages are used to adjust for the slight differences in the numbers of people found for each class year and median age is presented to relate better to the data already presented in earlier sections.

A very noticeable trend is observable. The engineers that work in salaried engineering positions dramatically drop off as the individuals get older. Each category of engineer is dealt with in detail below.

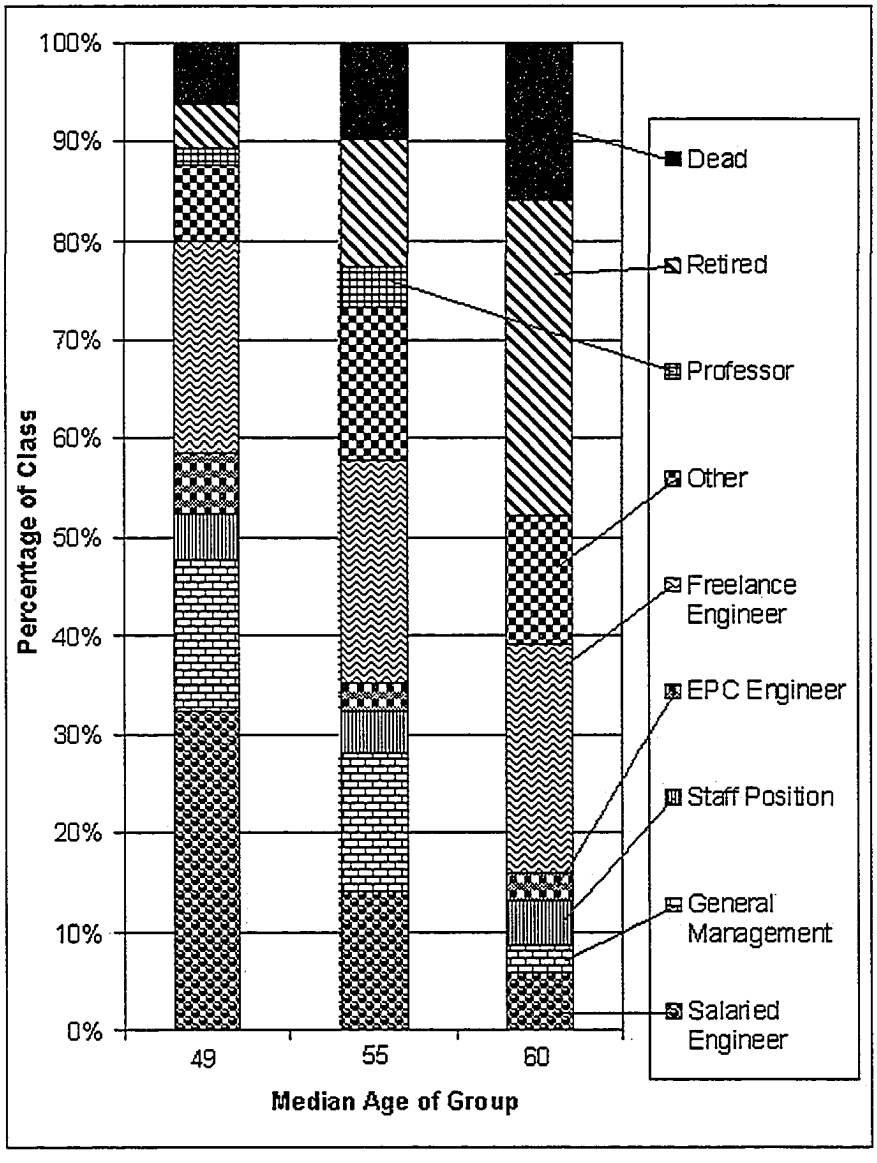

Figure 5.3: Results for the engineers in the What Study for whom the present status was found. The individuals for whom no data was found were excluded from this chart.

5.5.3 Retired Engineers

As can be seen in Figure 5.3, the number of participants that were reported as being retired was approximately 5% of the group with the median age of only 49. This increased to 13% of the group with the median age of 55, and 32% for the group with the median age of 60. If there is a shortage of engineers in the near future, this population of fully trained engineers could be tapped to alleviate the problem. Since there are approximately 33,300 registered engineers in Alberta, bringing these retired engineers back to work would increase the pool by 4%, or by a number equivalent to one year's input of young engineers. Simply extending the retirement age beyond 65, would do very little because of the large numbers that are already retired by the age of 60.

5.5.4 Professors

The number of graduates from the three class years that are currently professors is approximately 1.5%. There were no professors identified for the class of 1967, but the low numbers overall suggest that this may not be significant. A review of the academic staff listings of the University of Alberta and the University of Calgary indicated that there are 358 professors of engineering at those two schools. The total number of engineers registered in Alberta is 33,316, according to the July 2005 statistics of APEGGA. This yields a proportion of 1.1% of the engineers in Alberta are professors. Whether professors do engineering work is not of particular relevance to this study because of the small numbers they represent.

5.5.5 Other

The category of Other increased slightly with the age of the participants. The job descriptions that this classification covered included: policeman, clergy, dentist, lawyer, technical institute instructor, dairy farmer, grain farmer, truck driver, and a variety of non-engineering small business operators. One graduate of 1972 reported being surprised

when, at his 10 year class reunion, he discovered a significant number of classmates indicated they had never done any engineering.

5.5.6 Freelance Engineers

This category represented more than 20% of each graduating class studied. There is a perception by some, that engineers may leave the constraints of large organizations for the flexibility of the consulting industry. A more detailed investigation of freelance consultants was performed. Using some of the participants from the telephone survey, leads from the participants in all sectors of the study, and from personal contacts, 14 freelance engineering consultants were questioned regarding the circumstances behind their present situation. Prior to going freelance, 10 of the 14 engineers were engaged as salaried engineers of large companies and the other 4 were general managers of large companies. Five were terminated from their salaried positions and 9 chose to leave. Of those that chose to leave, the reasons were varied but most dealt with a unhappiness at their old job. Low pay, boring job, high pressure, stalled career, and high levels of unpaid overtime were the types of causes for the engineers to leave their positions for freelance work. One engineer was satisfied at his old job, but became involved in an opportunity that offered many career developing rewards and chose to leave. When the new business was bought out by a larger company, that engineer then turned to consulting in order to maintain an income. The average reported salary of all 14 of these people as employees was $98,000 a year (maximum was $140,000 and the minimum was $34,000), which represents an average hourly rate of $49, based on a 2000 hour work year. As freelance consultants, the average charge out rate of the group increased to $67 an hour. However, the group had very diverse experiences regarding the number of billable hours they worked a year. This resulted in the average annual take home salary being $77,000, or a drop of about 12% from when they were employed. Eight of the 14 engineers reported making less money as freelance consultants, one reported being about even and 5 reported making more than before. All reported a loss of perks,

such as health care, a company vehicle, and paid holidays. Only two of the individuals are receiving a pension that contributes more than 10% of their annual income. Only one of the individuals reported ever working for their former employer on contract. One individual that chose to leave was given a negotiated severance package with the condition that they do not ever work for that company again. The management stated at the time, according to the engineer, that they did not want the other workers to see that they could also quit as employees and then continue working there under new terms.

It is significant to note that freelance engineers represented the largest category over all the graduating years investigated, but that all 14 interviewed had started in salaried positions in large companies. They also noted the importance of contacts in industry in order to establish themselves. Often knowing one key person at a large company was enough to start a business. It would be very difficult for a junior engineer to have the networking base these engineers had when they moved to freelance work. This would suggest that an investigation of engineers in the first half of their careers may show an age where this move to freelance work develops.

A freelance engineering consultant who is past 65 years of age stated that he is taking work when it suits him and the weather keeps him indoors. This engineer accepted his latest assignment because his previous employer of 30 years had "asked him nicely" if he would help them out with expertise they were currently lacking. The engineer stated that he felt considerable loyalty to the company, despite them terminating him more than a decade earlier, and several years earlier than he had planned on leaving. This assignment gave him a sense of personal satisfaction for the chance to contribute his experience. The requirements to maintain his professional status are such that his ability to demonstrate continuing competency (Feisel 1998) are much below the minimum established by the APEGGA CPD program. The nature of his expertise is an understanding of the processes for generating applications and getting regulatory approvals for construction, estimating the capital and operating costs of the new system, and establishing a work plan that

identifies the potential critical processes in completing the project. This leads to the question of how does society benefit from regulating the profession to prevent this engineer from practicing? It has the direct effect of further reducing the supply of experienced workers. What types of training and other professional development activities are available that would enhance this engineer's abilities in his area of expertise and how would improving these skill levels impact public safety?

From the analysis done in the chapter on available data, the group of engineers from 49 to 60 years of age represents approximately 20% of the APEGGA membership. Of the subset of the participants from the What Study that are APEGGA members, 24% were found to be freelance engineers. This would indicate that the approximate number of freelance engineers is 0.2 x 0.24 x 32,568, which represents about 1,500 engineers. Only one of the 14 freelance engineers questioned indicated that he is currently billing the equivalent of a full time job. Many of the others are taking work only as it is offered, and some spend much of their non-billable time searching for more work. On average the group of freelance engineers is underutilized to the extent that they are producing billable work equivalent to 60% of having full time jobs. If the group of freelance engineers questioned is representative of their category as a whole, it would suggest that they could perform an additional 40% of a full time job each. This would represent the equivalent of 600 jobs. To put this in perspective, a reserve of fully trained, qualified engineers is available to be tapped that is equal in numbers to 50% of one year's total input of EIT's. The utilization of this reserve would, in part, be contingent upon convincing the group to put in the equivalent of a full time job. For those that are continually busy searching for work during their off time, this should not be difficult, but for those that choose when to work it may be a more complex task. One of the participants in the Why Study had a full time engineering job and in the year 2000 was forced out through a reorganization of his employer company. The engineer was very happy in his former position, but since he foresaw difficulty in getting hired elsewhere at the age of 52, he took time off and

developed a keen interest in a hobby. Now he finds traveling in pursuit of events for enthusiasts of this hobby to be his top priority and work is now secondary. In order to return this person to full time equivalent work, the benefits would have to be great enough to move work ahead of this new pastime. The point should be stressed here that this person did not plan to stop work, but was initially removed from the system despite his wishes to remain working full time. Once removed, however, the person found other interests, and after being freelance for five years he has expressed no interest in ever returning to engineering work on a full time basis. The work of a freelance engineer will be dealt with further in the discussion of the results of the Why Study.

5.5.7 EPC Engineers

Meiksins reports that a large focus of the regulatory activities of professional associations and the curriculum of university is based upon the work of design engineers and structural design in particular. The number of engineers in the What Study that currently work at EPC firms is 4% of the total. The small numbers again make trends more difficult to ascertain. A small study was deemed necessary to test the validity of the numbers reported, since the design work of EPC firms is often used as model for the typical job of an engineer. It would seem that such a model should be more representative of all the engineers given its high profile. To test the numbers in more detail, a list of EPC firms was developed. The list was distributed to senior people at these firms to review and recommend any additions based on the assumption that they would best know their competition. The compiled new list was used as a guide representing all the significant EPC firms in Alberta. The APEGGA database was again utilized to determine the proportion of engineers that work for EPC firms. The employers of 1700 randomly selected engineers were reviewed. A tally was kept of all of those that work for one of the EPC firms on the list with the year that they graduated included. Of the 1700 engineers looked at, 83 worked for one of the EPC companies. This represents 4.9% of the sample. Three of

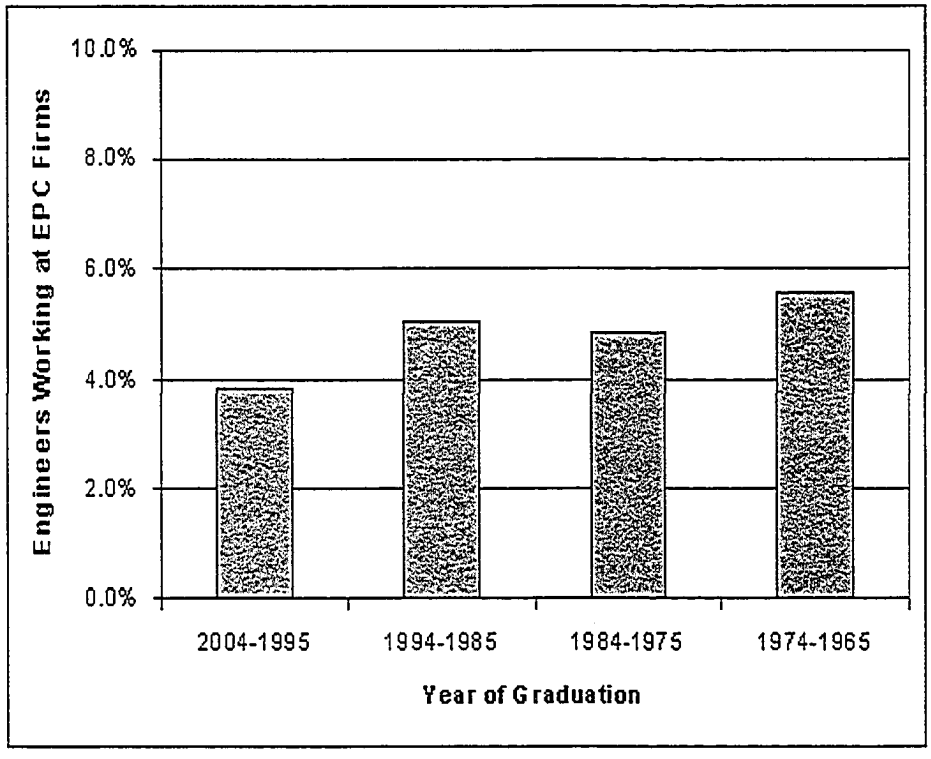

Figure 5.4: Proportion of the 1700 engineers sampled from the APEGGA membership registry who are employed at EPC firms. Three engineers (not shown on graph) were found from graduating classes earlier than 1965. The total number of engineers found to work at EPC firms, 83, represents 4.9% of the APEGGA members sampled.

the engineers were from graduation years prior to 1965. The distribution by age of the remaining 80 engineers is shown in Figure 5.4. One can see that the engineers at EPC firms do not follow the pattern noticed for engineers in general where there is a sharp drop beginning at the age of 40. This supports the data presented during the review of available data and the results presented from Beyer and Beaton in particular.

5.5.8 Staff Positions

There is a small portion of each graduating class that have jobs that are not defined as engineering jobs, but would be seen as a natural progression from an engineering position within the company. It would be foreseeable that the company would replace these people on their departure with other engineers. These people are unlike the general managers in that they do not have people reporting to them. Examples of these job titles are technical editor, market specialist, intervention coordinator, senior analyst, and market development officer.

5.5.9 General Managers

There is a common view that the move into management is particularly significant for the engineer (for example see Cordero and Farris 1992). A commonly used number is that 40% of engineers end up in a general management function. As can be seen from Figure 5.3, the figure of 40% would be approximately accurate if one looked at the mature engineers in large organizations. The numbers of salaried engineers in the What Study was slightly greater than the numbers in general management. However, the number of freelance engineers was double that in general management. The number of engineers that ended up in the Other category was also slightly greater than those in general management. One engineer from the class of 1967 was CEO of one of Canada's most profitable corporations. So the results do support that some engineers do have very successful careers in general management as do those that end up in other unrelated fields.

The importance of the concept of engineer as manager warranted a further examination of this category. An investigation was conducted to further study the possibility that, beginning around the age of 40, engineers only appear to be leaving the system because they are being promoted into general management positions. In order to conduct a test of this possibility using real data from industry, an electronic phone directory was obtained for one company that maintains several engineering departments.

Company representatives had indicated that employee levels have been reasonably constant over the past 10 years, as the company is established in a mature market. The employee directory was sorted by job title. The numbers of people were totaled by rank within the organization, with the engineers separated from the other workers. People with job titles suggesting they were in staff positions outside the line functions in the organization were considered to be front line workers on the basis that they had no people reporting to them. The job titles of the staff positions included the following examples: engineering specialist, safety coordinator, regulatory compliance officer, and taxation specialist. The non-engineering workers were assumed to include those people with job titles such as the following: plant operator, welder, administrative assistant, journeyman, pilot, truck driver, technician, auditor, clerk, nurse, customer service representative, IT analyst, legal council, accountant, and technologist. If an engineer has one of these front line positions, it would be reasonable to assume they are on a career path unlike one they expected upon graduating from engineering school and it would be unlikely that the company would seek to replace them with another engineer when they left the position. It would be difficult to argue that these people were promoted out of engineering into these particular front line positions, especially since they are not related to management, and would often be lower salary positions than a senior engineer. Front line supervisory positions were largely also assumed to be non-engineers, especially when they were people with titles such as welding foreman, supervisor - accounts payable, team leader - taxation, senior legal council, chief purchasing agent, head mechanic and supervisor - bookkeeping. However, random checks were performed using company representatives to test the validity of this assumption. For other supervisory positions such as leader - civil technologists and supervisor - financial analysis, a company representative was utilized to confirm the professional status of the individual. It should be noted that during these checks, it was discovered that some engineers are working in departments that are mostly staffed with people with non-engineering functions and they report to a supervisor that is a non-engineer. As well, 5

of the 44 engineering supervisors were not engineers in their previous jobs (for example, a senior technologist). By the definitions used for this dissertation, these people are doing engineering work and are therefore, now engineers. They are, however, also displacing front line engineers for these supervisory positions. To establish the status of the workers in general management positions, company representatives were consulted to establish the backgrounds of all the people involved. Once the numbers of people at the various organizational levels were compiled, the totals were uniformly factored to assure anonymity of the company investigated. Figure 5.5 shows the results of the study. As can be seen in Figure 5.5, the engineers as a whole make up around 11% of the total workforce at the company. Also, it can be seen that approximately 20% of the people at the company are involved in some managerial role. The sharp drop in numbers from the front line to general management levels is easily explained. If a person is two levels above the front line worker, the data for this organization suggests that on average they will have 5 people that report directly to them. These subordinates will also have 5 front line workers on average that in, turn, report to them. The manager will therefore have 30 people (5 direct reports and 25 front line workers) in their chain of command. Under these rates, the 1,951 non-engineering and 257 engineering front line workers could be controlled using only 74 managers at two levels above the front line. At the executive level, the engineers have increased proportionally to be 20% of the number of non-engineers. The numbers of engineers at general management and executive levels are about 5% of the total number of engineers at the company. Incidentally, the engineers designated as engineers in training (EIT's) in their job description total 53, or about 17% of all the engineers at the company. This is consistent with the proportion of EIT's compared with the general population of engineers registered within APEGGA. Since EIT's work 4 years before they are eligible for professional status, this would imply a hiring rate of about 13 young engineers a year at this company, or equivalent to the total number of engineers in general management at the organization. It would not be possible with this reasoning, that the 13 new hires were

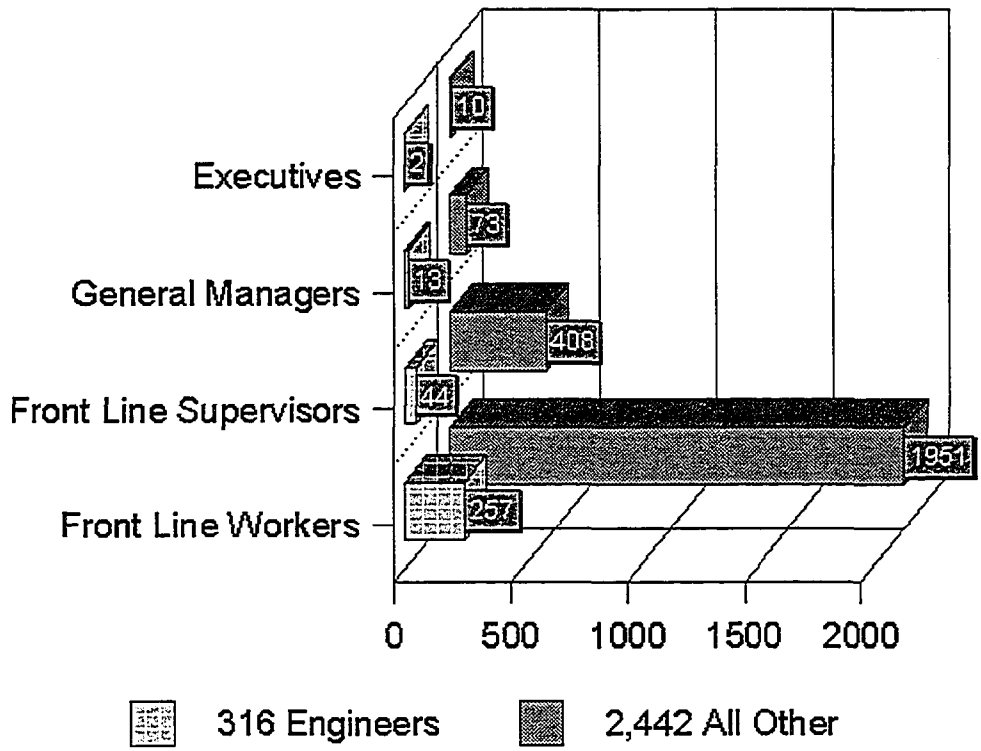

Figure 5.5: Distribution of the job levels within a large organization. The numbers shown have been evenly factored to disguise the identity of the company involved

replacing engineers that went into management every year, as this would imply 100% annual turnover for the managers. The 100% turnover would suggest that the engineers are leaving the system early, which is the opposite situation to the case for which the feasibility was being tested. If the age distribution of the general population of engineers as shown in Figure 4.5 is due to engineers being promoted into general management positions, approximately an additional 25% of the number of engineers at the company should be found in these general management jobs. In this case, that would mean 79 people, implying all the general management positions at the company would have to be held by engineers. This would displace all of the 2,300 IT, accounting, legal, business, and trades people that would also be aspiring for these same jobs. The data from the company list does not support such a scenario at any rate.

Of the executives at the firm, the three most common backgrounds in order of most to least common is accounting, business, and engineering, with the rest consisting of those from law, arts, and science. Even though engineering was the third most common background for the executives, the numbers of engineers in the executive positions represented only approximately 0.5% of the total of engineers in the organization. Considering a minimum turnover of about 4% a year within this group (on the basis of replacement at the bottom by EIT's), it is statistically much more likely that a new engineer will leave before making it to an executive position, or even into general management. For companies with larger proportions of engineers in their workforce, the ability of any front line engineer to make it into a general management position in a non-engineering area is reduced even more, because there are even a lower proportion of such positions. For companies with fewer engineers, it would be numerically possible for all the front line engineers to end up in management. However, because the numbers of engineers are smaller, they would represent a smaller proportion of the population of engineers as a whole. Also, in an organization with few engineers, the ability of the engineers to dominate the management may be reduced because of the potential lack of political clout to get the choice positions (for example, Weekes 2001). This study should make it clear that the apparent sharp drop in numbers of engineers near the early retirement age in organizations cannot be totally explained by them moving into general management positions. It strengthens the alternative possibility that they are instead choosing to retire and leave the organization. It also is in direct agreement with the findings of Dalton and Thompson (1971) discussed in the introduction. It should be noted for this study that since 20% of the company's workforce is in a supervisory role, it would seem that for any profession, movement into management is a normal progression. That the portion of engineers in management is increased compared to the general workforce is not that important considering the entire workforce of the company is composed of a lot of people that are not university trained. The findings of Useem that indicate engineers are

less likely to advance into management than arts majors is still consistent with the results of this study.

5.5.10 Salaried Engineers

This category covers engineers that work as employees in companies. This is the 'typical' engineer doing engineering work. These engineers made up approximately 5% of the group with a median age of 60 in the What Study. This would suggest that engineering truly is a job of the young. These numbers also support the findings of Pelz and Andrews in addition to all the other sources of data used in the earlier sections of this work.

5.6 Explanation of Observed Trends

One of the objectives of the What Study was to investigate the possibility that engineers are only appearing to leave the organizations because they are moving into managerial positions and no longer being counted as engineers. Figure 5.6 shows the numbers of engineers for each graduating class that belong to the categories of Salaried Engineer, General Management, and Retired. As can be seen, the former two categories are reducing at about the same rate that the latter is increasing. It would seem that the assumption that the people in engineering and management roles are in fact leaving the system is further supported by this graph.

The findings of the What Study suggest that the rate at which engineers leave the system is less than 2% a year for the first half of their career. For the ages of 49 to 55, engineers in salaried positions, including general management, retire at a rate of about of 4.5% a year. After the age of 55, these engineers are leaving because they retire at a rate of approximately 8.2% a year. This is consistent with the trend of the general membership that was presented in Figure 4.5.

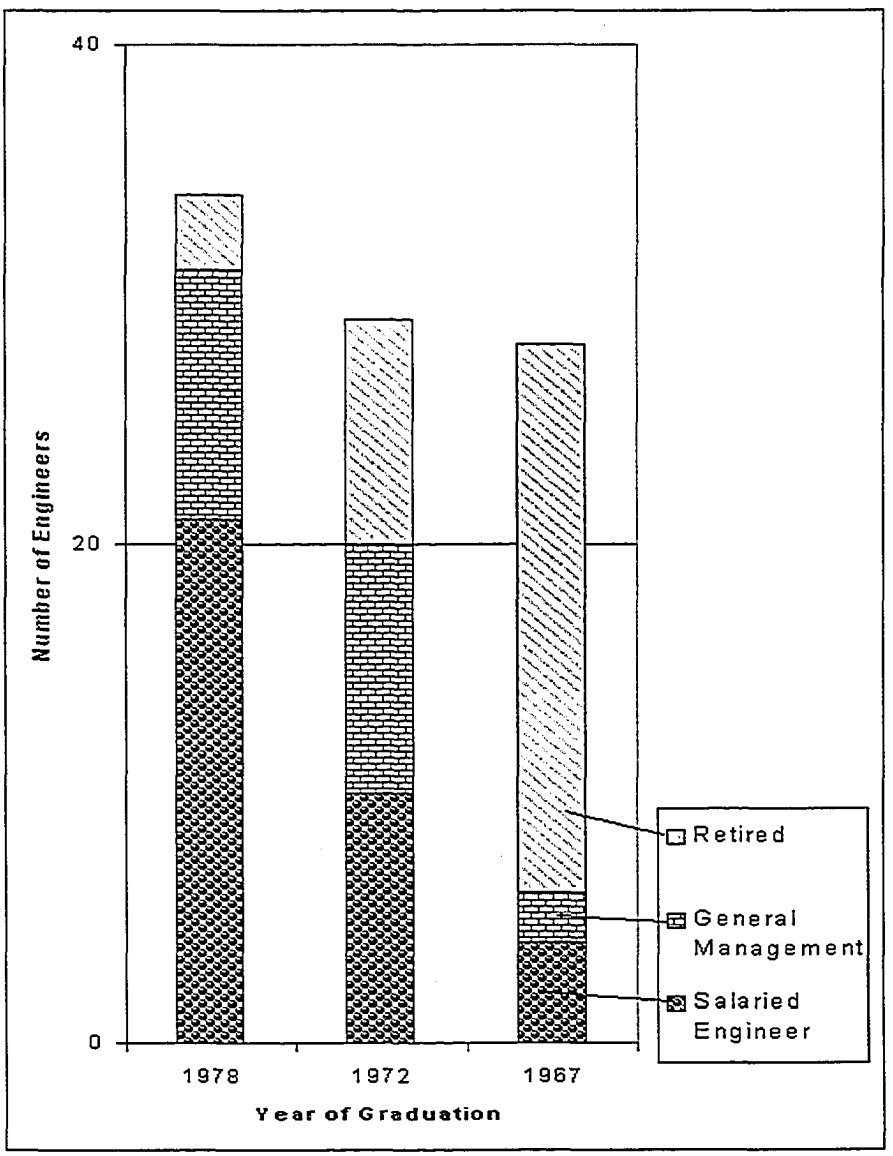

Figure 5.6: A possible explanation of the observed trends that engineers appear to be leaving organizations. The increase in the number of retired engineers approximately corresponds with the number that do not work as engineers or managers.

5.7 Statistical Analysis of the What Study

The following statistical analysis was performed using ANOVA tests in the same manner as the Statistical Tests 1 through 6, described in the earlier section.

5.7.1 Statistical Test 7

Null Hypothesis: The age distribution of the APEGGA database as determined from the sampling of the registry is not significantly different from the population of engineers still in the system as determined by the What Study.

$$H_0 : \mu_{11} = \mu_{12} \tag{5.1}$$

$$H_1 : \mu_{11} \neq \mu_{12}.$$

where: μ_{11} = the distribution of Engineers in the APEGGA membership database.

μ_{12} = the distribution of Engineers still in the system as found in the What Study.

Result: The engineers used from the What Study were those in the categories of Salaried Engineers, Freelance Engineers, General Management, EPC Engineers, and Staff Positions. The Pearson chi square test of association yields a p-value of 0.988. The likelihood-ratio chi square test of association also yields a p-value of 0.988. These values show a very strong similarity of the two populations and lead to the conclusion that the null hypothesis cannot be rejected.

5.7.2 Statistical Test 8

Null Hypothesis: The age distribution of the 2001 APEGGA salary survey results is not significantly different from the population engineers still in the system as determined by the What Study.

$$H_0 : \mu_{13} = \mu_{12} \tag{5.2}$$

$$H_1 : \mu_{13} \neq \mu_{12}.$$

where: μ_{13} = the distribution of Engineers in the 2001 APEGGA salary survey.

μ_{12} = the distribution of Engineers still in the system as found in the What Study.
Result: The engineers used from the What Study were again those in the categories of Salaried Engineers, Freelance Engineers, General Management, EPC Engineers, and Staff Positions. The Pearson chi square test of association yields a p-value of 0.005. The likelihood-ratio chi square test of association also yields a p-value of 0.005. These values lead to the conclusion that the null hypothesis can be rejected at a confidence level of 99.5%.

5.7.3 Statistical Test 9

Null Hypothesis: The age distribution of the APEGGA database as determined from sampling of the registry is not significantly different from the population of engineers in the What Study that work for companies that submit APEGGA salary surveys.

$$H_0 : \mu_{11} = \mu_{14} \tag{5.3}$$

$$H_1 : \mu_{11} \neq \mu_{14}.$$

where: μ_{11} = the distribution of Engineers in the APEGGA membership database.

μ_{14} = the distribution of Engineers working for companies that submit APEGGA salary surveys as found in the What Study.
Result: The Pearson chi square test of association yields a p-value of 0.968. The likelihood-ratio chi square test of association also yields a p-value of 0.968. These values show that there is also a very strong similarity between the two groups. This leads to the conclusion that the null hypothesis cannot be rejected.

5.7.4 Statistical Test 10

Null Hypothesis: The age distribution of the 2001 APEGGA salary survey results is not significantly different from the population of engineers in the What Study that work for companies that submit APEGGA salary surveys.

$$H_0 : \mu_{13} = \mu_{14} \tag{5.4}$$

$$H_1 : \mu_{13} \neq \mu_{14}.$$

where: μ_{13} = the distribution of Engineers in the 2001 APEGGA salary survey.

μ_{14} = the distribution of Engineers working for companies that submit APEGGA salary surveys as found in the What Study.

Result: The Pearson chi square test of association yields a p-value of 0.327. The likelihood-ratio chi square test of association also yields a p-value of 0.332. These values show that the differences between the two groups is not significant. This leads to the conclusion that the null hypothesis cannot be rejected.

5.7.5 Implications of the Statistical Analysis

A summary of the statistical tests appears in Table 5.4. The engineers that were involved in the What Study were also investigated regarding their employer. Figure 5.7 shows the numbers of engineers that are employed by companies that complete the APEGGA salary survey. The expected number is the proportion of the graduating class that would be included in the salary survey if the employees of these companies were evenly distributed by age. The question was raised whether the numbers of engineers reported in the survey decreases by age mostly because they are leaving or because the personnel completing the information are miscounting. The results tend to support the former because the numbers of engineers at the firm has dropped by approximately 50% over the 11 year range of the What Study. If the engineers no longer work at the company, it is more evident as to why

Test	Total size of sample tested.	Smallest population within total	Null Hypothesis	Conclusion	Confidence Level
7	642	124 where:	$\mu_{11} = \mu_{12}$ μ_{11} = the distribution of Engineers in the APEGGA membership database. μ_{12} = the distribution of Engineers still in the system as found in the What Study.	Cannot reject	n/a
8	3,438	124 where:	$\mu_{13} = \mu_{12}$ μ_{13} = the distribution of Engineers in the 2001 APEGGA salary survey. μ_{12} = the distribution of Engineers still in the system as found in the What Study.	Reject	99.5%
9	549	31 where:	$\mu_{11} = \mu_{14}$ μ_{11} = the distribution of Engineers in the APEGGA membership database. μ_{14} = the distribution of Engineers that work for companies that complete the APEGGA salary survey as found in the What Study.	Cannot reject	n/a
10	3,345	31 where:	$\mu_{13} = \mu_{14}$ μ_{13} = the distribution of Engineers in the 2001 APEGGA salary survey. μ_{14} = the distribution of Engineers that work for companies that complete the APEGGA salary survey as found in the What Study.	Cannot reject	n/a

Table 5.4: Summary of the statistical tests between the previously published age distribution data and the What Study results.

Median Age 49	
Employer Organization	**Count**
Operating Company	5
EPC Firm	3
Government	3
Service Company	2
Median Age 55	
Employer Organization	**Count**
Operating Company	4
EPC Firm	3
Government	3
Service Company	1
Median Age 60	
Employer Organization	**Count**
Operating Company	1
EPC Firm	2
Government	3
Service Company	1

Table 5.5: Count of engineers by age and organization type: Employer completed the APEGGA salary survey - the What Study.

they are not showing up in the survey. It is not a matter of how the survey is completed, but rather that the numbers do reflect the actual situation within in these companies. The assumption made in the analysis of previously published data that the results of the survey are relevant is supported by the What Study.

Table 5.5 shows the types of organizations that employ the engineers that are part of the APEGGA salary survey. As can be seen, the number that work for operating companies decreases with age, but the numbers for the government and EPC firms is level with age. The one engineer that works for an operating company in the 60 year old group is the CEO. The higher proportion of engineers by age that work in government organizations supports the findings of Pelz and Andrews.

The age distributions of the categories in the What Study support the implications suggested from the earlier analysis of the available data. The results of the What Study

show a very strong similarity in the age distribution of the group still in the system to that of the APEGGA general membership. The results of the statistical test between the engineers in the system and the APEGGA salary survey show that the two groups are significantly different. This is easily explained by the fact that the category of Freelance Engineers was the largest single category and these engineers are not a part of the salary survey. Since all the Freelance Engineers interviewed indicated that they had originally worked in large companies, the sharper decline in numbers with age in the survey would be expected.

The tests between 1.) the engineers in the What Study that work for companies that complete the APEGGA salary survey, 2.) the general membership, and 3.) the data from the APEGGA salary surveys suggest that the administrative groups completing the survey may not be accurately representing all the engineers within their company. Although the results were not significantly different between the study and the survey, the engineers in the study that work for these companies are closer to the general membership in distribution than they are to the reported distribution in the survey. The inaccuracy of the survey population can also be demonstrated by another finding. The one engineer from the 60 year old group that is CEO of a large company earns a salary significantly higher than the highest salary reported in the survey, as confirmed by an APEGGA representative. Therefore, the HR group that completed the survey for that company did not include this executive in their submission. However, the APEGGA salary survey distribution was not different enough from that measured in the What Study for these omissions to be statistically significant. Another complication is that the population represented by the APEGGA salary survey distributed by age is only a subset of the population of the companies that complete surveys. This is clarified in Figure 5.10. One can see that the population represented by the APEGGA salary survey includes employees that are not engineers, and misses reporting on some engineers. As well, the number of engineers for which their organizations included the year of graduation with the survey

submission is only about half the total number of salary surveys submitted. Pelz and Andrews found that government organizations tend to have a larger proportion of mature engineers. Table 5.5 also tends to support this finding. The representative from APEGGA confirmed that many of the government organizations are among those that do not submit information on age. The lack of significance in the findings for the group of engineers that work for the companies that submit salary surveys is also impacted by the very low numbers of mature engineers that still work for these organizations anyway.

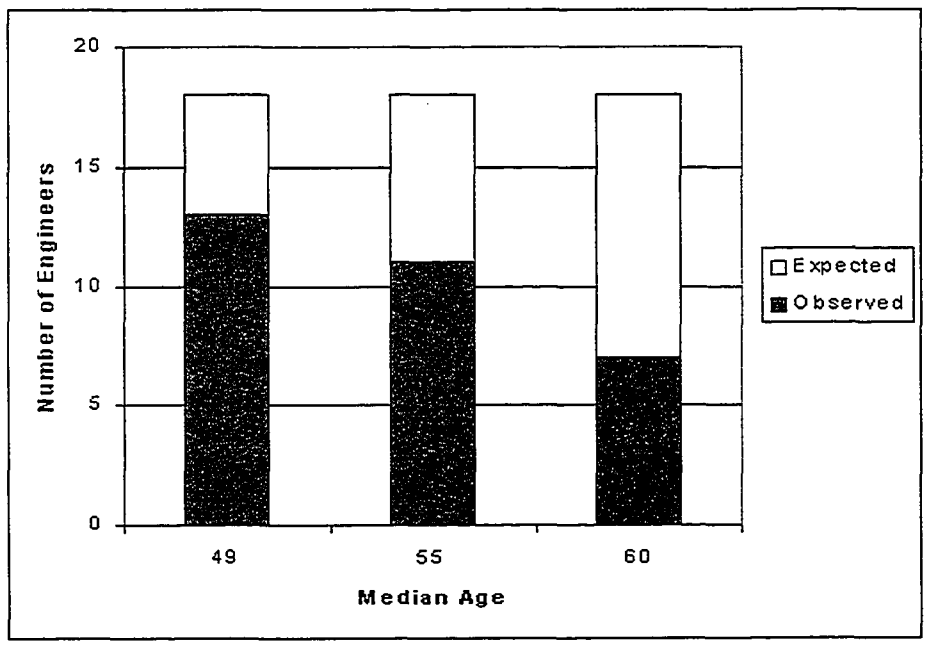

Figure 5.7: The number of engineers in the What Study that work for companies that submit an APEGGA salary survey.

5.8 Engineering Work

A detailed examination of the question of what constitutes engineering work is outside the scope of this study. However, the participants in the telephone survey were asked if they are currently doing engineering. The job descriptions that fit the definition of engineer as

provided by the CETS Panel are those that belong to the following categories used in the What Study: Salaried Engineer, Freelance Engineer, and EPC Engineer. Figure 5.8 shows that 33 of the 34 of these engineers stated that they are currently doing engineering. The one engineer that did not think he was doing engineering was a front line supervisor of engineers. He stated "I do no technical engineering, and I have not done any for 24 years." The other front line engineering supervisors all felt they were doing engineering.

Figure 5.9 shows the answers given by 3 of the 5 remaining categories of engineers, namely: Other, General Management, and Staff Positions. The Retired category does not practice by definition, and the Professor category is treated separately. One of the engineers from the group in Figure 5.9 stated they were doing engineering, but their job title is Sales Manager at a company that does not have a permit to practice engineering. This was not considered to be engineering according to the definitions used in this dissertation because of the specific exclusion of both general management and sales by the CETS Panel. According to Alberta law, the employer of the engineer is required to have a permit to practice if engineering is being done. Another engineer from this group that stated they do engineering is in general management. The rest of the General Management group stated that they are not practicing engineering.

From the answers to the question of whether the engineer is doing engineering work, it appears that, in general, the engineers themselves agree with the CETS definition of engineering work. There were a few individuals (representing less than 5% of the test population) that did not agree with their own placement. However, the CETS panel acknowledged that resolution of a definition of engineering that satisfied all stakeholders would require a large expenditure of resources, without confidence that a solution would ever be reached.

The one group for which 100% of the participants stated they do engineering was the group of engineering professors. The inclusion of professors in the group of engineers that are engaged in engineering, as they state they are, or placing them in the group that

does not do engineering, as the panel of 5 mature engineers from industry stated, is not very relevant to this study. It should not warrant resolution because of the very low numbers represented by professors in the overall population of engineers and the inclusion of them in one group or the other would have no significant impact on the findings. However, it is a very emotionally charged issue that could tie up future discussions on the career paths of engineers. A review of the APEGGA publications indicated that professors have an active participation rate in the organization and the policies that impact the regulation of the profession. Of the 231 engineers that volunteer on APEGGA boards and committees, 18 (7.7%) are professors from the University of Alberta or the University of Calgary. This is 7 times higher than their representation in the general membership as was determined earlier. Hence, it may be more prudent to include them in the group that does engineering. However, the activities performed by a professor do not closely resemble those of the engineers studied by Zhou (1998) or the nature of the engineer's duties as studied in the Why Study of this study.

5.9 Comparative Income Data

Hale (2004) reported on an American study conducted by the National Society of Professional Engineers (NSPE). Over 20,000 practicing engineers completed surveys through the NSPE website. Job function was broken down into 11 categories including Higher Education Instruction, Research / Development, Quality Management, and Sales. The job function category that had the lowest median salary was Design at $58,000 USD. The job function with the highest median salary was Executive / Administrative / Legal at $111,300. Hale states:

> *There are times when employees who work in a large companies may daydream about what it would be like to work in a smaller company where there is less red tape, your plans have a better chance for implementation in a more timely fashion, and you don't spend countless hours/days/weeks in what appears to be*

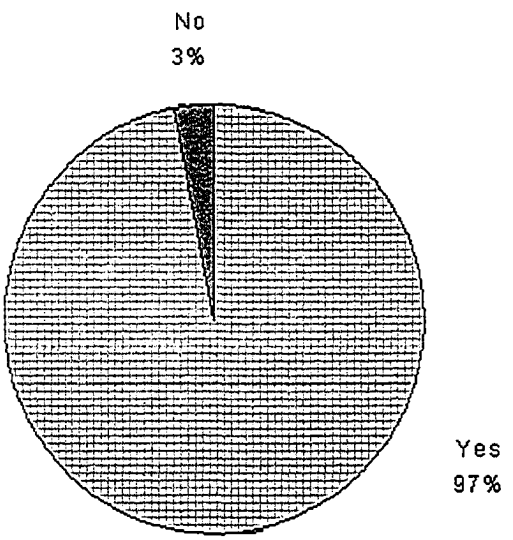

Figure 5.8: Distribution of Salaried Engineers, Freelance Engineers, and EPC Engineers' answers to whether they are currently doing engineering.

> *the a continuation of the same meeting. That is where the trade-off comes in. If you work in a large company, your compensation will be higher.* (p.35)
>
> plus
>
> *If you have a Ph.D. in engineering, your median income is $93,250, but if you have a doctorate in a non-engineering area, your income is nearly $10,000 more at $102,650.* (p.34)
>
> and finally
>
> *... if you are a boss, a teacher, or a salesperson, you have a higher likelihood of earning more than if you are truly producing product...* (p.34).

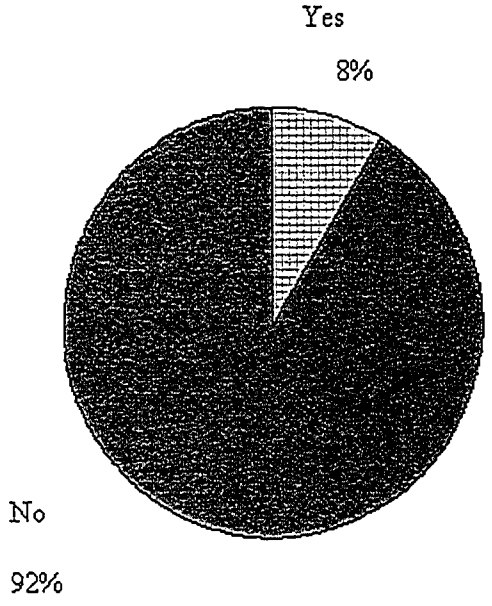

Figure 5.9: Distribution of General Management, Other and Staff's answers to whether they are currently doing engineering.

From the reports of the more than 20,000 participants, it would appear that the traditional engineer involved in the design of something has the lowest paid job function of all the categories investigated.

5.10 Summary of the What Study

The graduates of 9 engineering classes between 1967 and 1978 were tracked down to determine their current situation. Data was obtained for 225 of the 270 potential participants.

The careers of engineers were found to not follow a typical pattern. Figure 5.11 is a graphical representation of the distribution of engineers by job function following graduation. The values for the periods prior to 25 years after graduation were estimated

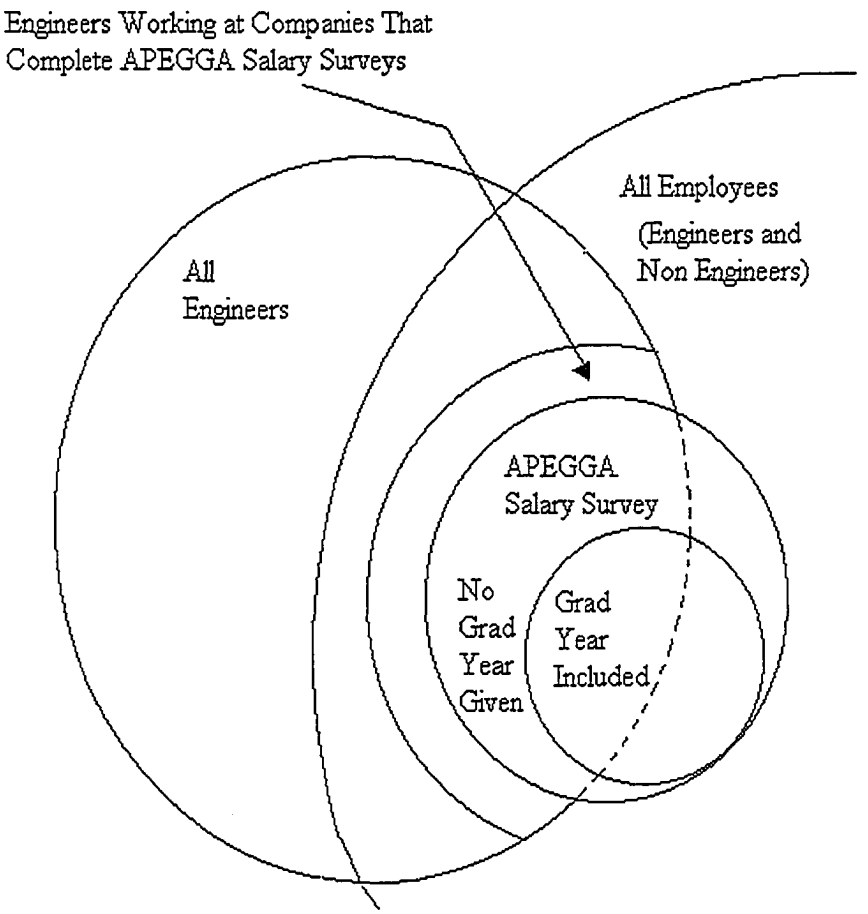

Figure 5.10: The populations represented by the data sources used.

from the findings of the What Study and enhanced by the descriptions provided by the participants in the Why Study and the smaller studies. All of the Freelance Engineers asked about their past had started their careers as Salaried Engineers, for example. Salaried Engineers appear to leave their jobs at a high enough rate so that very few (5%) are still at this job category at the end of their careers. The values in Figure 5.11 are not meant to suggest that the same individuals are in each job category throughout their career. In fact, examples were found during this study of engineers leaving each of the

categories and going into one of the other categories at different points in their careers. The only exception is that no ex-professor was found currently in another category.

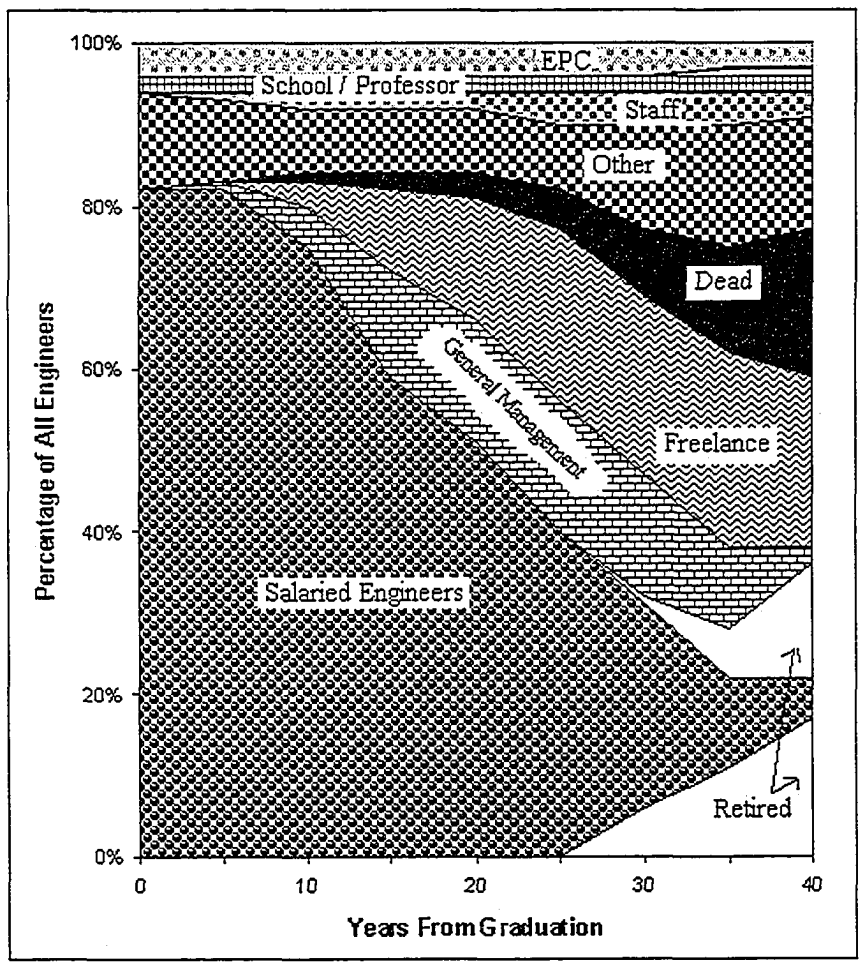

Figure 5.11: Distribution of engineers by job function.

The results of the What Study suggest the following conclusions:

- Engineers are not a homogeneous group concerning their careers and types of employers.
- Engineers that work in salaried positions leave the system at a rate similar to that suggested by the available data.

- Freelance Engineers make up a significant portion of mature engineers and this group is not working the equivalent of full-time employment. Also this group tends to originate from the engineers working in salaried positions at a younger age.

- The Retired group and the Freelance group made up approximately half of the engineers 55 and over. Returning the Retired group to employment and putting the Freelance group on full time work would create an input of fully trained and experienced engineers greater than the annual input of junior engineers at the other end.

- A significant portion of mature engineers are involved in careers unrelated to engineering.

- EPC firms are minor employers of engineers. However, these companies do not have the same departure rate as the general population of engineers. Along with the government employers, EPC firms retain their levels of mature engineers. For the group with a median age of 60, these employers become very significant for the engineers still in the system.

- A move into management does not explain the observed reduction of engineers in organizations. Proponents of this view are not supported by the findings of this study.

- In general the engineers performing engineering duties as defined by the the CETS Panel viewed their work as engineering. For the engineers not performing engineering as defined by this panel, most also agreed that they were not performing engineering. The professors were the noted exception to this finding.

Since the results of the What Study confirm the conclusions suggested by the literature and the analysis of the available data, an exploration of the factors producing these results was in order. The Why Study was developed to address the question of the value employers place on the experience these mature engineers gained during their careers.

CHAPTER 6

FIELD STUDY 2 - THE WHY STUDY

6.1 Research Design and Methodology

Once the results of the first study were analyzed, questions naturally developed around what could be some causes behind the trends observed in the review of the literature and re-confirmed in the field. For one, why were the identified groups behaving in the observed manner? In order to answer these questions a separate experimental design was required. A review of possible methodologies was outlined in the previous chapter. Using a similar analysis for developing the experimental design and methodology as was used for the What Study, all identified alternatives for conducting research were reviewed. The result of the analysis as it pertains to the Why Study is outlined in Table 6.1.

Method	Example	Advantages	Disadvantages for use on the Why Study
Laboratory Experiment (Note 7)	Duggan and Thachenkary (2004)	Controlled variables, highly repeatable methods.	Not feasible (Note 8), results may be meaningless (Note 9)
Mail or Web-based Survey (Note 10)	Laws (2004)	Convenient, ease of statistical analysis, fast turnover of projects / papers	Typically low response (<10%), questionable reliability, difficult to formulate questions in advance, iteration required.
Telephone or in Person Survey	Mitchel (2002)	Higher response rate (>50% on cold calls), convenient, immediate feedback on potential sources of error.	depth limitations
Secondary or published sources	Ojala (2002)	Convenient, draws on analysis of others	Data may not exist, be inappropriate or incomplete.
Critical Incident and Sequence of Events	Bradford (2003)	In-depth analysis of single factor, intense probing	Some factors not investigated, low transferability
Diary	Cortvriend (2004)	Efficient, many people collecting data	Not feasible, verisimilitude
Activity Sampling	Towill et. al (2002)	Efficient, recorded by researcher, ease of statistical analysis	Non-continuous, difficult, no historical record.
Participatory Action Research (Note 11)	de Guerre (2002)	Researcher can develop new dimensions, effective at probing and exploring (Note 12)	Difficult to replicate, inefficient, not feasible for long time horizons
Structured Observation	Mintzberg (1973) (Note 13)	Researcher can develop new dimensions, effective at probing, structured	Not feasible for long time horizons, difficult to interpret some activities
Interviews (Note 14)	Whitehead (2004)	Flexible, in-depth, low impact, direct to source, feedback on analysis	Time consuming, difficult to find some members of population

Table 6.1: Research methods considered for exploring the factors behind the observed trends, the Why Study.

Notes to Table 6.1 (sequential numbering from Table 5.1)

Note 7. In addition to the comments presented in the review of methodologies, Gill and Johnson (2002) provide an evaluation process and the topic of 'the careers of engineers' seems best suited for unobtrusive as opposed to obtrusive methods of study.

Note 8. According to engineering management researcher, Zhou (1998), the process of scientific discovery can be represented by a continuous loop that connects theory, hypothesis, data and generalizations. When considerable data exists, the scientist starts with known theory. From this a new hypothesis can be derived through deductive reasoning. An experiment can be modeled to collect data which tests the new hypothesis. From this a new generalization and theory can emerge. Kuhn (1970) noted that deductive methods are useful for testing and confirming theory, but are very limited in actually discovering anything new. Zhou points out that inductive research begins with the data collection phase and from the observations. New generalizations, theory, and hypotheses can then emerge from the data.

Note 9. Duggan and Thachenkary (2004) note that the results of their experiments may have limited application to the working world and other methods would be required before these results could be applied to a real work setting.

Note 10. Citing the example of the Ohio State Leadership Studies, Mintzberg (1973) notes that after almost 20 years of data collection, ending in the mid 1960's, the great quantities of data collected have received little interest. The problems are stated as being related to inappropriate data and inappropriate dimensions. The inappropriate data derives from the discrepancies between what managers do and what they report on questionnaires relating to what they do. Without a mechanism for expanding on the answers, there is no way to determine what

the level of discrepancy is. The inappropriate dimensions resulted from the emphasis on analyzing the data collected from predetermined questions, and almost no emphasis on the background of the questions being asked. The data reflected a situation determined by the structure of the questions asked and not an inductive conclusion resulting from the system under study. As well, Lewis (2001) notes that all the surveys being conducted by different bodies are tending to decrease the public's interest in them. Political polls are becoming less reliable because the participation rate of people being approached is dropping. It is now typical to get only 15% participation rate, therefore the characteristics of the people agreeing to be sampled are becoming less representative of the general population.

Note 11. The data Chris Argyris used to formulate his theories was typically obtained by participant observation and included interviewing to follow up on survey results (Argyris 1994).

Note 12. Mintzberg (1973) states that the inductive approach has great advantages over other methods when applied to management. The researcher is able to proceed when little prior data is available, new dimensions can be explored and developed, and rich data can be probed for further analysis.

Note 13. Mintzberg selected structured observation for his classic study of managerial work. This method has many of the strengths associated with unstructured observation, but it has the additional advantage of a systematic approach and therefore greater repeatability. Mintzberg notes that structured observation is inefficient in comparison to the other methods. As stated in more detail in Chapter 5, Gill and Johnson note that Mintzberg developed his taxonomy of managers after field observations of only five managers.

Note 14. As noted earlier, Herzberg et al. (1959) regarded interviewing with engineers to be particularly effective. Other examples of successful studies that show the usefulness of semi-structured interviewing in certain circumstances are as follows:

- Clark and Colling (2005) studied the lack of engagement between engineering project management and human resource literature through semi-structured interviews.
- Pilgrim et al. (2003) used semi-structured interviews to improve the interpretation of on-line survey results for the low use of computer modeling in the construction industry.
- Semi-structured interviews provided Wood and Ellis (2003) with rich data suggesting that, although there is a positive emotional response to Risk Management techniques, clients with limited budgets are less likely to pay extra for these services.

6.2 Research Method

It was determined that the most effective method to obtain data relating to the factors that determine the career paths of engineers was through semi-structured interviews, similar to the tradition utilized by Herzberg. It must be noted that very few other methods would be feasible and the remaining alternatives have been noted to be of questionable reliability. The methods used by Herzberg served as models for the development of the Why Study. The permission by the University of Alberta to conduct the interviews was again contingent upon approval by the Faculty of Engineering Research Ethics Board. In following with the methods used by Herzberg and subsequently adopted by researchers such as Campbell (2004), Stimpson (2004), and Fottler et al. (1995), the use of open-ended questions increases the validity of the responses received. As Herzberg noted, there is a

particular strength in a theme if the participants volunteer a particular concept such as a lack of money to a general question about their job situation. As Mintzberg suggests, results from a questionnaire that asks the participants' opinions about money has less strength in the findings since the researcher has already determined that money is a factor to be explored by putting the theme into the question. In light of this, the researcher for this dissertation took considerable care to not introduce bias by leading the discussion. It was felt that it is preferable to miss data than to risk introducing a theme by leading the participant in a particular direction. The procedures used and results obtained were reviewed by a methodology expert to ensure this principle was adhered to. Through this method of data collection, if a number of independent participants from different organizations volunteered similar information, this was seen as a strong indication of the validity of a particular theme within a sector of the population of engineers under study.

The participants were selected in the tradition of theoretical sampling, as outlined in Chapter 2. To obtain potential participants from the mature engineers that were practicing engineering at the time of the interview, a seventeen year old high school student was selected to pick names from the APEGGA membership registry. The random number generator developed for the age distribution data was now used to pick a new set of numbers and the high school student located the APEGGA member represented by each of those numbers. They were then instructed to use that position as a starting point for locating a potential participant with the following characteristics:

1. Professional Engineer.
2. Located within 25 kms of Edmonton, Alberta due to travel budget constraints.
3. Continue and find a number of potential participants that graduated in the 1960's, 1970's, and 1980's.

Using this random technique, 10 engineers were selected and interviewed. Pelz and Andrews noted that a shortcoming of their research was the inability to study any subjects

that had left and were outside the organizations they were at. As well, Drucker had noted that much useful information can be learned from those that are not still within the system being studied. Therefore, additional participants were sought that were not working within the system and may not be found by selecting from the registry of practicing engineers. This was achieved through a snowball sampling technique as outlined by Frankwick et al. (1994). Out of the proceedings of the interviews of the randomly selected participants, another 2 engineers were referred to the interviewer as having stopped practicing engineering early in their careers. These 2 engineers were contacted and also interviewed. From the telephone surveys in the What Study, another participant was selected on the basis of their stating they were contemplating leaving engineering in a few months at the age of 55. During a casual conversation with a third party individual who expressed great interest in the study, another participant was suggested due to their having left the engineering profession because of a bad experience with a large operating company. The potential participant had been fitting into the job from management's perspective and all indications pointed to a successful engineering career. The engineer, however, joined the city of Edmonton police force with no apparent intention of returning to the profession. These participants then made up the 14 engineers with whom in-depth interviews were conducted. In the grounded theory methodology, the number of participants or sample size is determined by the objective of reaching saturation, as demonstrated by IT researchers Sarker et al. (2001). The theory should only be considered developed when no new ideas or evidence emerges from further data collection. As noted above, Mintzberg was able to build his theory on the nature of managerial work based on the data collected from shadowing 5 senior executives for one week each (Gill and Johnson 2002). This dissertation used many different sources of data for triangulating the results obtained from the in-depth interviews in keeping with procedures established for multi-method investigations.

In order to address and mitigate the potential errors introduced by bias, the potential sources were investigated and considered prior to the beginning of the interview

process. Smith (1981) describes sources of error and those applicable to this study were considered. A summary of these follows:

- Knowledgeability - In order to ensure that the interviewees are knowledgeable of the topic, the questioning was limited to self-reporting of personal experiences. Although the interviewee may have been aware of more information about acquaintances, this information was followed up through the snowball sampling technique as referenced above (Frankwick et al.) It is unlikely that the interviewees did not have an understanding of the topic concerning their own careers and aspirations.

- Reactive Effects of the Situation - It is possible that the interviewees would be concerned about providing answers perceived to be the correct ones. Using Herzberg's practice of beginning with situations that help establish the circumstances behind the message, this was likely reduced to an acceptable level. Further, by not revealing the topic of the research until after the questioning, it was hoped that any potential resulting bias was minimal.

- Ulterior Motives - It was made clear to the interviewees that no information that could identify them would be used in the published results. As well, it was mentioned that there is a very remote chance that any results from the study would be somehow used to change their particular situation and their benefit of participation was more at a self gratification level.

- Idiosyncratic Factors - It is possible that certain major current events may have influenced the behavior of a participant in a way that was out of the ordinary for that person. By continuing the interviews over a period of time, and requiring the project to reach saturation, it is believed that idiosyncratic factors may have only created minor, if any, aberrations.

- Reportorial Ability - It is felt that an in-depth interview will reduce any error caused by the interviewee incorrectly communicating a particular point. Again, the use of

situational examples hopefully reduced the chance of an interviewee conveying an unintended answer.

- Bars to Spontaneity - It is considered that the sense of professionalism in engineers as reported by Badawy (1978) reduced errors caused by lack of a willingness to participate on the part of the interviewee. Also, the ethics requirements of obtaining full informed consent on the part of the participants should have deselected any of those that would be reluctant to provide information. Further, it is felt that since the interviewing was held in neutral environments, such as coffee shops and other public places, there was a lower chance of the interviewee being pressured to limit their answers.

The 14 in-depth interviews were conducted in the manner required under the proposal to the Faculty of Engineering Research Ethics Board. The interviews were tape recorded and transcribed. The transcriptions of the initial interviews were reviewed by an independent and qualified researcher to ensure the techniques used were in keeping with traditional research standards. Modifications were made to ensure the highest standards toward validity, reliability and credibility were maintained. One alteration that was made in subsequent interviews was to reduce the impact of the interviewer in order to increase the spontaneity of the responses of the participants. It was felt that the risk of losing important rich data due to the lower use of skills of the interviewer was less significant than the ability to demonstrate that any qualified interviewer would get similar responses from interviewing the same participants. As well, care was taken to not lead the participants into certain areas of discussion. The general questions were used as a framework for the interview. The appearance of recurring themes was the result of the participants independently providing them, which strengthens the validity of the results obtained. If a participant did not discuss a particular theme, the researcher did not introduce the subject. This creates a situation where some data may not be gathered in an interview, but again, it strengthens the validity of the themes presented. Rubin and Rubin

Standard Questions	Follow-up Prompts
Please give me an outline of your career as an engineer starting with summer work (if any) then graduation until today	
Can you think of a particularly important event that had a lasting impact on how your career developed? Tell me about the details of that event.	How did your attitude impact how you approached your work?
(Wording adjusted to suit the age of the participant) What are/were your objectives or expectations for a career when you were/are starting out as an engineer?	Mature engineers only: Were your expectations at the beginning of your career much different than the direction your career took? Mature engineers only: Have you noticed any changes to the way you approach your job over the duration of your career?
Was there a time that you felt the need to change your job situation?	If so, what action did you take? How comfortable were you with your action? What were the consequences?
Are there any changes you would make to your current job if you were in a position to do so?	What do you feel would be the impact of these changes?
Do you believe there is a noticeable difference between engineers' abilities at different stages in their careers?	Can you provide examples?
Is there anything else you think I should know?	

Table 6.2: Questions used to guide the semi-structured interviews, the Why Study.

(1995) was used as one of the key references for building a strong foundation in standardizing the interviewing techniques for data collection.

The questions used as a guide to solicit data from the participants are shown in Table 6.2. The interviews averaged about 1 hour in length with the shortest taking 45 minutes and the longest taking 2 hours. The interviews resulted in 260 pages of transcripts. These transcripts were analyzed and coded according to major themes that were repeatedly expressed by the participants during the interviews. The themes were then grouped in order to build an understanding of the complexities at work. Following the established practice for such work as outlined by Anderson et al. (2003), several of the

transcripts were coded independently by experienced qualitative researchers. Such comparative coding can identify similarities and differences in the coding process. Discrepant interpretations were used to identify areas for further exploration, reinforced the investigator focus, and enriched the data interpretation. This contributed to a systematic and rigorous development of the code categories and subcategories as they evolved.

6.3 Results

6.3.1 Procedural Results

A total of 14 interviews were held. They ranged in duration from 45 minutes to 2 hours. The conversations were transcribed into 260 pages of text. The transcripts were reviewed and from them were drawn 371 data points with a particular depth of concept. These points were then coded into 30 recurring themes. The list of all themes identified appears in Appendix F. The themes that were mentioned less frequently (by only two or three participants) do not appear in elsewhere in this dissertation. The themes that were mentioned by all or most of the participants are referred to as 'strong' themes, those that were mentioned by about half the participants are referred to as 'common' themes, and those that were mentioned by only a few (but more than three) participants, but carried particular importance for those individuals are referred to as 'nascent' themes . Some of the particularly revealing quotes are presented along with the interpretation of the results in the body of this text and other typical comments are included in Appendix C.

Due to the small numbers of mature engineers in the field, providing a detailed breakdown of the individual characteristics of the participants would likely lead to providing enough information to reveal their identity. One participant noted that when he solicits bids from EPC firms, he is surprised by the number of names that repeat on each of the firms' lists of key resources. When a certain special skill is required, there are a very limited number of people that can be called in to do the work, and each EPC firm must draw from the same small pool. As another example, a table that stated year of

graduation, engineering discipline, and current job as professor, would often provide enough information to pinpoint the identity of the individual. (It must be noted here that no professors were interviewed during the Why Study). The characteristics of the participants at a summary level are provided in Table 6.3.

It was also decided that to attribute quotations to a particular participant (for example stating 'Participant 1A stated that') would be a major violation of the ethics requirement to assure anonymity. It would also be a deviation from the established procedures for performing solid qualitative research (for example see Creswell 1995). Since the population of mature salaried engineers employed in Edmonton is of the order of magnitude of about 100 per year of graduation, it would be foreseeable that comparing quotes from one participant could pinpoint their identity. Also to quantify the numbers of participants that provided comments on a subject could also provide evidence that an individual identified elsewhere likely held this particular view. The following is a hypothetical example of an analysis where the anonymity of the participant could be jeopardized. If it stated that 10 of the 14 participants reported a large part of their job dissatisfaction derived from their relationship with their direct supervisor, and elsewhere it stated that 4 out of 14 reported not having direct supervision, then the boss of a participant could conclude their subordinate reported having a poor relationship with them. During some of the interviews, the participants were assured that the data would be presented in such a way that such conclusions could not be drawn. Although the protection of the participants may produce less texture in the presentation of the data, the current high focus on ethical conduct in research must be given a higher priority. Failing to honour such trust may jeopardize participation in future research attempts.

6.3.2 Participants' Careers

Figure 6.1 shows the distribution of the duration of the jobs held over the careers of the participants in the Why Study. The average job lasted 7 years and the median was 4 years.

Characteristic	Value
Earliest Grad Year	1961
Latest Grad Year	1995
Discipline at Graduation	Chemical, Electrical, Mechanical(5), Civil(4), Petroleum(2), Bio Resource
Currently doing Engineering Work?	Yes (8) No (6)
Category as per What Study	Freelance, EPC Engineer Retired, Salaried, General Management, Other

Table 6.3: Particulars of the 14 participants in the Why Study.

Two of the engineers only had one employer over their careers, one for 20 years in industry and the other for 30 years with the government. Another engineer had two employers over 23 years, with an agreement between the new and former employer to maintain the engineer's continuous employment.

6.3.3 Job Security

The theme of job security was a strong theme and was mentioned frequently by the participants. Many of the instances where the engineer quit one job for another was due to a sense of greater job security at the new position and their salary may not have been better. In one instance the engineer went into farming after 4 of his employers failed to stay solvent in a 10 year period. Another engineer stated that management recognized the opportunity to pay the mature engineers less money because of their unwillingness to leave the organization. This was also tied to the pension plan available to long term employees:

- *...most of the older people 10 or 12 years plus are on the defined benefit pension plan. So you get 15 or 20 years and it gets more difficult to leave. There were about half a dozen people who were in that situation and they had not moved up the ranks and you do not want to be in your mid 40's and be looking for a job. I do not know if it was conscious or not, but management felt that they were locked into this job and they did not have to pay them top dollar. The younger people are on the dollar purchase plan.*

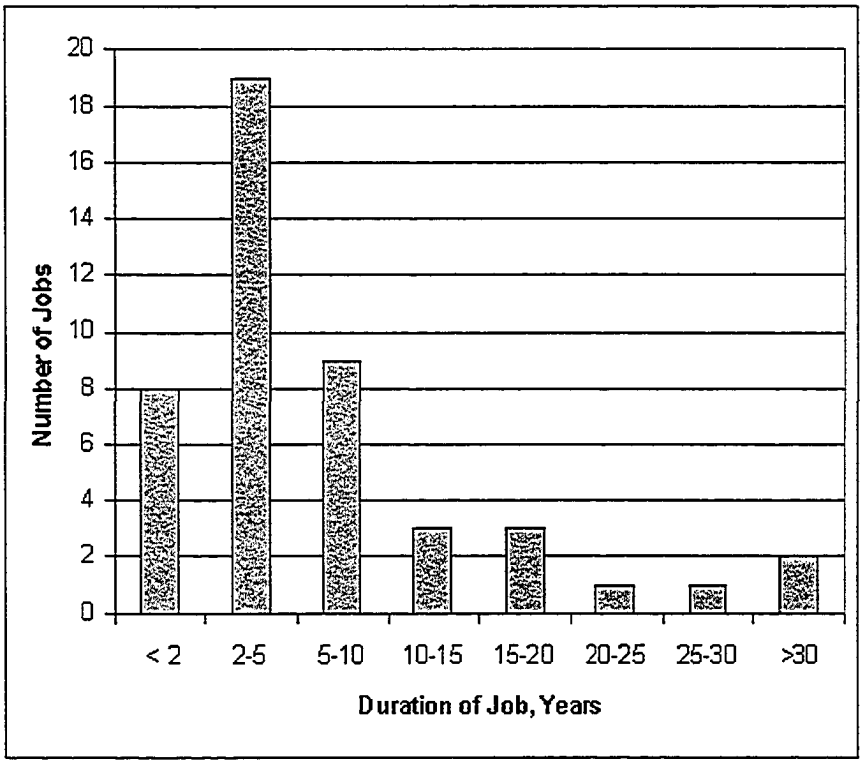

Figure 6.1: Duration of each job held by the participants - the Why Study

So they are much more portable. And they see their pension is portable so they were butting up against the salary. They do not have the same strings.

Others reported that they knew many of their peers who had difficult times finding and holding jobs. In 1980, the Canadian federal government unveiled their National Energy Program (NEP) (James 1990). The Canadian government installed pricing regulations on petroleum produced in Canada. The oil companies selected more investments in other countries where the commodity produced would reach a higher price on the global market (Berkowitz 1985). Some of the participants held this program in particular to be responsible for many Alberta engineers being unable to get work after key oil related projects in the area were cancelled. The poor market for engineers during the 1980's may have been partially responsible for their attitude towards job security:

- *It was just that I was pretty young and it was more of a learning thing. I did not understand these things. Just learning that the world economy can impact you personally. I never had a grasp of that before and when it hits you personally you start grasping at it. A lot of people my age, virtually all my friends were out of work at that point [mid 1980's] and jobs were tough to come by. So when an opportunity came from what I felt was a quality employer I grabbed onto it and I have been reluctant to [leave] through the years, even if things have not gone so well, because the recognition that the economy can change, through the rough times I hung in there. I value the stable employment.*

- *After graduation in the summer 1985, I looked for work, but it was a slow time for engineers. I was offered and accepted a job with [company name] as a rodman on a survey crew. It paid $8/hr. I graduated with the sense that there was not much out there for engineers.*

6.3.4 Lifelong Employment

Lifelong employment was a common theme. Peter Drucker (1999) states that it will be difficult for employees of the future to spend an entire career with one company because it will become increasingly difficult to find corporations that last as long as the average career. Many of the engineers interviewed saw that the value of loyal employees was becoming lower in the eyes of the employers:

- *What's really changed is that people from my era, I'm going to be 60 in two years, so when I graduated the culture was that you got with a good company, you gave them the best that you had and they looked after you from beginning to end, that doesn't happen anymore, everyone is a temporary employee now.*

- *I think it's just a societal thing. You know if I go back, we had a management training course in Calgary and I identified this meanness in the industry thing. And I*

actually believe it was in the early '80s when the contract between employee and employer was altered, dramatically and for a long time. So that contract being you come, you work hard, you're going to have a job. Nope, it was you come, you work hard, if we're not making enough money, you're gone. And so I think a lot of people my age are still "I'm going to look after myself and not the company" and that's the motivator is looking after yourself.

6.3.5 Job Satisfaction and Recognition for Performance

Two themes that were often linked were low job satisfaction and the failure of management to recognize the level of performance the engineers were operating at. These were also strong themes. Many engineers reported that the client was often the source of praise in recognition of good work completed. Many of the engineers derived satisfaction for their work on a personal level and noted that they did not expect others, including their supervisor, to recognize when they completed a particularly difficult task. There were also cases where the emphasis by management would change at different stages of task completion and the engineer was required to make judgement calls when the directions provided conflicted. Examples of these comments are as follows:

- *Oh ya we [management] are right behind you, unless you get in a bit of trouble and then they show they are not. I had quite a few examples of that sort of thing. It makes you nervous and it makes you paranoid and sometimes it makes you smarter. But that is what it is like working for a bureaucratic organization. You learn when to shut up. But it is usually after I say it that I learn I should not have said it.*

- *There was no incentive to do a good job. There may have been a noticeable improvement in plant operation if someone was doing a good job, but it was unlikely that anyone would actually notice or at least bother to figure out why things were going better. You just did the job you felt like doing for personal motivation, not because anyone would thank you or care.*

6.3.6 Career Planning and Serendipity

Many of the participants had clear career plans when they left university. However, in most instances, their actual career path was highly unrelated to the plans they had made. They had discovered that the positions they found themselves in were not what they had expected. Once the engineers gained experience, their plans became much more short term and they were often unsure what they would be doing one or two years in the future. The realized path their careers took was much more the function of chance than any planned action on their part. These were common themes among the participants. Some examples of the quotes are as follows:

- *It was just that I wanted to get away from this job and the opportunity at [utility] came up. So I left as soon as I could.* [participant then spent 32 years with that utility company]
- *My dad was with the city, I started as a life guard.*
- *Then I was called into here at [department] to fill in for someone that was sick, so I was let in here, and I was here the longest I have ever been in a job, eleven years.*
- *Everything just seemed to happen in my career, mostly by accident.*

One engineer was clearly an exception to the general pattern. As a graduate of petroleum engineering, the participant had a clearly defined career goal early in life and selected jobs to realize that goal. The plan was to get a variety of experiences and learn the nuances of the petroleum business to the point of having the skills for making a living at freelance consulting:

- *When I graduated, I had a plan to get into companies and learn and eventually go off and do the work for myself. So I wanted to learn every facet of the business as steps towards independence from these companies. The only real difference in reality is that it took much longer than I had ever expected.*

6.3.7 The Value of an Engineering Degree

In general, the engineers that were interviewed did not see much practical application of the material they learned in engineering school. There was often the complaint that the engineering education they received trained them to look for data to be provided and it was their job to calculate an answer from this information. In general, this type of approach proved to be impractical and generated frustration early in their careers. There was also an indication that those participants involved with hiring engineers looked for applicants that had more of the arts electives or business related courses and less of the technical electives. In order to emphasize these points, and to demonstrate that this was a strong theme, most of the comments pertaining to this theme are provided here or in Appendix C:

- *Again it has to do with the training you receive in engineering school, there's a question, there's a solution. But real life isn't like that, there's a bunch of stuff happening out there that you have to be concerned about and that may weigh your decision one way or another, it's just simply not an A to B exercise to get an answer.*

- *The education at the University appeared to be practical and the theoretical was downplayed. I had an expectation that an engineering job would involve applying the things I learned during those 4 years. In my experience, it did not.*

- *Schooling did not help in anything I did.*

- *I found very early that out of the 18 courses I took on a subject I would be lucky if I applied one quarter of one course.*

- Interviewer: *Could a non-engineer have done your job?*
  Participant: *I think so. But it was kind of a bonus having a guy in the office that could sign passport applications.*

- *It [engineering degree] wasn't related to what I ended up doing at all. All that degree proves is that you're trainable, I don't think it means you know it too much when you get out.*

The comment above leads into another theme regarding the value of the engineering degree, which was repeated by most of the participants. This is that part of the value of an engineering degree is as a way to select the type of people that have the ability to learn the work that will be expected of them.

- *I always knew that the engineering education was there to serve as a selection process for future workers. So I was not surprised when I went to work as an engineer.*

- *When I try to recruit engineers, why do I ask for an engineering degree? It's more like a probability of success when I am recruiting someone for a project. With an engineering degree, they will probably have 70% chance success. 7 out 10 will be good at it. When I recruit technologists, maybe 4 out of 10 will be good at it. But for a high school graduate I will probably get 1 out of a 100 who will be good at it. But I am just saying that if I did find that 1 out of 100 they would be good at it just as good as the engineer.*

Despite the view that the content of the engineering program at university is not related to what many engineers find themselves doing, there was also a strong feeling that the degree was a solid educational experience:

- *I quit my job as soon as my application for seminary school was accepted. My B.Sc. in Engineering was not wasted because it qualified me for all the prerequisites I needed to get in... Having an Engineering background is helpful as a priest. On a hard practical level, I used my structural learning during the construction of some substantial church renovations. I was able to give hard direction to the contractors. They were a little surprised to have a priest directing them on design and fabrication issues. On a softer level, the degree and my training in engineering helps in the*

day-to-day job by giving me the ability to bring in practical illustrations on theological issues. The engineering training gives me a background to use as a source of stories to give the people analogies that they may be able to relate to.

- *I do not want to put engineering down. It has allowed me to do my job and explore things that I would not have had the opportunity to do. I am interested in that, I will investigate that. It is a way to approach things. I think it gives you a chance to follow things. You can listen to an expert explain something and you can think, it might be because of the rotating end of a torque or something. You got to follow it. I deal a lot with consultants and you have to know if it is just shuck and jive or if he is giving you a half-assed job. You can tell if you have a first class person on the team. You can tell this. There are so many aspects, politics, and budget and schedule. I do not figure out the cost, but once I am told the cost, I then ask what will this do to our budget. You get another piece of paper, is it above the line or below the line, that is all there is. Is it red or is it black. Engineering is a fine mechanism to open the doors. The education provided me the chance to stay busy my whole life.*

- *So I actually apply basic principles in my job.*

At the same time, the engineering education was seen to change the people in the way they approached things. The engineering training was seen as providing the participants with a sense of community or belonging to a special group. Sometimes it was seen as a positive, but other times it seemed to be a liability:

- *Years ago I lost my iron ring. Because I was not practicing engineering, I did not get a replacement. However, a widow gave me her husband's ring because she knew that he would want me to have one.*

- Participant *And it can really get you into a lot of trouble, you know that?*
  Interviewer: *Education?*

Participant: *Yes ... Well there are a couple of things. I think what it is called is a structured approach. I really frustrate people because I will not skip steps that I cannot follow. I have to do the A then B then C my way. Don't you goddamn miss the B because I will make you go back and cover it. If I can see how the C came up it is okay, but if not, we have to go back and cover the B first. People will get mad and get frustrated, and that is one reason I have moved around. I will not let go until I get to B. I will not move onto C. Other people want to jump to C and I have to pull them back my way. I think engineering did that to me. I have my way. And it is my logical steps and I cannot move that cloth door [weak barrier], I am not prepared to do that. I have to take the felt pencil and move back. I have to take the options and do the checks and the calculations.*

- *A lot of times I can sit with a group of engineers and we all know what we are thinking. We say insert joke 47 here, and everyone thinks of joke 47 and they laugh. You get two groups, the engineers and the non engineers.*

- *I was originally very gung ho about APEGGA and belonging to the whole engineering community. Now I do not really care about belonging to the association except that there is a perception that the APEGGA membership brings to some potential clients. It does not impact me or guide me, but there will be some people that will see the registration as a requirement. So I maintain my membership to not exclude myself from some engineering work.*

6.3.8 The Work of an Engineer

In interviewing the participants, it became apparent that the job of an engineer often deals with things of a less technical nature and more dealing with procedural items and issues relating to human relations items. This was also a strong theme.

- *But what they should have also taught was how to communicate. How to write a letter. Writing letters is important. How to fill out proposals, well maybe that is too specific, but definitely something about communication. Someone should have told us that our job was going to involve a lot of shouting with the general contractor. A lot of the job was dealing with errors and arguing over who has to pay to fix the errors. Whose fault is it? [when the errors occur]*

- *Well, engineers became a commodity instead of an asset. But it is going that way for the whole industry or world. A lot of companies are just going to having the supplier do all the engineering. The manufacturers are doing a lot more of the engineering. In the old days, you needed to do studies. When it went to digital, the engineering is done at the manufacturing level. The engineers here just look in a catalogue.*

- *You do not do the calculations. The technicians know what they are doing. A lot of them taught me a lot of stuff.*

- *Our stuff is pretty much straight out of the code [gas distribution]. I do not think there is a whole lot of calculations. We are doing very, very complicated designs... But we sometimes need to bring in the consultants to do the complicated calculations. The senior guys are better at recognizing that. When we need to bring in the consultants.*

Another aspect of engineering appears to be the responsibility to keep things running:

- *I never used the technical stuff [learned at university]. Like my first job, there was all this complicated equipment and we had to know how to fix it. We were in the middle of nowhere and there was nobody to take it to, so we had to fix it ourselves...[company] gave specific training ... we had to learn geology and we had to handle radioactive materials for sending radioactive material down the well.*

- *The situation at the plant was too complex to solve through theoretical modeling or by breaking the work into small parts. The solutions to problems were solved by trial and*

error. If a pump bearing goes, you replace it. If it goes again, you look for things to try until the problem goes away. Often you try many things, so you never even learn what exactly solved the problem and you just try them all again the next time that situation comes up.

- *I had a low level of job satisfaction the entire time I was an engineer [4 years]. The job I had was called "Production Engineer" but really it could have been performed by anyone with some plant experience. The tasks were not technical in that they did not require the application of the things we learned in University.*

- *In the old days the analog equipment needed someone to engineer it. You needed to do a lot more engineering. For example on a radio system, you had to engineer a lot more where the towers go. And what kind of reception you get. When you go to fibre optics for example, you just run a trench where ever you need it and put a repeater every 30 miles.*

6.3.9 The Boring Aspects of the Engineer's Job

A strong theme that was not initially picked up on until a few interviews were already transcribed was the number of references made to many of the duties of an engineer being boring. Some of the references to boredom appeared to stem from a cyclic nature to the work and the engineer having little to do in the slow periods. Other references appeared to stem from the assigned duties requiring few technical skills, underutilizing their talent, or repetitive calculations. A few examples of each type of comment is as follows:

- *They lose interest in the work. That seemed to be the career path that I know.*

- *I returned from working in Russia and returned to the office in Calgary. I was not doing anything at all. I was told to wait for responses to requests. They would be sent by fax. The typical waiting period was about 2 weeks between sending out a request and the reply. There would be a few days work and then a lot more waiting. This*

continued for 3 months. I requested more work from my bosses. I was told to just accept the waiting as part of the job. I drank a lot of coffee over that time. My title was Facility Engineer, but it could have been anything based on what I was doing.

- *I have never had the patience to sit through and come up with the answer, to work it all through.*

- *I really like engineering but I never liked the calculations. I don't like the tediousness, I like variety.*

- *The job entailed counting the number of hits by the pile driver on each pile. I also had to record how much the pile moved for each hit. There were two other young engineers on the site with me. They were pretty much doing the exact same thing. Not that they were doing it in different areas, but they were standing with me counting the same blows. I was with the construction company and needed to inspect our work. One of the others was with the government who was the owner. The third was with the design engineering company and needed to also ensure the work was done correctly. All three of us were collecting the same boring data, but we were using different forms and formats for recording the data.*

- *I would continue to work longer in this company, if the job was interesting at all.* [planning to retire at 55.]

6.3.10 Learning on the Job

Although it appears that the University education engineers receive often does not prepare them for the work they end up doing, a strong theme was the on-the-job training period early in their careers when they do start to learn the skills they need:

- *When I started here, I would work the noon hours designing a garage for myself. I was working on snow loads and wind loads and I was calculating the spacings. A*

technologist came and asked me what I was doing. So I told him. I said I think I had it down. There should be 18 inch spacings. The guy told me that the plywood is in 4 foot widths. So 24 inch or 16 inch spacings that is it. No 18 inch. So that was a big wake up call for me. A few weeks of noon hours spent trying to do the calculations. But there is none of that.

- *When I took that job I expected to be in charge of draftsmen, not be a glorified draftsman... After it was done I had no regrets. But at first, when they first put me there I was disillusioned, but only for a short period of time... I wasn't allowed to approach it the way I thought I was going to. I was put where I would gain the necessary experience.*

- *I learned not to complicate communications with day-to-day detail or technical detail. What do they [management] really need? What is the key information that they need at their fingertips to understand what is happening and that's gotten better. Just wording things more precisely. Wording the communication more precisely... stripping away anything extraneous that is ... really not necessary. Being very precise in the wording. I am a lot better at that.*

- *One thing that maybe companies could do would be to assign a mentor, it would have to be someone with at least 5 years experience, to the beginner to show them the job and the workings of the organization. There would be an introduction to the world of what engineering really is. The junior engineer would know not to try to 'reinvent the wheel' thinking that their job was supposed to be designing. However, it may be difficult to find enough good mentors.*

6.3.11 Five Years Experience

The engineers spoke often of needing time in the field to learn what to do. In regards to this, as in the comment above, a common theme was that it took approximately five years to achieve the experience necessary to be a fully competent engineer:

- *When I hire I look for a certain amount of experience and the right attitude is the kind of person that I am looking for. I would not hold lot of weight concerning 30 years of experience versus somebody with 5 years of experience. 5 years is enough to have learned everything. Learned what is involved in working, work life things as much as whatever the job is itself.*

6.3.12 Management Positions

It has been assumed in the earlier sections of this dissertation that management positions are a significant part in the development of an engineer's career. It has been noted that many see the move into management as a natural progression of the engineer's life at work. A common theme of the participants in the Why Study was that the move into management was very much expected of them in the organizations they found themselves working for. It appears that the management stream is easier to assess for performance reviews than the more senior technical positions. Some took the move to management as a positive step, but many of the others saw it as a way to trade a higher salary in exchange for less job satisfaction. Management positions appear to be more socially isolating than front line jobs. Some of the participants emphasized that they try to minimize the amount of management duties they perform with their subordinates. In a few cases, the move into freelance consulting was chosen as a way out of management positions.

- *Now [at 45], I can lead my independent life [freelance] so long as the economy is hot enough to allow me to work at what I like. When things slow down, I will jump back*

into the corporate life and make more money in management positions and wait for the opportunity to jump out into interesting work

- *...anyone that sticks around too long ends up in management. If you are not inclined to management you just leave the system.*
- *I know a lot of good engineers, and by good I mean good technically, who go into management and they are bad managers. Then they stay there.*
- *I have enjoyed that I have been moved to a supervisory role and that has been positive for me. I think probably a lot of people, I don't know, but I think that a lot of people have had to do more with less in lean and mean organizations and it has had its toll, certainly for myself for a period and that is working late sometimes. If it was easy they would not be paying you, so that is one of the things to consider.*
- *Didn't feel comfortable in the role [management]. I didn't like what I saw in management. It's overtly competitive with no real reason. I made a decision to make a career change and it was going to be going back to university. Maybe do sports medicine or go to the environmental business, so I ended up going to [organization]. So that put me on a whole course for the rest of my career, environmental law as opposed to engineering.*

Some people reported accepting the management role more to prevent the alternative of someone they did not want in the role to get it. They saw it as their duty to fill the position and thereby make their life and those they work with lives better:

- *Supervision is very painful at times. I often think about doing something else totally, and letting someone else handle the idiots. But I never took any action towards making a change. I am happy with my choice not to quit. Sometimes I feel that I am not a good supervisor. Then the realization sets in that someone else would be assigned to my vacant spot and it is most likely that the people I see around me that*

could be in my job would be much worse that I ever could be. I feel that it is my duty to hold the position for the benefit of those that report to me.

- *I try to keep people that are working for me in very tangible things, you try to insulate them from these other pressures that I am in. I kinda cover them off without impacting what I think is important to the company. I try not to lose their focus to get too far into these intangible corporate kinds of activities. I take the crap from upper management and try to keep the workers working so they are not involved in whatever schemes management has to hinder the smooth running of the company.*

6.3.13 Summary of Results

A few specific themes are summarized below:

- Many of the engineers stated that they had little knowledge of what engineering was before they started work. Some of the engineers interviewed had their careers planned by the time they graduated, but the path they took was often very different from this plan. There was some degree of randomness in how the engineers' careers developed.
- Many of the engineers stated they valued security and a stable work environment.
- A frequently mentioned theme revolved around dissatisfaction and management's lack of recognition for good work. Many engineers stated that management appeared to not be aware of their contribution to the organization.
- An engineering degree was generally regarded as a screening process for selecting people suitable to train for the job. Few of the participants found the content of the university courses relevant to their work. Most stated that they needed to learn skills on the job to function as fully trained engineers. It was often stated that five years was seen as the length of time required to become fully qualified.

- The work of an engineer was often seen as being highly people oriented. There are often periods where the engineers feel under-utilized and tasks were often referred to as "boring."

- Some engineers in management saw a distinction between doing work and being in management. There was often an expression of the line position being more appealing from a job satisfaction level, but it was generally recognized that the management positions were better paying. Some engineers at the front line saw a conflict between the stated goals of management and the tasks required for the effective running of the organization.

6.4 Discussion of Results

6.4.1 Discussion of Procedural Difficulties

Unlike the What Study, the solicitation of participants for the Why Study was an entirely positive experience. All the engineers approached were very cooperative and eager to help a fellow engineer. The more informal tone of one engineer asking another engineer to talk about their career was met with curiosity and enthusiasm in every case for the Why Study. The 100% participation rate in the Why Study is in sharp contrast with the suspicion and 25% rate of refusal to participate encountered in the What Study. The formality of sending the letter of prior notification of the request to participate and the requirement to audio tape the participants' informed consent was seen as the major difference in the approach used for What Study. The demonstration of conformance to the Faculty of Engineering Research Ethics Board requirements may have hindered the data collection process for the What Study. The postponement of introducing the topic of Research Ethics until the scheduled in-person interview for the Why Study was seen as a better approach for data collection. It should be noted that for the participants employed in large organizations, the clarification of confidentiality and the assurance of anonymity appeared to create an

increased willingness to respond to some of the questions. For the participants that were either freelance engineers, doing non-engineering work, or retired, there was a sense by the interviewer that the assurance of anonymity was of less concern.

There is considerable attention paid by the authorities towards the assurance of the safety and potentially negative impacts on the researchers and participants in studies involving human subjects. Having to explain these concepts to a qualified professional and to follow-up on their psychological well-being at the end of the interview seemed to some of the participants as being the product of a bureaucracy more concerned with standardized methods than a response to an assessment of realistic situational risks. In every instance, the interview experience appeared to be a positive one for the participant. In some instances, due to the relatively small numbers of mature professionals in Edmonton, subsequent to the interview, the researcher and participant met on the street in their business suits at coffee time and realized why at the interview they felt they had seen each other before. The nature of the interviews were very similar to the conversations the participants would have at technical society functions.

During the interviews, the participants displayed the awareness of their situation that was noted by Herzberg in his work. These participants were able to provide vivid descriptions of their careers and recalled their work histories in detail. Some had to take a moment to recollect events that in some cases occurred over 40 years ago, but the researcher discovered that the development of their careers had left a definite impression on them and the details were readily provided. In some cases, names (such as professors from engineering school) were suddenly recalled for people that the participant had not seen in over 40 years.

6.4.2 General Results

The duration of the jobs held by the participants had an average of 7 years and a median of 4. This would suggest that an engineer should expect to change jobs up to 10 times over

a career, as many papers suggest (Broscio and Scherer 2003). However, it appears that with the profile shown in Figure 6.1, it is more a case of the engineers moving frequently until they find a job they settle into. The importance of security suggests that most engineers would prefer to stay in a job that is acceptable, rather than seek out jobs that they may consider better than the one they have. This parallels Herzberg's two factor theory of motivators and demotivators being different elements rather than extremes of the same scale. The engineers that had jobs lasting more than 20 years all had very little change in their duties. One engineer purposefully switches employers when the current one changes his duties to something he does not like to do:

> *When I got out of University, I had the expectation that I was going to apply science to the oil and gas business. I have been able to move around companies enough to get opportunities to do this, but there is a lot of pressure from organizations to not do this. They would like to have me do the management stuff. One of the pressures is more money. In order to do what I want, I have to sacrifice some money.*

In contrast with this is the opposite tendency for some engineers to become dissatisfied with the lack of response from their employer to allow them to try new things:

> *Companies would want to keep me where I already learnt everything and knew things, I was pigeon-holed, but this prevented me from learning. So I had to leave every few years and carefully plan where I was going so that I would learn the things I was lacking.*

Given that many engineers reported a lack of knowledge of engineering work when they graduated from university and their career plans were seldom followed, this may indicate a need for better orientation to the profession at the start of the engineers careers. The participants often mentioned the impact of the co-op program (practical work terms included in the degree) for providing this needed function. They also recognized the

advantage the co-op students have from their five year program over graduates of the regular four year degree:

- *The co-op students when they graduate, they generally have a good working grasp and issues about what they want to do and a business understanding. When we interview we notice a big difference between the co-op and the four year students. But we do not write off the four year students, we have to account for them being a little more rough than the co-op students.*

- *Younger engineers with 2 to 3 years experience are much more mature than they were in 1966. They seem to be able to work better without as much supervision. Able to take on work. They seem better prepared. I am not sure why. Maybe they take a lot more courses on how to do engineering instead of things like higher math and complex subjects that will never be used. But that is not the impression I get. Maybe kids are just more aware... The co-op program takes an extra year of school, but it is definitely worth it. It is a good thing.*

Based on the statements by the participants, it appears that the University of Alberta Petroleum Engineering program has addressed some of the concerns of earlier exposure to engineering by focusing their courses on training applicable to the work expected to be encountered by the graduates. During a conversation with Dr. Marcel Polikar of the School of Mining and Petroleum Engineering, University of Alberta, the course work often focuses on problems taken from industry. These include problems where data may be incorrect or missing and the students are exposed to more of the types of tasks they will be asked to perform in the workforce. Dr. Polikar also noted that the numbers of University of Alberta B.Sc. Petroleum Engineering graduates that continue on to further education are limited. He credits this to the high placement rate of the students into jobs related to their studies. For individuals concerned with curriculum development for engineers, the Petroleum Engineering program may provide a model to follow.

6.4.3 The Engineer's Career - Early Stage

From the comments of the participants, a picture emerged of a trend in the way their careers developed. A strong theme emerged from comments relating to their experiences at the beginning of their careers, as also shown by the comments in the Results section relating to 'reinventing the wheel.' The engineers remembered being enthusiastic early in their careers and being in a hurry to solve the problems through systematic calculations. They expressed frustration at their inability to immediately make a contribution and often having little guidance on how to proceed:

- *I think it was about a year before I felt comfortable that I was making a contribution, it takes you that long to get familiar and comfortable and you don't know a lot when you start so you have to know where to go to get answers, it takes a while to get that figured out.*
- *...working early in the career you are more on your own.*
- *...when you first start you are pretty naive about everything. After a few more years of experience, you get more comfortable speaking your mind*
- *The juniors need to be smacked a few times to get them to listen.*
- *When I first started out, at the beginning I just jumped into the problem solving part of the work.*
- *And I couldn't wait to get to work in the morning. To get your ideas on paper because when you're looking at ideas and concepts, you're thinking of them all the time not just at work.*
- *I wanted to have a backyard with green grass and a toddler. Go for a drink with the boys once in a while. And a home, maybe a wife to go with the toddler. Very simple. I was young, hell I can barely remember that far. Not too big. I wanted to have a job,*

to be able to afford a drink, a car, a family, maybe to be established somewhere. Life was so simple then. I had all the answers for everything. I would come to work and do what they asked me to do. I was very yes man then, I did not argue then, I would voice opinions but I would then go along, you could probably read my face, but I would go along.

- *Younger engineers tend to be a little bit more wild being all alone, flailing away doing it there. A lot of trial by fire.*

In addition to the statements on attitude and performance of the young engineers, there were also some comments about the organization using the young engineers as a lower cost alternative to other trades:

- Interviewer: *So what was the difference between the technician's duties and the engineer's duties?*
  Participant: *There was the aspect of needing the engineers to oversee the job. But then again the jobs were often done by either one. But the engineers were cheaper.*

- *That was part of the problem. The technicians were hourly and the engineers were salary. The technicians often ended up with higher pay. But the engineers were needed to be there.*

- *I started school in 1981, but it soon became known around university that there was not much out there for engineers. People in class were saying that it did not make sense to hire a young engineer to make the coffee and distribute the mail when you can hire a professional engineer with 20 years experience to do those tasks for the same money.*

6.4.4 The Engineer's Career - Middle Stage

During the progression of the engineers' careers, the participants reported both high points and low points. They reported particular incidents that provided them with learning

experiences. In lower management positions, the engineers found themselves preparing reports for upper management. It appeared these reports seldom resulted in directions or feedback. The engineers in front line positions have modified their approach to looking more at the impact of their assigned task on the organization as opposed to just calculating a solution to the proposed problem. The enthusiasm of some of the engineers appears to be lower at this stage than when they first started working. Some of the participants noted that their pension was beginning to become significant and they felt their mobility was being reduced by the value they placed on keeping the pension they were building.

- *There was a high profile job and I got caught in the backwash, everyone did. Everyone that worked there got tarred, feathered, hurt, there was a lot of hurt there.*

- *I think the point of this thing is trying to figure out why there's so few engineers doing engineering work when you get older. And you know what, I'm just thinking up of a few overall things. Number one, it's a hard life, to be an engineer you're working hard, in a lot of situations you're on call a lot, so it's more than an eight hour a day job, a lot of people get sick of that pace, frankly.*

- Quitting after being in a project management position: *I was so stressed out. The management was pissed off that I did not inform them of my feelings. I do not think I was thinking straight. But still had I told them, it would have been a black mark against me anyway. My career would be stalled there. I need to be a top performer according to them, so if I was having trouble it would have made me look bad anyway.*

- Participant:*I experienced a lot of rampant self promotion. Those things I'm not interested in.*

  Interviewer: *Self promotion to what end?*

  Participant: *To get a promotion. A lot of times it seemed to me that it was just competition for competition's sake. I used to envision that the knife would just be*

passed around the room. People would talk and there seemed to be a need to make people eat their words and like that. Not a healthy environment.

- *Why am I even here? Why am I working right now? What is the purpose of all this? And that's a lot of attitude because I have the idea that the purpose of work is to help [employer] build these facilities right now whereas a lot of people's attitude would be that corporations exist to give them a career.*

- *"You [management] tell me that my name is in a 400 page report that is being released to the Edmonton Journal that afternoon!" That sort of puts you in your place as an employee. I have numerous examples. This hardens you.*

- *What do you think about when you're in a job for fourteen years, I didn't know how to write a resume, didn't know what one looked like.*

- *Once I progressed, the focus of my job changed from coming up with a solution to being responsible for the financial aspects. The money I was spending was becoming more like my money. I tend to now draw back and look at the business case and the risk of failure. The financial aspects took on the highest focus and I became more conservative with decisions. Still it is fun to look at some new technical solution and if I am spending someone else's money that is more freely available, I will want to give the unproven a try.*

This last quote shows that there may be a need at times to control the inquisitive nature of engineers.

6.4.5 The Engineer's Career - End Stage

Whereas the junior engineer was often stated to begin with calculations and solving some problem, the mature engineer was seen as being more inclined to question the task and to look for possible alternatives. The knowledge gained by the mature engineer was often just

knowing who to ask or where to look. There were many instances where the experience of the mature engineer was stated to be of particular value, although it was not always recognized by management to be so. The engineers have often had successful enough careers that money begins to lose its ability to motivate them to continue at jobs they may not like:

- *... with some of the corporate changes the records get changed and systems get changed and yet they maybe are not the official company records but they are valuable. They may be archived but they may still be relevant and to know where they are... we run a pretty complex system so on the technical side just understanding some of the complexities of our operation and things may not always be as simple as management may think it should be. So having the understanding to get things done. So getting a safe solution and the right solution. Knowing who to talk to. Knowing who to go to to get the proper reviews.*

- *I think a lot of people if you asked them and they were honest about it, would be sick of the competition, having to prove themselves at sixty years old, who the hell do you have to prove yourself to? If you get into a situation where you are proud that you did something special but someone's going to be beating your balls because it's running over budget a bit or it's slow or something like that, you're going to say "screw this." So I think there's a lot of that and the fact that it's a well paying job and if you stick with it when you're younger, you're going to be rewarded with all these stock options a lot of times to the point when you're sixty and you've added all these other stressors to it, why would you be doing it? Why not go be a Wal-Mart greeter because all you really want to be is busy or volunteer or something like that. That's the way my career's going to go, it has been going because the money's not the driver, it's the lifestyle.*

- *Do you know what? In my entire career, I have seen very very few engineers that are sixty years old. I don't know what it was most managers and stuff like that they're usually gone before they're sixty years old, so I've met, in my entire career people that I've worked with that are over sixty, I'll bet you that I've only worked with twenty. They'd be retired mostly by then or part time, contracts something like that. Generally managers, there's the odd guy, I think I'm going to be one of these guys who does line function work and he's old and very enigmatic, like you don't expect to see a sixty year old guy cranking out drilling plans but there were a few, a very odd few. Most of them at that age are managers, so they're running entire departments or they're part time or consulting, a lot of older engineers get into consulting. We don't have that many, president of our company is an older fellow.*

- *The old person is needed in my work because of the network of people they know for specialized tasks. Let us say there is a person working on an apartment site. Let us say [utility] is really screwing them around and the application is going nowhere. The experienced person will know who to contact and when they beg, the other person knows they really are serious. It takes many years of dealing with people to gain the mutual trust. If a new person goes begging, the other person does not know if this is important or if the person is just whining. Experience has value and it has to do with established networks. That is the beauty of our business. The power base is the client relationship. When the experienced person leaves, the business may suffer. The certain key people are needed and are rewarded accordingly.*

- *How do you regain old people? Or is it even a problem? The value of mentorship is starting to rise now because the old guys are quitting. Even in my job, my covering letter was mentorship not my experience, what I can bring back now being gone eight years, is mentorship. We were talking about leadership and as soon as a guy calls himself a leader I go "not!" Just that guy: "oh I'm the leader of that organization."*

You don't announce your leadership, you are bequeathed your leadership by the people around you.

- *One of the problems was that the more senior people would get the more difficult or messy problems or projects and sometimes there is no quick answers and management cannot see this. ... And management fails to realize that when push comes to shove and things get difficult we are always leaning on the same senior people. Because they understand the issues and they know where to find the information a bigger depth of understanding. Management would not always recognize this.*

- *I believe that the maturity and experience is worth something. But nowadays organizations are flatter and the junior person can get noticed easier than in the days of more hierarchy. The young person might be told to set up a meeting and then be noticed by someone high up. If they say the right thing and tell the boss they are great, they can jump up faster. They can end up earning more than the person with a lot more years on them.*

Many of the comments already listed from the mature engineers suggest that their level of enthusiasm has dropped considerably from when they started. Some have noted that they wish to continue working in order to feel productive or useful. Some have noted that they were moved out of their last organization and do not desire to start anew with another employer. This again reflects the serendipitous nature of their careers, where they would be happy working, but if they were removed from their job they may not make the effort to return to a new one. It was surprising to the researcher to discover that a number of the mature engineers saw their careers more as a means to acquire a comfortable lifestyle than as defining who they were. When they moved out of the workforce, they did not really miss their former careers. As noted with the freelance engineer who went to work for his former employer, the task was accepted in a large part because of a desire to be helpful. In keeping with the findings of the Hawthorne experiments (Roesthlisberger and Dickson 1964), the

engineers in general looked at their employer organizations with respect, even when they may have had some resentment towards certain individuals within them. Still the mature engineers at the end of their careers often saw themselves as expecting something to trigger them to stop work. A nascent theme is for some mature engineers being placed in positions where they were getting reduced responsibilities while they waited to move into retirement. A common theme among the mature engineers is that they often did not see the importance of following orders that did not have tangible results they could understand:

- *Ah, I had some interesting times with [company]. I cannot say I really had any bad times.*

- *The next change was that I got laid-off at my job and I will probably get laid off from this one, so I have lost control of my career. I am not as bad as some my age that can barely keep a job as an old guy, but I may get there.*

- *I was offered a job where it was good for a guy looking for retirement and getting ready to go out the door. And I had just come off a donneybrook. And this other guy started putting his fingers on my turf big time. And I was being asked to do things that I did not think was right. And it is not his turf and he was not using the engineering approach. And I refused, and it got to be almost day-to-day. And the boss took his side. And then I was offered this job forcefully.*

- *I am going on holidays soon and I know that when I get back, I will be less concerned about many of the political issues at work that seem very critical right now. I will hate coming back to work. I will have a hard time getting excited and will likely blow off an afternoon or two if I have nothing important on the table. I doubt that I will miss the work.*

- *We had one person working for us that was over sixty years old and I think they were just as able to do the work as the younger guys. However, it seemed that they had a*

lot lower output because they seemed almost semi-retired or getting ready for retirement and they just did not want to work too hard.

- *This was a downsizing business and there were several rounds of downsizing. They had a number of rounds. They had a few five years before. When I left they got about 1000 people. It was a case of getting an offer I could not refuse. I felt that if I did not accept this pretty good deal, in a few years I may be out anyway, with a much worse deal. By the time I left, they had reduced it from about 11,000 people to about 7000. It is hard to figure out what the rationale was. They claimed it was economics, but it did not make sense.*

- *They give up on you. I have a reputation for breaking the rules. I used to have a theory about doing things in one of two ways. We can do it right and follow the rules, or we can get it done. But you cannot do both. There a lot of rules, but you try to find the way to do get it done and not really breaking the rules but looking for a way to get there in the shortest path.*

- *Was it worth it, my whole career? Yah who knows? I got my retirement coming up and then it is all done and it won't matter.*

- *And I was basically done full time work by the end of 2002 [age 55], so 2003 and 2004 I did some consulting work and I'll continue to do so as long as it's available and the projects are interesting.*

- *Honestly I'd still be doing it [engineering] if I had the opportunity but that time is past.*

A nascent theme is the view that recognition inside government jobs was more based on tangible performance than for jobs in the private sector. Some stated that the people in management within the government organizations had much less discretionary power than

their counterparts in industry. Some engineers working for the government reported that they would be less happy in the private sector:

- *I do not know of any employer other than a government that would tolerate people being honest. To let me stand up and say what I believe without firing me.*
- *I am like this here because I am allowed to be that way. I could have been much higher up the ladder if I had been more of a team player, or at least up a few rungs and the rung I am on now may have fewer notches chewed into it.*
- *I felt there was no future in taking a job in the government, because there is not the same authority and power.*
- *...the private world scares me... In industry you have to answer to a boss. Dissenting opinions are not tolerated in private sector. Then I see ads in the paper for jobs, but talking to people in the private sector it seems the actual jobs they do are totally different from this description that appears in the paper. Government is a lot more forgiving and people look at results, not behavior. There are more checks and balances, not just how the boss feels about a particular person.*
- *But the [government] is secure and routine. It is a good job.*

6.4.6 Comparing Young Versus Mature Engineers

At a job interview with a local firm, the potential employer stated that the researcher would not be considered for the job due to being recently married and too financially secure. The employer was looking for someone that would be more willing to put in long hours and work for low pay. They stated that they were looking for someone with about 5 years experience, single and without significant external interests that could interfere with working through many weekends and evenings without compensation. A strong theme from the interviews is that younger engineers with about 5 years experience are preferred

for most tasks over mature engineers who may question the particular task at hand. In some instances, the experience of the mature engineer may have enough value to be the preferred choice, but at times it is difficult to justify the higher cost:

- *Since starting [small consulting company] we have hired 3 engineers and one technologist who were over 45 years old at the time. Now that it is four and a half years later, we still have one of these engineers who is over 45, and he is excellent. The others were encouraged to leave or even fired because they were incompetent or they lacked ambition. I would not hire anyone my age or older, if there was a younger person who looked to be about the same in ability. The older person will likely cause a lot of problems because they are like me and will not just do what they are asked to do, if they think there is a better way or their way to do it.*

- *My ideal employee is one with about zero to five or even ten years experience. They would have to be bright. Older hires would have this resistance to change. Companies change.*

- *If you're looking for someone just to crunch data, you can get anybody to do that, but if you want a problem solver and you want someone that has had a lot of general experience then I'd look at an older guy. You know the young guys have tunnel vision, I know I had it.*

- *Honestly the biggest stumbling block that companies are involved with today, you take a young guy, he's still impressionable, you can mold them the way you want to. While when you take someone like me, I'm bringing baggage with me, I've got ways of doing thing, I'm opinionated in areas, I'm not so flexible anymore, that's something you have to be aware of.*

- *I think that if we charged less per hour to the client for my services, I could probably then justify sending myself out the odd job on occasion, I like to be out in the field, I*

like to be out and about to solve a problem and I find that I'm in the office all the time. But if you do that then they're making less money, they'd probably ask me to take a pay cut for that type of work, so I'm not prepared to do that either.

- Interviewer: *If you were in charge at [company] would you prefer a recent graduate to someone with a lot of experience?*

  Participant: *For [company] it probably would not make much of a difference. There is not a lot of actual technical design required. It is more systems design. It involves picking boxes that work. It would not make sense to [company] to prefer an experienced person because there is not much to the job.*

6.5 Explanation of Observed Trends

The Why Study was designed to probe the causes of the observed decreasing numbers of engineers employed in engineering or management with increasing age.

The 14 participants in the Why Study describe young engineers as being enthusiastic and often willing to work long hours without extra compensation. The reasons for this included needing a job in a difficult market, hopes of advancement, and professional responsibility. Many of these young engineers entered the workforce expecting their job tasks to be related to the course work they studied in university. While a few participants observed that they used the material they learned in school, the majority felt that schooling basically served as a screening process to pre-select people from the general population that have a better chance to perform well at the work expected of engineers. Many of the participants reported doing work in junior positions that was similar to the regular duties of a tradesperson or other labourer. They commented that the engineer was often paid less than the person whose duties they were performing would receive for the same work. Some of the participants felt a need to do work that was more interesting or socially responsible than their experience in an engineering position provided, so they chose other professions. One of the participants had problems finding a company that would stay

in business for more than a few years and felt that farming offered a more economically secure future. The young engineers were often unsure of what to do and were viewed as trainable and willing to please management. As one participant stated:

- *I had been with the [department] more than two years, and I had already been burned by the bureaucracy, and they had people applying and we were viewed as a dime a dozen. Things were going crazy. They could pick whoever they wanted. They said "you have only been here two years, we can just take a junior guy and train him right this time." And it was the truth.*

The trial by fire nature of introducing the engineer to the workplace can create a sense of excitement. However, Wolverton (1996) notes that the lack of preparedness for life in the workplace can also have the effect of producing a very negative impression on some graduates. Pinto and Kharbanda (1995) note that it is most common in organizations to develop their project managers through "fly or die" (p. 42) techniques. They state that some of the novice managers succeed but many fail, which creates a considerable waste of potential, money and human resources for the organization. One of the participants that left engineering early in their career stated the following:

- *I may still be an engineer today if I had experienced the proper orientation to the field, but I am not sure. I have a lot of bad memories of my stint as an engineer.*

Many of the participants commented on the value they placed on job security. As young engineers, many of them had very demanding jobs but they kept their eyes open for more stable and secure positions. Some were able to hire onto companies early that then employed them for the rest of their careers to date.

As the engineers gained experience, they became more aware of the impact of their actions on the organization. They began to notice that there were often better ways to do things than the procedures mandated by management. The engineers discovered that the

factors their performance was judged upon were often very loosely related to the factors that bring success for the organization. As two engineers reported:

- *I had a project that was incorrectly estimated and I realized early that to do it, I would need about double the budget. I was told to "sharpen your pencil and do it for the funds given." I ended up coming up with a facility that was on budget but was about a third the design capacity. The economics would be terrible. All management cared about was that I met my budget and I escaped getting hell. In a complex process, they often cannot tell what any component is contributing, unless someone tells them. I knew the facility was underdesigned but very few other people figured it out.*

- *The consultant was to receive a big performance bonus if the project they were building came in on budget. They did it and received the bonus. But once the plant was operating, we experienced very large maintenance costs much earlier than anticipated. Skimping on materials resulting in meeting the budget, which is what management wanted. The operating cost increases were much more than the savings from skimping but these costs were another department's problem.*

Many of the engineers were promoted into jobs in management that were higher paying than their engineering duties and therefore were seen as an advancement in their careers. As noted in some of the quotes, the middle managers were often working on reports that went up to senior management. Mintzberg reported that upper managers had these reports on their desks but they stated they never had the time to look at them. One participant in this study noted that a big part of learning in his management role was to prepare the reports in the format required by his superiors. He noted that there was seldom any action that resulted from the content of the reports. Jackall (1983) observed managers in large organizations. He proposed that for management in the modern corporation, efficiency or cost effectiveness is considered secondary to the ability for "hitting your numbers" (p. 124). The tendency for managers to pay less attention to actual company performance and more

to simply meeting the established quantitative targets is also reported by Harari (1992). The participants that were in front line positions reported recognizing the difference between these two factors. This created a conflict they were faced with between following instructions and operating the organization effectively. From their comments, there appears to be a communication barrier between the technocrats (as defined by Galbraith) who run the business and management who have the control of the resources and the organizational power over the workers. This barrier to information flow was also reported in the literature review (eg. Gummesson). Management may be getting information that has been adjusted to fit their perceived expectations. Because management is not receiving a clear picture of the situation, their judgment could be flawed and the decisions they make may not be in line with the best direction for the organization. This could perpetuate the perceived need by the technocrats to minimize the input from management and to filter the information they provide. Comments from two of the participants highlight this situation:

- *We are expected to perform the work in the budgeted amount of time. If you put in extra hours, you may not report them if it is going to put you over. If you have two projects, you may charge more to the one with extra room. Therefore, everything works out from management's perspective. Because people are able to meet the targets by the way they report, the system sort of works and the expectation of being able to meet the targets remains. If someone is honest, they are seen as not being as good because everyone else is able to do it on budget. Because people do not report all the time something takes, it is never clear exactly how long things do take and the next time the budget is also too small.*

- *The V.P. of engineering was addressing us at a monthly meeting. A big part of the group was involved in estimating the high profile project that was being built. We said that it would cost $3.5 billion. We had to sharpen our pencils until the number was down to 2 billion. At this meeting, the V.P. stood there and told us that the project was 60% complete. The costs to date were 2.5 billion. He said that they were all*

putting a lot of pressure on the number to keep it below 2.85 billion. We had no idea what that could mean 'putting pressure on the number'... The V.P. was essentially saying that we could do the remaining 40% of the project for 350 million, when the first 60% cost ten times that or whatever... It looked like he believed what he was saying. After the meeting, I wondered if he believed the numbers he was being told. I wondered if maybe he knew the truth and hoped he was fooling us, making him a good actor. Or he could know that he was lying and knew that we knew he was lying, but it was just part of the game to deny the obvious. I hoped that the last one was the truth. I hoped that he was not that stupid to believe the numbers as is and that by staring at the numbers he could keep them down. I hoped that he did not think we were so stupid as to believe him. The project was in the paper and it was at the end and it cost $3.8 billion, I seem to recall, close to what we had said at the beginning.

The annual performance targets of one engineer in middle management were reviewed. From the statements in the corporation's annual report, the company is focused on improving operational efficiencies and increasing revenues through strategic investment. In order to help achieve these goals, there would be an expectation that the manager of an engineering department would have annual performance targets that would be related to these items. Although the manager had people assigned to him that were involved in developing, assessing and executing capital intensive projects, the manager's performance targets were largely not relevant to the economics of the company. The manager's performance targets centered on initiating safety awareness programs for office workers, ongoing revision of the engineering procedures manuals, developing a new filing method for engineering records, producing a long range resource plan, producing a brochure to target inclusion of smaller construction companies in project work, meeting the department operating budget, and developing a program to assess compliance levels with regulatory bodies. In no instance was there a clear correlation between the manager's performance target and the impact meeting it would have on the profit level of the company. Although

the item of meeting the operating budget numbers appears to be related to efficiency, the technique for achieving this was to regulate the costs allowed to be charged to the operating (expense) accounts and to put less scrutiny on the charges to capital accounts. Although maximizing the charges that a company capitalizes decreases their cash flow by increasing the income tax they pay, publicly traded companies may have managers that do it anyway to help them meet their earnings numbers (Berman 2002). In reviewing the quantifiable measures that often form annual performance targets, KPMG partner Donald Brookes (1994) concludes that when there is a correlation between the target and company performance, it is actually the undesirable level that is most often rewarded. For example, a manager with a greater number of personnel in their department may get a higher salary than the manager who is able to perform with few workers. The person with the higher operating costs receives a reward.

Near the end of their careers, the engineers often reported becoming less concerned with the regulations and procedures they were expected to follow. They reported a loss of enthusiasm and often an unwillingness to do things that they view as counter-productive to the organization. The importance of being a team player in large organizations is often viewed as being greater than absolute performance (Hymowitz 2004). One participant reflected this in his preference for hiring younger engineers who will learn the company way, even if it is not the most effective way. As demonstrated in the discussion of the What Study, the number of management positions in large organizations can be very small compared to the number of engineers in the firm. One participant noted that his perception of the emphasis on the reports produced by middle management was more as a test to qualify them for higher positions:

- *I notice that the middle managers that are not promoted are usually sent back in with the workers at the next reorg[anization]. If they have shown that they are not suitable for upper management, there is no point in having them in a position that does not add value. At least they did no harm in producing those reports and meeting their*

targets. They have to vacate the seat for the next contender. They are run off or sent back. Sometimes the guy just resigns to prevent a demotion appearing on his resume, if he still has hopes of being an executive somewhere else.

Some of the participants noted that they had learned to play the games required to stay employed but that they often did not like it. They also noted that when the conflict between doing what was good for the company prevented them from following the rules expected of them, the ones that stayed in the organization would tend to follow the rules. Many of the others left to go into freelance consulting, citing this as one of the drivers to move. The trial by fire when starting a new position, as reported by the one participant, appeared to be one of the exciting parts of the job that kept the junior engineer enthused about their work. As the tasks became familiar, the politics of the workplace often made the work seem less appealing. Moving into freelance consulting was one way to maintain a sense of purpose and lets the engineer choose what work they want to do. When they were forced out of their organization, some of the mature engineers found things to do that were unrelated to work. They then found they had lost the desire to jump back in. Many of the engineers that left large organizations cited the pressures to move into management positions as one of the factors that helped them to decide to not seek salaried positions.

The progression of the engineer's career will also have an impact on the decisions made by people in management. Many of the participants stated that they felt there was often little difference in ability between someone with about five years experience and someone with many more years. This often was the result of the underutilization of the experienced engineer's skills in their job function. This is particularly the case where the tasks involve selecting materials from a catalogue, following the procedures outlined in a design code, or coordinating the work of experts. If there was a difference in the salaries of the person with five years experience and the person with many years, it would make economic sense for the manager to select the lower cost person. This person was also seen as being more likely to put in longer hours and create less problems for the manager by

doing what they were instructed to do. In a case where the manager has the main concern of meeting a budget, the lower cost person will help fulfill this goal, regardless of the value obtained for the money spent. There is also the possibility that a young person's enthusiasm is chosen over the knowledge of a more mature, but less enthused mature person for more social than economic reasons. A preference for personal likability over competence was found in a recent study of more than 10,000 work place relationships performed by Casciaro and Lobo (2005).

A further factor to be considered is the stated alteration of information provided to management by the engineers. It was reported that in many instances the engineers felt that when they did achieve high performance levels, it was largely unrecognized by management. In some cases, the performance measures did not take the difficulty of the tasks into account. Even if the more expensive mature engineer was performing at a level that made their extra cost justifiable, it may be difficult for someone in a managerial position to recognize the benefit, especially if the information is being filtered. It should also be noted that if the manager had a clear picture of everyone's performance, the very nature of modern organizations may make it impossible to quantify the benefit from any individual's output. In studying the impact of quality programs, Beruvides and Chiu (2002) express it well when they note that firms usually do not consider the costs of some engineering activities until they become significant enough to be a clear financial burden to the firm.

Weissman (2001) states that micromanaging is the most common complaint leveled at poor managers. The findings of this study may explain in part why an engineer would turn to micromanaging. When an engineer is promoted to manager from a position where they had found themselves controlling the message they were giving their superior, they may develop a sense of not getting the total truth from their subordinates. They may wish to get more involved with the work to determine what the truth is and to have a better feeling that they are in control of the situation. As one of the participants explained:

- *I always thought the worst boss was the one that demonstrated the Peter Principle. But now I find that the boss who is not even good at my job, but still insists on micromanaging, is by far more painful. He does not know what is going on, but he still needs to control the message he sends up to his boss. What am I needed for if I already know the report is going to say everything is going according to plan?*

Regarding the move to freelance work, the benefit to the organization is unclear. Although there is a potential for savings by bringing in the freelance workers to fill in the peaks of cyclic workloads, as noted by Zhang and Flynn, the freelance workers expressed the advantage of fitting work to their preferred schedules. As further developed below, the implementation of using casual employees to meet cyclic needs often only results in losing more control over the scheduling of the work to meet the needs of the resource availability. The replacement of employees with freelance workers likely results in reduced costs for the company through the elimination of providing long term benefits. The freelance engineers were generally given less than full time work and this resulted in lower take home pay on an annual basis. They also seldom worked for their original employer. Therefore, the replacement of employees with freelance engineers results in the commoditization of the engineering function as owner company loses their specialized knowledge and turns to drawing from a pool of common talent. As some of the participants reported, the move to standardized practice reduces the need for specialized knowledge anyway.

6.6 Engineering Work

The findings of the Why Study indicate that in many instances, the work of an engineer is neither highly technical nor specialized. The education the engineer received at university was seen as a way to select people that would be suitable to perform the tasks required, not to provide them with a skill set necessary for the completion of the work. As noted by Useem (1985), when they were able to compete against engineers, graduates of other programs were often able to outperform the engineers in the measures of the corporate

world. Engineers in Alberta have the tactical advantage of being able to use government-based authority to dissuade non-engineers from practicing engineering. The results of the Why Study suggest that few of the engineers perform duties that could be regulated as exclusively engineering. One way to reduce the demand on the numbers of engineers would be to select non-engineers to perform these functions. Several technical organizations have produced credentials to allow for the recognition of skills for non-engineers. One such designation is the Project Management Professional (PMP), awarded by the Project Management Institute (PMI) as described by Duncan et al. (1994). Another is the Certified Cost Consultant (CCC) awarded by the Association for the Advancement of Cost Engineering (AACE) as described by McDonald Jr. (2005). Promoting the acceptance of holders of non-engineering degrees or other professional certification for jobs traditionally filled by engineers would increase the supply of individuals and would likely decrease the average cost of such services. As reported by some of the participants, even EPC firms have successfully used non-engineers to perform technical work. This approach is in contrast with the attempts by APEGGA to broaden the definition of engineer to bring these other people under their jurisdiction. Some engineers view this proposed inclusivity model as having the potential of diluting the quality of the practice of engineering (Toogood et al. 2004). Having organizations utilize non-engineers for the majority of the administrative work currently done by engineers would both maintain the status of the engineers and would not jeopardize the safety of the public (which is a major argument used to counter the inclusivity model).

For the engineers that do perform duties resembling the more classical understanding of engineering work, the regulations of APEGGA and the university training may be more applicable. A good example of these types of engineers would be those few involved in design at EPC firms. In an interview with a senior partner at a large EPC firm, it was stated that the people they seek as employees are those with specialized technical skills, such as rotating equipment or high voltage harmonics, or those with experience in

managing large complex projects. These skills must also be in line with those frequently requested by clients. For example, a civil engineer with a specialization in large dams for hydro-electric power development may not get enough continuous billable hours to be of interest to the company for their Alberta offices. Most of the engineers that have many years experience with large organizations have not learned the types of skills that are sought by the EPC firms. These include general management and project control functions such as producing schedules. There is a perceived lack of talent in some areas of technical specialization so that when the EPC firm finds such a person available, age is not a factor considered in their soliciting for this person. Also, since the impact on revenue to the EPC firm is typically simply a function of the number of hours billed to clients, there is an easy method for recognizing the contribution of the employee. Performance is the guiding factor in the retention of their people.

6.7 Anti-Management Sentiment

During the review of an early draft of this dissertation, one of the committee members noted a pervasive anti-management sentiment in the comments presented. As noted in the sections on research methodologies, great care was taken to not introduce bias in the data obtained by asking the participants general questions and allowing them to volunteer information based on their own personal experiences. The profile of the participants and the presentation of their comments show that some are currently in management positions. Eight of the fourteen participants have held management positions at least 2 levels above the front line personnel. Most of the participants currently in freelance positions have held senior executive positions in international companies. The majority of the participants who are still working in engineering are in supervisory positions. The comments that reflect an anti-management sentiment are, at least in part, from people who have the perspective gained from being in management positions.

While the data was being analyzed, the researcher drew from the experiences of five third-party managers who were requested to reflect upon the conclusions being drawn. These review sessions took place in casual settings and generally lasted between fifteen minutes and half an hour in duration. These industry experts were all engineers in general management positions working at organizations with at least 500 employees. Many of the conclusions drawn were reached in collaboration with these people. As one of the managers noted, even many managers will have an anti-management sentiment as they either report to someone higher up who causes them some pain or they are suspicious of the motives of the managers that report to them.

One of the participants who has never held a management position is a former employee of a defunct company whose former CEO is now the subject of a number of legal proceedings regarding the misuse of company funds for personal gain. A general anti-management sentiment is prevalent in the popular works of W. Edwards Deming, as indicated by the following quote:

> *People are born with instinctive motivation, with a need to be loved and esteemed by others. Management grinds that intrinsic motivation out of people...* (Bhote 1994, p.158)

As well, there is a general anti-management sentiment in the *Dilbert* series of works produced by Scott Adams. Feldman (2000) states that the popularity of *Dilbert*:

> *...highlights a phenomenon already palpably evident in business today: Many employees are highly cynical about the effectiveness of management and view large, bureaucratic organizations with disdain and contempt.* (p. 1286)

Grullon and Ikenberry (2000) studied the increasing occurrence of stock repurchase programs by public companies in North America. They noted that 1998 was the first year in history when American publicly traded companies spent more on stock repurchases than on issuing dividends. They concluded that the distribution of cash through dividends was

more beneficial to the general shareholder and to the companies' financial health than using the funds for a stock repurchase program. However, the senior management would preferentially benefit from the higher share prices produced by the latter through their stock option plans. Grullon and Ikenberry concluded that the senior management of these public companies were generally demonstrating action that was self-serving, especially when it was noted that there was a correlation between announcements of share repurchases and executives exercising stock options. These types of actions may be viewed suspiciously by employees who do not qualify for option incentive plans.

Since engineers are a group of employees who have a higher attrition rate than many of their similarly educated counterparts, it is possible that they would share in the sentiment expressed by Feldman (2000). It would then follow that interviews with a number of engineers would generate some themes with a general anti-management sentiment.

6.8 Supporting Evidence

6.8.1 The Trojan Horse

Kennedy and Whittaker (2002) studied a large company that attempted to form an alliance between an EPC firm and their in-house engineering department. Management exhibited strong support for the initiative despite being presented with the results of a benchmarking study that showed none of the previous attempts by other companies had results that were deemed satisfactory. The salaried engineers in the organization had voiced their concerns about the alliance and by the time of implementation, 95% of them were no longer in the organization. The driver for the move to the alliance was presented by management as operating cost reduction. However, the cost of the in-house engineers for the economic analysis was calculated including the allocation of fixed costs in the company. When the salaried engineers were removed, the majority of these costs were still being paid by the organization. In addition, they were required to cover the overhead costs of the EPC firm

that was now their alliance partner. The cost of engineering as a proportion of total project cost was found to be double under the new system. The promise of using the EPC firm to fill in the peaks of the cyclic workload was not realized. The original in-house employees would work extra hours without compensation to adjust to workload demands. The EPC firm requested compensation for overtime and forced the owner to reschedule the workload to flatten the demand. This was done to ensure the alliance members were kept busy with the owner's work and preventing them from moving to other projects. More importantly, the quality of the projects as reported by the users of the facilities were found to be below acceptable levels and considerable re-working of designs was required and many installed facilities operated below specified performance criteria.

A follow-up of the company since the Kennedy and Whittaker paper was published was performed as a part of this dissertation. Some of the disgruntled ex-employees of the owner company reported to APEGGA that the EPC firm was using non-engineers to displace them. It was ironic that these non-engineers were actually seen by the client as the more valuable members of the design team. A compromise was reached with APEGGA where the non-engineers could continue to provide the needed service, but their business cards would remove any reference to engineering. After a few years, the alliance was dissolved and the owner company has attempted to rebuild an engineering knowledge base using salaried employees. The engineers in the owner company's departments that used the output of the alliance could see that the process had resulted in a very large waste of resources in the order of magnitude of tens of millions of dollars. The potential saving that initiated the program was in the order of magnitude of hundreds of thousands of dollars. It is unclear if management recognizes this outcome, however. The price of the commodity the company produces has seen drastic increases over this same time period and corporate profits have increased in the order of magnitude of hundreds of millions of dollars. According to the company's reports, the CEO was awarded a bonus in 2004 in excess of

one million dollars, in addition to his regular salary. This parallel's Herzberg's comments regarding the low correlation between employee satisfaction and corporate profits.

6.8.2 Continuous Rewriting of Engineering Procedures Manuals

Kennedy and Whittaker (2000) observed that many companies expend considerable resources in producing manuals that are intended to direct the work processes of engineers. Some of the developers of these documents saw the work as an attempt by companies to reduce their dependency on the more costly experienced knowledge worker. However, most participants in the 2000 study felt that it was beyond the ability of the writers of the manuals to capture the important aspects of their skills. This would be particularly relevant if the value of the mature engineer is largely in the rapport they have developed with contacts. In the 2000 study, one participant reported that their organization had implemented a policy where the junior engineers were not allowed to look at the procedures because they were deemed too full of errors to effectively guide them and only the experienced engineers could tell which parts were accurate. In a follow-up to the study, performed as a part of this dissertation, it was found that this same organization has spent considerable effort issuing new procedures manuals that attempt to correct the errors identified in the original and subsequent revisions. In 2005, the company is currently working on the fourth major revision to their procedures manual in five years. Despite the organization's focus on procedures, an unrelated review of the actual processes of their engineering group by a third party consultant revealed that the engineering department ranked very low against their peers in operating efficiencies. One of the engineers working on the capturing of knowledge in a manual stated that he was willing to work on the task, but he drew the line at outlining anything that he felt was valuable tacit knowledge he had acquired from his unique experiences. He was not willing to freely surrender what he felt was his contribution to the organization.

6.8.3 The Soul of a New Machine

In his Pulitzer prize winning book *The Soul of a New Machine*, Kidder (2000) records the events around the development of a new computer at Data General. The book has become a staple for many MBA courses and was included in a Business Week top ten list of classic business books (Byrne 1990).

In *Soul*, a manager named Tom West proposes to run a low budget project to develop a lower tech computer that can serve as a backup plan for Data General if their higher tech proposal fails to get to market in time. West hand picks a few experienced people with specialized skills to play key roles on his team. For the rest of the workers he brings in young programmers and hardware designers. The team is allowed to believe that there will be rewards after implementation that will more than justify the long hours and low pay they are asked to put in. Upper management puts most of their attention into the higher profile competing project and West's team is largely ignored. The team is able to get their Eagle computer to market in time to save Data General, whose flagship project has indeed proven to be overbudget and not scheduled to be complete in time to meet market demands. West becomes the hero and savior of his employer. The lessons that are taken from the book are those that are repeated by many of the behaviorists such as McGregor and Herzberg (Collins 1996). The key to motivation and having high performing teams comes from triggering the satisfaction individuals get from doing a good job and wanting to make the team succeed. The reward for such work is the ability to have more work of a similar nature, or what Kidder called "pinball." If you are good, you get to play again. One complaint voiced by Herzberg was that many modern organizations reward good performance in the opposite way with promotion or holidays, which is seen by him as emphasizing the undesirable nature of the tasks.

In a follow-up of the events portrayed in the book *The Soul of a New Machine*, Ratliff (2000) provides some clues as to why it was important to have so many young members on West's team. In providing more background to the story, we find that Tom

West develops the concept of the Eagle in response to the company's announcement that they are relocating their best talent to headquarters in another state. West felt that the company was failing to recognize the value of their more senior engineers in the old location. West turned the perceived corporate neglect into a motivator for his team. With regards to the conflict between management and the technocrat, Ratliff quotes West's key aid, Carl Alsing as saying, "When your company doesn't do the right thing, you manipulate it until it does" (p. 359). After the success of Data General's new Eagle computer, the company experienced a period of renewed financial strength. Ratliff states that the new vice president of engineering, appointed around the time the Eagle went to market, openly criticized the accomplishments of the team that saved Data General. Most of the young team members left the company within a year after the end of the project. Ratliff notes that although the young engineers may have viewed a senior management position as the ultimate goal, very few of the Eagle team actually made any moves in the direction of management throughout their later careers. Some of the alumni mentioned that they found management to be an activity that keeps them out of the mainstream of the technology and when they need to move jobs, they are now unfamiliar with the newest tools.

Ratliff reports that Tom West himself was punished by being sent to a remote branch office of the company. This was a move that West viewed as being 'effectively fired'. West lamented being removed from the team and being powerless to protect them considering what they had done for the company. Once the success of the book was realized, Data General acknowledged the high profile of West and the value to the company in keeping him around. West was returned to his old post. But when the fast pace of the computer industry caused Data General to again fall into difficult times, they did not provide West with the resources to save the company a second time. West promoted the need for the company to develop his idea for a thin Web server that would keep it ahead of the customer demand. Ratliff states that the demise of Data General was due mostly to management's failure to recognize their engineering talent and inaction in the areas of most

importance. Despite his threats to quit Data General, even at the time of the events in the book, West stayed with the company to the end, even though his major responsibilities were often to just sign autographs. Being the topic of a Pulitzer Prize winning book was not enough to help Data General recognize the potential value of their star employee.

6.9 Summary of the Why Study

The Why Study was developed to investigate possible reasons for the lack of mature engineers in engineering and management roles. Fourteen engineers were selected for in-depth interviews regarding their careers.

The results suggest that young engineers leave university with very little vision of what their future will be like. Some come into the workplace expecting to perform the complex mathematical calculations they did in university. The employers of engineers generally view the university experience as a means to screen people from the general population that are suitable for the duties they need. These talented people are enthusiastic and have a strong sense of dedication and responsibility. They will work long hard hours and will do what is asked of them. They may even be asked to be lower cost replacements for skilled labour. Some engineers have trouble with the early years of their careers and choose or are forced to pursue non-engineering roles.

As the engineers gain experience, they develop an understanding of the effects of their actions on company performance. It was often mentioned that after five years of work experience, the engineer has gained enough knowledge to be nearly as effective as the most mature engineers. The engineers become functioning members of the technostructure described by Galbraith. They learn that their accomplishments are often unrecognized by management and there may be a conflict between what is best for the company and what management asks of them. Engineers that move into middle management develop new skills that involve the gathering of information from their subordinates and formatting it in ways that are requested from their superiors. The duties are often loosely related to

corporate effectiveness and there is little direction from upper management. Engineers in the government feel that the politics of corporate life make the private sector more subject to the whims of the manager and less focused on real results.

The engineers near the end of their careers may become bored with the duties they are assigned and may also lose interest in playing the games required to meet performance targets that may be unrelated to organizational success. Those that become financially independent may choose to turn to non-work related hobbies and volunteer work. Those that desire continued income may turn to freelance engineering as a way to have more control over their duties. Engineers that are near the end of their careers also perceive it to be a very difficult task to get full time employment if they are forced out of an organization. Most of the engineers had a strong desire for job security and a suspicion towards the dedication of their employer towards their well being.

Figure 6.2 is a graphical representation of the results of the Why Study. The engineers are selected from the general population through the university screening process. Most of the engineers become involved in the business processes of large organizations. The majority of these are involved in the operating side of the companies and these are referred to as the technocrats. The other significant group is involved in the control of the company and is represented by management. Because of the conflict between the interests of management and the technocrats, a communication barrier exists between the two groups. This creates a situation where the decisions management makes may not be the most desirable from the technocrats' vision of organizational effectiveness or their own self interests. This promotes further barriers to clear communication. The tension of the situation may cause the technocrats to leave the organization. The awareness of altering information by the technocrats may create unease in the manager. The manager may desire more junior subordinates who will lack the skill to manipulate the system. The manager may also lack the information required to recognize the value of certain high performers, so they go unrecognized and unrewarded. The desire to produce standardized

procedures also reduces the dependence on experience and increases the degree of underutilization of the best people. The lack of general management positions under a typical hierarchy limits the number of managers in an organization. If the middle managers serve as a pool for potential senior executives, a position held by someone who is not deemed to be executive material prevents the opportunity for another prospect.

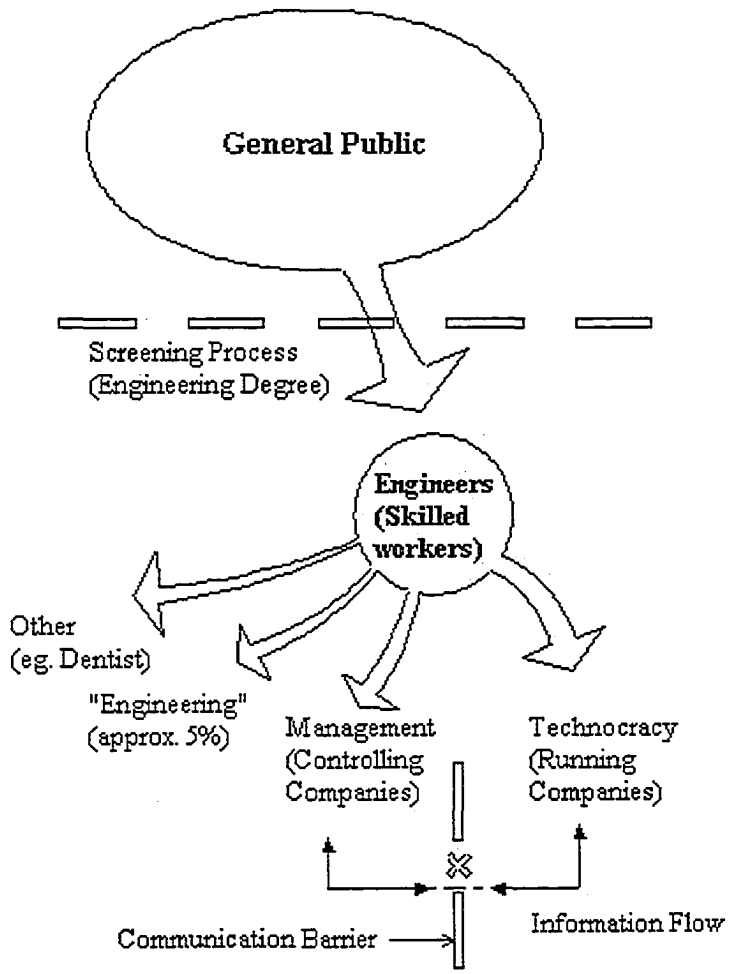

Figure 6.2: The engineer's career.

The situations described above can explain the lack of mature engineers in salaried positions. Some of the engineers choose to follow non-engineering functions such as dentist,

farmer, police officer, or clergy. Some of these may leave engineering for a while and return when the job market is more favourable or a better perceived opportunity becomes available. Of the engineers interviewed, such a move back into engineering generally involved freelance work or signing on with either the government or an EPC firm. A few engineers move directly into more classical engineering work, in particular the design work performed by EPC firms.

CHAPTER 7

CONCLUSIONS AND IMPLICATIONS

This dissertation was developed to address certain specific questions regarding the careers of engineers and the value of the experience an engineer gains. The findings of the What and the Why Studies, and the supporting data can now provide a number of insights to these questions.

7.1 Instrumentality, Validity, Generalizability and Bias

It is understood that in studies performed by humans, bias will exist. I am an engineer who is 45 years old and am, therefore, at the transition age identified by Dalton and Thompson. I have worked in all 7 of the active job categories presented in the What Study. Although considerable effort was expended to reduce the amount of conscious bias introduced into the study, there is also the potential for introducing bias unconsciously. The data gathering in the What Study was performed by seven different people, not associated with other stages of the work. The data gathering for the Why Study was performed by myself, but the transcription of the recorded interviews was done by others. A triangulation of the coding of the transcripts and the final analysis was achieved by having the work audited by experienced qualitative researchers who are neither involved with management research nor on my committee.

It is also acknowledged that the results obtained in this study may be different than those obtained for another study performed at another location in the future. The general economy in Alberta at the time of this study is one where mature engineers have reported it being relatively easier to find work than in the recent past. The number of mature female engineers was found to be very small, in the order of a few percentage points of the

overall population of engineers. The Alberta economy is heavily driven by the oil and related industries.

It is recognized that this study dealt with the careers of engineers from their perspective. Their comments are largely the result of their perception of the events that shaped their careers. For example, their reporting of being subjected to conflicting expectations is a result of their perception based on the information they have available. It is also possible that the reporting of the inability of management to accurately determine the value of their contribution may be the result of the Fundamental Attribution Error, whereby people are more likely to attribute their success to things they can control and to attribute their failures to the things they cannot control. It must be stressed here, however, that this study verified the existence of these opinions and the cause of the opinions is secondary. These opinions were obtained by asking general open questions to members of the overall engineering population, including those that would be missed by only looking within organizations that still have mature engineers on their payroll.

7.2 The Nature of Engineering Work

In keeping with the findings of Meiskins, the group of workers referred to as engineers was found to consist of a non-homogeneous body of workers that perform a wide variety of functions for a great number of companies. In general, the participants reported a discrepancy between the content of the university engineering courses and their relevance to any duties they performed as engineers. A large part of engineering work appears to be following procedures, selecting items from catalogues, recognizing potential problems to delegate to experts, and dealing with people. The data suggests that the newly graduated engineer lacks the skills to function independently, but these skills are acquired within five years on the job. The engineers were found to represent a large part of what Galbraith referred to as the technostructure, which is the body of workers that provide the knowledge for running large organizations. The engineers themselves seemed to be able to distinguish

between engineering and non-engineering functions. The opinions of these engineers also agreed in general with the working definitions provided by CETS.

7.2.1 Tacit Knowledge Acquisition

Companies were found to value certain types of knowledge the engineers gained over their careers. The more valued types appeared to centre around the knowledge that would be contained in an address book. Who does the engineer know that can do a certain kind of work? Does the engineer have a contact that can help get an application approved? Does the engineer remember who did a similar application the last time? As the engineers gained experience, they often learned more effective ways to perform certain tasks. In general, these methods were seen as a nuisance to an organization that had a greater focus on teamwork and established procedures than operational efficiencies. Some of the participants reported problems around the conflict between established procedures and individual preferences of more mature engineers. In general, the reported preference in the organization was for junior engineers who were seen as more malleable.

Engineering, Procurement and Construction (EPC) firms were found to employ approximately 5% of the total population of engineers. Their work centers around designing and building facilities. They value knowledge around specific technical skills or the ability to execute large complex projects. They do not place any particular value on the skills most engineers acquire in operating companies, such as general management and administrative functions.

7.2.2 Knowledge Obsolescence

There is a perception that the advances in technology result in an increased rate of obsolescence of the knowledge learned at university. The results of this study indicate that in general, the university training is viewed only as a method for selecting people out of the general population that would have the abilities to perform the functions of engineers. If

the content of the courses is not relevant to the work of engineers, there would be no rate of obsolescence of this knowledge. Some participants noted exceptions to this, in particular the field of Petroleum Engineering was seen as having course content relevant to the work of engineers.

7.2.3 Continuing Competency

As noted by Dalton and Thompson, external training was seen to have no impact on the competency levels of engineers. As well, the engineers in their study were reluctant to forego their leisure time to devote to continuous schooling. The nature of engineering work appears to center on skills that would not be subject to loss in value from advances in technology. Knowledge concerning history of the company or the phone number of a key contact is not the type of tacit knowledge that would be enhanced through formal training. The requirement for demonstrating continuing competency through professional development may prevent a number of freelance engineers from maintaining their professional status. As noted earlier, full time employment can be a major contributor to meeting the CPD minimum requirements. If companies were to recognize the low value that the professional status was reported to bring to the services the freelance engineer provides, this could reduce the administrative burden to the system and increase the supply of available resources to choose from. This is similar to the findings of Kennedy and Whittaker (2003) when they looked at the extra costs of certifying quality programs in EPC firms with little supporting evidence of any added value.

7.2.4 Engineers Leaving the Profession

There was no evidence discovered in this study that disproved the original published data that tended to indicate that engineers leave their profession at a faster rate than other university graduates. For the years when the mature engineering participants graduated, the profession was very largely dominated by males. Hence, it is even more surprising that

they would have higher attrition rates considering many women would leave their jobs when they raise children. Engineers were found to leave salaried positions of both engineering and management at a rate greater than 8% a year after the age of 55. At this age, only about one third of the engineers are still in salaried positions, most having moved into the freelance business or retiring. Noted exceptions to the high attrition rates were found in EPC firms and the government.

7.3 Engineers in Management

One of the possible explanations provided at the beginning of the study for the lower numbers of salaried engineers observed as they mature was that they were moving into general management positions where they were not being counted. The belief under this scenario is that engineers are particularly suited for management duties and a normal progression of their careers is to advance into general management. Although engineers do advance into management positions, there was no evidence in this study that they do so at a rate greater than other professions. Accountants, lawyers and science graduates all appear to have a portion of their workforce that move into management as well. The engineers that were in general management were most often still registered with APEGGA and appeared to be counted in most instances among the engineers in the system. Although approximately 40% of the engineers still in salaried positions at the age of 55 were in general management, these engineers only represented about 15% of all engineers of that age group. Many of the engineers interviewed that had experience in general management reported disliking the actual job duties. Many of the engineers considered the higher salary to be the main factor in favor of considering leaving the more interesting engineering work for the promotion into management. Engineers in management appeared to have no lower turnover rates than those in the front line positions.

7.4 Freelance Consulting

For the mature engineers studied, the largest group by numbers was the freelance consulting group. All the freelance engineers questioned concerning their past indicated that they had left a salaried position to go into freelancing. Some had stated that they looked at the salaried positions as training for learning the skills required to promote themselves to industry. These skills were often related to understanding the processes involved in getting approvals and completing documentation. A few freelance engineers were involved in design or calculations. Many freelance engineers had quit their salaried positions and others were let go, with the distinction between the two being less clear in some cases. The freelance engineers saw their new role as a means to escape the politics and dissatisfaction of the salaried position. They were less than fully employed and often timed their work around their personal life. Some of the freelance engineers worked only a few months, or even one month, a year and were not much different in output from the engineers that had retired early.

7.5 The Impending Shortage of Engineers.

As noted, there are many articles that predict an impending shortage of engineers in the near future. Some of these articles cite the wave of baby boomers that are nearing retirement age as the most significant cause of this shortage. The literature suggested that the impending shortage of skilled labour has been proposed many times in the past. Some papers note that a shortage in any field will typically be reflected in higher starting salaries and this proves effective in encouraging more university students to enter these programs.

7.5.1 The Baby Boomers in Engineering.

The findings of this dissertation tend to indicate that there is no large number of engineers in salaried positions that are nearing retirement age. The largest two groups of mature

engineers were found to be those that are already retired and freelance consultants who typically work on a less than full time basis. The age profiles studies tended to indicate that the vast majority of engineers in the system are in the first half of their productive years. This situation was found to be similar to available data going back at least 40 years. Since the premise of an impending shortage of engineers is based upon the baby boomers leaving the system, this study indicates that any crisis should have already happened.

7.5.2 Extending the Retirement Age Past 65.

Some papers have proposed a solution to the perceived impending shortage of engineers by extending the retirement age past 65. This would appear to have negligible impact on the numbers of engineers in the system as most are already moved on by that age. If there was concern about keeping more engineers, efforts may be better utilized by paying attention to keeping more engineers employed until they reach 65.

7.5.3 Importing Engineers

The literature suggested that programs have been established to promote the immigration of skilled engineers into Canada. The government expends resources to try to place foreign-trained, but experienced, engineers into Canadian companies. The findings of this dissertation suggest that companies are less inclined to hire engineers that they feel may have their own established work patterns that may be different from their organizations. If there is a perceived cultural difference between organizations that produces a preference for the young engineer who would not have established work processes, it would be even more unlikely to find companies that would be willing to take someone with experience from another country. For engineering, the data suggests that young graduates or engineers with only a few years experience from other countries may have a better chance of being placed in Canadian organizations than those with extensive experience.

7.5.4 Supply and Demand

It appears that any impending shortage of engineers could be resolved through increasing salaries. If the early departure of mature engineers is caused in part by the higher cost effectiveness of the junior engineers, then paying more for the work should mitigate the situation. If engineers are becoming more of a commodity, as reported by the participants in this study and as suggested by the goals of the Knowledge Management movement, then the simple interactions between supply and demand economics should hold. Higher salaries could attract more of the underutilized or retired engineers back into the system, which would have a very short response time frame. Higher salaries would attract more students into the engineering programs. The work of engineers suggests that many of them perform duties that do not require the technical training of engineers. A simpler process for screening potential candidates could be found and organizations that desire lower cost workers could draw from this larger pool. It should be noted that most engineers in management positions felt that technical school graduates are not the type of people they are seeking. Any university degree (for example a B.A.) was generally seen as a better indicator of the person's potential for the required duties than graduation from a technical school.

A lower cost solution could also involve the better utilization of the engineers currently in the workforce. It appears that a lack of recognition of their talent and the political pressures of providing management with non-productive work may be contributing to the high attrition rates of experienced engineers. Government organizations and EPC firms were cited as having better systems for assessing talent and rewarding performance. These groups were also found to have significantly lower attrition rates among their mature engineers.

7.6 Recommendations and Further Research

As noted by Mintzberg and Herzberg, the researcher often intends for their findings to influence policy or at least lead to an exploration of the impact of changes based on their findings. What they often discover is that their research mostly led to replicating the studies under different situations or simply verifying the results under similar situations. For this dissertation, most assumptions about the consequences of changing policy around the management of engineers would be of a speculative nature since these results were aimed at exploring the current situation. The context of this study was during an economic boom in Alberta. Although the findings were supported by the details of many studies performed in different locations and over a wide time frame, there may be some significant differences in the situation of mature engineers in less strong economies. Similar research could be conducted under different economic and cultural conditions to explore any differences in the circumstances of those mature engineers.

As noted, there is little evidence to support any assumptions regarding the outcome of policy changes based on these findings. There are a number of different stakeholders whose interests may conflict with each other. If the education the engineer receives is often seen as a screening process for selecting capable workers, it may be possible to develop a more efficient screening mechanism. The development of a larger supply of workers who could fill the role of technocrat in a large organization (perhaps by simply drawing from graduates of more general programs) may decrease the salary an individual of this group receives. The findings of Parkinson would suggest that this may not actually reduce the net costs to an organization, as there are pressures on the individual manager to maintain or increase their budgets. The findings of Brookes also suggest that the manager's salary is linked to the size of the budget they control. The lower individual salaries could potentially result in increased numbers of employees and actually decrease the efficiency of the individual worker.

An alternate scenario for future research could entail testing the impact of retaining the mature engineer in organizations and allowing their experience to shape company policy. Recognition of the role of the technocrat and reducing the role of management in controlling these individuals should impact company performance. The lack of control could increase the amount of wasted effort and capital expenditures. It is possible that the preference for young engineers stems from the lack of trust a manager may have for an engineer well experienced in the workings and manipulation of metrics for their organization. On the other hand, allowing more freedom to the mature engineers could potentially reduce a lot of waste produced by both mistakes and intentional efforts to meet targets. Lessening the control over the technocrat should decrease the consistency of meeting level target numbers, which could lead to either a positive or negative impact. It should be clear that implementing a pilot study of having management relinquish some of their control would be expected to encounter considerable resistance. The managers could view the change as a competing alternative to their personal responsibilities.

It has been noted a number of times in this dissertation that the definition of engineer and the regulatory control of the use of the term in Alberta is a contentious issue. It should be expected that any significant shift in the status quo regarding the roles of engineers and the numbers of engineers in the system would be met with considerable resistance from the parties negatively impacted. Even suggesting that there may not be an impending shortage of engineering talent is expected to be met by resistance to those that benefit from that scenario, as identified by Teitelbaum. The requirement for demonstrating continuing competency is beneficial to those who provide training, despite the evidence suggesting that this training may have little impact on the individual or their employer.

The retention and recognition of mature engineers has benefits to this group, both financially and emotionally. A decrease in the demand for young engineers could negatively impact their present situation as well as the infrastructure dedicated to producing the new graduates. In a highly complex system, outcomes from changes in inputs are often

impossible to predict based on deductive reasoning. This dissertation provides many areas for future study to determine realized outcomes from changes in the present system. A clearer understanding of the current situation through directed research is required before policy changes could be made with any degree of confidence for the impact of the changes.

7.7 The Value of Experience

To repeat the research question:

> "What is the economic value of the experience engineers gain after qualification?"

The findings of this study suggest that there is an initial period where the engineer requires experience to function independently following graduation. The most valued knowledge gained appears to center around how to function in a large organization. After about five years, the salary increases that are expected by the engineers appear to move them towards the upper limit of the cost employers are willing to pay for their services. The management of large organizations appears to lack the tools necessary to determine the differences in value of the output between different engineers. There also appears to be a desire to standardize work to decrease the dependency on the knowledge of particular workers. Both these factors work towards a preference to the lower cost individual, regardless of the value of the output they produce.

Employers may desire more effective workers, but they appear to be unwilling to pay for it.

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Appendix A

Breakout of SESTAT Data by Degree Held

The following is the listing of all degrees held by the 148,932 people involved in the detailed interviews conducted by SESTAT in the early 1990's.

Degree	Percent of Total
Computer and Information Sciences, General	0.39%
Computer Science	1.13%
Computer Systems Analysis	0.14%
Information Services and Systems	0.23%
OTHER Computer and Information Sciences	0.06%
Applied Mathematics	0.21%
Mathematics, General	1.18%
Operations Research	0.16%
Statistics	0.11%
OTHER Mathematical Sciences	0.01%
Animal Sciences	0.27%
Food Sciences and Technology	0.10%
Plant Sciences	0.28%
OTHER Agricultural Sciences	0.18%
Biochemistry and Biophysics	0.26%
Biology, General	1.32%
Botany	0.08%
Cell and Molecular Biology	0.09%
Ecology	0.08%
Genetics, Animal and Plant	0.05%
Microbiology	0.24%
Nutritional Science	0.14%
Pharmacology, Human and Animal	0.06%

Degree	Percent of Total
Physiology, Human and Animal	0.10%
Zoology, General	0.24%
OTHER Biological Sciences	0.23%
Audiology and Speech Pathology (PhD only)	0.01%
Health Services Administration (PhD only)	0.01%
Health + Medical Assistants (PhD only)	0.00%
Health & Medical Technologies (PhD only)	0.00%
Medical Preparatory Programs (PhD only)	0.00%
Medicine (PhD only)	0.09%
Nursing (4 Years or Longer Programs; PhD only)	0.01%
Pharmacy (PhD only)	0.04%
Physical Therapy + other rehab. (PhD only)	0.01%
Public Health, inc. Environment (PhD only)	0.02%
OTHER Health/Medical Sciences (PhD only)	0.03%
Environmental Science Studies	0.15%
Forestry Services	0.18%
Chemistry, Except Biochemistry	1.08%
Atmospheric Sciences and Meteorology	0.04%
Earth Sciences	0.07%
Geology	0.39%
OTHER Geological Sciences	0.06%
Oceanography	0.03%
Astronomy and Astrophysics	0.03%
Physics	0.53%
OTHER Physical and Related Sciences	0.11%
Science, Unclassified	0.10%
Agricultural Economics	0.28%
Economics	1.21%
Public Policy Studies	0.04%
International Relations	0.22%
Political Science and Government	1.52%

Degree	Percent of Total
Educational Psychology	0.32%
Clinical Psychology	0.36%
Counseling Psychology	0.73%
Experimental Psychology	0.13%
Psychology, General	1.5%
Industrial and Organizational Psychology	0.18%
Social Psychology	0.09%
OTHER Psychology	0.3%
Anthropology and Archeology	0.22%
Criminology	0.14%
Sociology	1.43%
Area and Ethnic Studies	0.14%
Linguistics	0.12%
Philosophy of Science	0.09%
Geography	0.23%
History of Science	0.04%
OTHER Social Sciences	0.47%
Aerospace and related Engineering	0.32%
Chemical Engineering	0.56%
Architectural Engineering	0.18%
Civil Engineering	1.12%
Computer and Systems Engineering	0.22%
Electrical, electronics, and communications engineering	2.06%
Industrial Engineering	0.42%
Mechanical Engineering	1.54%
Agricultural Engineering	0.07%
Bioengineering and Biomedical Engineering	0.04%
Engineering Sciences, Mechanical and Physics	0.15%
Environmental Engineering	0.12%
Engineering, General	0.11%
Geophysical Engineering	0.01%

Degree	Percent of Total
Materials Engineering	0.12%
Metallurgical Engineering	0.11%
Mining and Minerals Engineering	0.04%
Naval Architecture and Marine Engineering	0.07%
Nuclear Engineering	0.06%
Petroleum Engineering	0.08%
OTHER Engineering	0.19%
OTHER Agricultural Business and Production	0.25%
Accounting	4.83%
Business Administration and Management	8.51%
Business, General	1.86%
Business and Managerial Economics	0.65%
Financial Management	2.14%
OTHER Business Management/ Administrative Services	1.45%
Audiology and Speech Pathology (non-PhD)	0.35%
Health Services Administration (non-PhD)	0.35%
Health & Medical Assistants (non-PhD)	0.02%
Health & Medical Technologies (non-PhD)	0.42%
Medical Preparatory Programs (non-PhD)	0.14%
Medicine (non-PhD)	3.37%
Nursing (4 Years or Longer Programs; non-PhD)	1.94%
Pharmacy (non-PhD)	0.64%
Physical Therapy & other rehab. (non-PhD)	0.51%
Public Health, inc. Environment (non-PhD)	0.22%
OTHER Health/Medical Sciences (non-PhD)	0.47%
Education Administration	1.51%
Computer Teacher Education	0.06%
Counselor Education and Guidance	0.79%
Elementary Teacher Education	5.53%
Mathematics Teacher Education	0.37%
Physical Education & Coaching	1.36%

Degree	Percent of Total
Pre-Elementary Teacher Education	0.3%
Science Teacher Education	0.28%
Secondary Teacher Education	1.69%
Special Education	1.4%
Social Science Teacher Education	0.28%
OTHER Education	3.09%
OTHER Philosophy, Religion, Theology	1.74%
Social Work	1.32%
Computer Programming	0.17%
Data Processing Technology	0.03%
Electrical and Electronics Technologies	0.33%
Industrial Production Technologies	0.33%
Mechanical Engineering-Related Technologies	0.27%
OTHER Engineering-Related Technologies	0.21%
Business Marketing/ Marketing Management	2.49%
Marketing Research	0.34%
English Language, Literature, and Letters	2.39%
OTHER Foreign Languages & Literature	0.84%
Liberal Arts and General Studies	0.71%
History, OTHER	1.76%
Dramatic Arts	0.35%
Fine Arts, All Fields	1.44%
Music, All Fields	0.89%
OTHER Visual & Performing Arts	0.53%
Architecture and Environmental Design	0.79%
Actuarial Science	0.03%
Communications, General	0.91%
Journalism	0.9%
OTHER Communications	0.76%
OTHER Conservation/ Renewable Natural Resources	0.16%
Criminal Justice and Protective Services	0.76%

Degree	Percent of Total
Home Economics	0.75%
Law, Prelaw, Legal Studies	3.96%
Library Science	0.5%
Parks, Recreation, Leisure, and Fitness Studies	0.57%
Public Administration	0.55%
OTHER Public Affairs	0.04%
OTHER Fields (Not Listed)	0.57%
TOTAL	**100%**

Appendix B

Resources Used During The Studies

The amount of labour required to perform the What Study is broken out as follows:

- Set-up, planning activities - 5 person hours
- Locating and selecting random participants - 13 person hours
- Searching present whereabouts of the participants - 72 person hours
- Creating and distributing information letters - 60 person hours
- Data collection and compiling - 77 hours person hours
- Total resources to collect data for the What Study - 227 person hours

The amount of labour required to perform the Why Study is broken out as follows:

- Set-up, planning activities - 6 person hours
- Locating, selecting, and contacting random participants - 8 person hours
- Data collection - 32 hours person hours
- Transcribing - 86 person hours
- Coding and organizing - not tracked
- Total resources to collect data for the Why Study - 134 person hours, plus codification and organization of data.

APPENDIX C

TYPICAL COMMENTS BY THEME - THE WHY STUDY

The following are additional comments presented to support the interpretation of the results of the Why Study. These quotes do not necessarily represent all the comments obtained on a particular theme. As explained further in the body of the dissertation, the speaker is not identified (even through a coded name) in order to maximize the anonymity of the participants.

C.1 Job Security and The National Energy Program

- *In 1981, it soon became known around university that there was not much out there for engineers. People in class were saying that it did not make sense to hire a young engineer to make the coffee and distribute the mail when you can hire a professional engineer with 20 years experience to do those tasks for the same money.*

- *I guess one event that goes back that I mentioned is the NEP recession that was important to me... The younger people now are more used to that sort of thing. Having been laid off and having gone through a serious recession, I aligned myself with a more stable company that would be able to ride out the recession so that was one of the real shocks of my life I guess.*

- *I used to envision that the knife would just be passed around the room. People would talk and there seemed to be a need to make people eat their words and like that. Not a healthy environment. Frankly there was a bunch of lay offs happening and they started in '83, so I got into this thing right when lay offs were the big thing and I didn't like what I was seeing, there was no security in the job, I really cared at that time. And I*

saw that this isn't my future career, it's too mean spirited. And it's the industry, I don't think it's the engineers in particular, it's the industry [oil] that's very aggressive

- *That summer was the summer of the NEP and I got laid off after about a month.*

C.2 Lifelong Employment

- *I really did enjoy my time with [name] Company and had it not been for that merger and subsequent skidding of me, I probably still would be there.*
- *I wanted good money, continuous learning opportunities, and interesting work. The reality of my time with large companies was different or maybe even the opposite.*
- *I was never in a job for very long.*
- *The younger people now are more used to that sort of thing... being laid off*
- *Things have changed. My son is an engineer in the oil field. He is always on contract. There is no security. The last few years he has only been on contract. He has to continually look for the next job. It seems like that is the way it is going. There does not seem to be anywhere that you can sign on for 30 or 40 years like I did.*
- *When I talk to young graduates or young professionals, they expect to change careers three to five times in their lifetime which is something I never expected to do, that's really what's different.*
- *In the beginning, I had to quit [resign] to learn other areas and to develop new skills. As I became more senior in organizations, I found that companies would undergo some merger or reorganization and I was paid to make the move. [Name of company] provided me with the seed money and cushion to allow me the opportunity to go out on my own full time.*

- *[severance package offer] It was a general offer, but it was particularly good for the more experienced. If you got 2 months for every year, anyone with 30 years got a pretty good deal. I knew some people that only had a few years that took the offer, but it was more that they had other places lined up and this was just gravy for them.... I decided it was time to go before they told me I did not have a job. It happened to a friend of mine that was on holidays and they called him back to tell him that he did not have a job anymore. His job no longer existed. It has changed a lot in the last few years I was there anyway. They have become a lot more marketing oriented and much less towards anything that has to do with engineering. They have forgotten that there is any engineering aspect.*

- *This was a downsizing business and there were several rounds of downsizing. They had a number of rounds. They had a few five years before. When I left they got about 1000 people. It was a case of getting an offer I could not refuse. I felt that if I did not accept this pretty good deal, in a few years I may be out anyway, with a much worse deal. By the time I left, they had reduced it from about 11,000 people to about 7000. It is hard to figure out what the rationale was. They claimed it was economics, but it did not make sense.*

- *The best way to get something changed is to break the rule and have someone catch you. Then everyone knows and they start thinking about it. You still get hell, but they think about it. They may come to realize that they should not have fired you after all.*

- Interviewer: *So why did you change from gas to oil?*
  Participant: *I got run off.*

C.3 Job Satisfaction and Recognition for Performance

- Participant:*I had a situation with my direct supervisor and that was a tough situation. I kind of rode it out but it was not enjoyable and it lasted a couple of years.*

Interviewer: *What made it tough?*

Participant: *I felt that I was not being treated fairly relative to the group. I was not getting recognition for what I was producing and it made me feel that the supervisor was not supporting the work very well in that if I or someone else needed the supervisor to do something he was not very accommodating, but I was being held accountable for the result. That was a tough situation.*

- *Good work feels good because the paper work gets finished up and there is positive feedback from the clients. This gives you the energy and confidence to take on the next project. There is not much that comes from management, but the clients would likely notice a difference in the final product due to improved motivation.*

- *Their actual measurement criteria for this problem is that you are to do things by a certain day for a certain amount of money...As an example I will have to hold twelve meetings with the safety inspection group at the plant site and document them. The minutes are the proof that they were held. That is the proof. The same with budgets and times.*

- *One of the problems was that the more senior people would get the more difficult or messy problems or projects and sometimes there is no quick answers and management cannot see this. ... And management fails to realize that when push comes to shove and things get difficult we are always leaning on the same senior people. Because they understand the issues and they know where to find the information a bigger depth of understanding. Management would not always recognize this.*

- *It can come up and bite you big time. The other one [regular job duties] everyone says is important and you need to do it, but it is the annual one [performance target] that really matters and what can do you in. You got to learn to play the game. I still have trouble with that one after 30 years.*

- *I was managing the winter drilling program. I had a feeling of high satisfaction for about 3 months. I accomplished a lot of work in a short time. I was doing coordination and supervision. The program was completed on time and on budget. I think the feeling of satisfaction was only on a personal level, it was probably not really noticed by anyone else. During the period of feeling high, I was giving 110% on all my tasks. My peers would have noticed some improvement in performance, just being around me, or at least they would have noticed a good attitude, but probably performance would not be measurable. But my supervisors were either not concerned or maybe not even aware. Or at least it was never acknowledged that I had done anything good. I did not really care what they thought, anyway.*

- When higher sales are realized: *Management recognizes the performance by monetary rewards, bonuses. More importantly, the client often says "good work." The reward is repeat business.*

- *That is what you learn, you have to learn to when to shut up, when to move, when to go along. There is so much here. They give you drivers which are supposed to be measures for the day-to-day stuff that can really wear you down. And at the end of the year they review that you were 10% this and that and that is what they report to [senior management]. They report on variances and budgets and that is what they need to report at the higher level. But through the year they have their needs like the guy next door got flooded or the other person was ticked off that in the grand scheme of things is not important. I know that service matters, but it is not what turns the crank at the end of the year. You have to meet your target and it is all the little things that are going to interfere with meeting your target, so it is a balance between doing your job and meeting your target. You learn that too. But there is a lot of smoke and mirrors. You have to give it the lip service but never lose sight of the real job.*

C.4 Career Planning and Serendipity

- *I sent out resumes to specifically two companies [smaller company] and General Motors and I had job offers from both of them. And I often wonder where I would be now if I had gone with General Motors...I love cars but I made a decision to go agriculture. That's the only thing, I don't regret it, but I often wonder would I be vice president of Corvette or something like that?*

- *I actually had a plan and that's why I took chemical engineering because I wanted to be a refinery or chemical industry guy and couldn't get there. I just ended up in the pipeline business, I had no thoughts or training about it before, because I got hired there.*

- *I just felt that I would try to do the best I could at whatever I did at whatever I did do. I just drifted into jobs. Once I got some experience, I had enough of a reputation that work just seemed to come.*

C.5 The Value of an Engineering Degree

- *Well, specifically in the courses you take, there are right and wrong answers. Pipeline construction, there's certainly incorrect ways to do things but they're not necessarily wrong and you have to view it in the context of what you're trying to accomplish.*

- *I particularly remember having to learn something about how carbon atoms link in organic compounds or something. I never saw that or most of anything else I took ever again. Survey class was the exception. Surveying provided me with a job skill ... I was stunned that there were no "given that's" in the real world. In school, everything was phrased "given that" then do the calculations. I spent a lot of time early on looking for those givens. Now, I just try to break everything down into very*

simple terms at the very simple level. Nothing complicated from an engineering or technical level.

- The engineer is describing hiring new graduates for the engineering department at a large operating company: *...one of the things that surprised me is that we used to have the four arts electives. And I guess they have gone by the wayside. I don't think very many have that. So instead of arts courses we also like to see a little bit of business or economics background or engineering management, a few of the people mentioned that kind of thing. But we also like to see a bit of the arts kind of thing. I will have to make sure that people are not holding back that they have the arts electives because they may think that is a bad thing and they will talk about the technical courses, but that we do not really care about.*

- *Funny, but one of the questions we ask at interviews is what are the electives you took and we try and evaluate if someone is geared to be a specialist or whether they are geared to be a generalist. If they are broader in their interests. In our company we have a need for the more generalist. In our company we do not have much of a need for the specialists or the technical. Those kinds of people tend to struggle here so we try to make that assessment when we talk to people.*

- *Engineering to me is not the calculations that the computer can do, engineering to me is the common sense you can put into it.*

- *In the end the schooling didn't matter.*

- *I kept my notes for many years, as I knew they must be important. When I finally dug them out and looked at them, I could no longer understand them. It was so far between when I finally had to refer to something.*

- *Getting my P.Eng. was something to strive for and therefore it is of value to me. I do not look at having gotten the engineering degree as special in the same way.*

- *The big difference in reality is that I thought I would do lots of problem solving like the engineering education was composed of.*

- *Some of the disciplines [in school] may relate to work, is what I perceive. It may be true in electrical, petroleum or some other degrees. But I graduated from Mechanical Engineering. I mean I started in piping and support, and that's sort of a thing that I never even touched in the engineering school. I learned all about hydraulics and sizes, stress analysis and that kind of thing at work, and what kinds of materials they are made of and all those kinds of things basically I learned from work. I am not really sure how much background in engineering these courses that I took helped me out. They must have helped me out a little bit. I guess it had to have helped out somewhat, but it is not just always evident how. It must have had some impact.*

- *I went in [to University] with what I believe to be my eyes wide open all along. I took Mechanical engineering because it was the most general. I did not see the point in learning too narrow a field of things that would never be used.*

- *I took a degree in Bio Resource Engineering. I have never seen ads asking for this field in the newspapers. I think if I was to try and get a job in engineering, I would have to sell the abilities learned to the other disciplines that are actually advertised for.*

- Interviewer: *So what about those calculations?*
  Participant:*I don't know, they're just so stupid. I do use engineering but again, I would say maybe 50%. A lot of my training which I think people like very much is I always give a lot of examples of my engineering background and construction. I worked as an actual engineer, design, I only worked two years, and the rest was construction.*

- Interviewer: *Was your education related to your work?*

Participant: *Well not the technical stuff.*

- *We do not use the technical electives at our company.*
- *They [experienced engineers] said to forget about ever using equations on any of the kinds of problems they came across.*
- Interviewer: *Could a non-engineer do your current job?*
  Participant: *Sure. I think that the kind of skills that I learned I have developed through work. I don't think that I learnt too many skills from engineering school.*
- *But it is a kind of a screening process, that's probably what you will get out of school and the degree and everything. It is a screening process on who can apply themselves to issues and problem solving at work.*
- *You could not just take a person off the street and expect them to do the work. These University students have shown that they have a certain level of ability. And an ability to think in a particular process so that you can get the task done.*
- *So it was just basically, either continue being a foreman, there were no qualifications required to be an engineer, to practice, but the degree gave me more authority on site.*
- *On a business level, it has opened so many doors for me.*
- *We [engineers] think different... We or I, try to deal with facts. Because then you will paint people into a corner. I will bring my own brush. "What do you mean by" You try to quantify. That is on a personal level. It makes it difficult to deal with non-engineers.*
- *First we have to define what my attitude is. It is pretty stubborn. I believe in right and wrong. It is very hard for me to see your world. If I can see it, I will move there. If I do not understand it, I ain't moving. That has a lot to do with it. I am often the ornery SOB because it was either not explained or I did not pick it up. I am just*

missing the mark or else I disagree with the mark which is worse because I will shut up and dig in. If I could not understand, I would argue. But if I disagreed, I just shut up and would not budge. That is how it affected my work. Sometimes if no one would get hurt, I would just say, okay go ahead but not with my fingerprints on it.

- *If you deal with the ten commandments or whatever. But of course it gets drummed into you in engineering. We hold the banner high. I look around and I do not see a lot of people that still do that. Here I am on my white horse tooting my horn.*
- *There are issues that are the same. You talk to people in the industry and they all tend to have the same issues. That sort of thing. They all have degrees of differences but they are all struggling with the same kind of thing.*
- *I never worked as an engineer long enough to get a P.Eng. I stopped wearing my iron ring, but many of the older members of my parish asked what happened to my iron ring. I said that since I was not practicing engineering, I should not be wearing the ring. They said that was nonsense and an engineer is always an engineer. So I often put it on and it really helps me relate to engineers on their level because they see me as being one of them.*

C.6 The Work of an Engineer

- *A big part of my job is understanding how to get things approved.*
- *I see the seven pieces of paper I need to fill out for any given project and I see that it is not important. There are a number of different codes I need to put on the various reports and they are not related to each other. I had one project that was $6000 for the entire work. When I needed to fill out the seven reports and then submit revisions when there were slight changes in scope, I knew the overheads were much higher than the total value of the project. My boss still wanted to go through each of the reports on each of the projects. He did not see the non relevance of the act.*

- *Then once early in my career, I took the formula and plugged it in the Apple computer we had and after that it was done. There was no more design, just plug the number into the Apple. Then what? The rest is just get some drawings done up and get them out the door. The rest is all the personal issues.*
- *You can design something, or you can have the pipe supplier come up and say: "Here use this."*
- *In my work, I explained that I have learned to make the problems so simple that there really is not much to the technical work. Anyone could do the calculating and figuring out.*
- *I did very little if any engineering with [name] Company but it was valuable to me from the contractual side and also when I had to deal with the design people in Houston on developing new equipment because I could talk to them.*
- *Problem solving turned out to be a small portion of the job, maybe somewhere around 10% of the time is there some calculation done or some analysis done. Most of time is spent supervising and general management. I started supervising technologists after about 2 years on the job.*
- *It was almost a purely mechanical job and a lot of electrical [the engineer was a civil graduate] . I was put in charge, but I felt I was way over my head. I had to do critical path schedules. I had to work out delivery times of things I was not sure what they were. I needed to leave. I had definitely reached my level of incompetence.*
- *You just make sure that you know the guy knows. You have to say "look, do I trust him?" Does he know what he is talking about, is he up in the air? Does he do the checks does he do the balances. Does he probe?*
- *We run a pretty complex system so on the technical side just understanding some of the complexities of our operation and things may not always be as simple as*

management may think it should be. So having the understanding to get things done. So getting a safe solution and the right solution. Knowing who to talk to. Knowing who to go to to get the proper reviews.

- *So I am not supposed to let the contractor talk directly with the designer. But I trust him enough that if there is a problem and they need to get something done, he can talk directly. But here is a guy that needs something and another that has it, just do it. Both are honest as the day is long, and I trust them. The rule says you should not let them talk. But I have feedback so I know what they are up to. If I follow the rule and play mailman, it just delays the project. So do I allow communication to go on or do I follow the rules? But as soon as someone else finds out about it, then I get in trouble. It is a bureaucratic rule. So that is the difference. Getting the job done, but don't let anyone know the rules were not followed.*

- *Well I was in planning for 10 years. But then I was finance. I was in finance for about 5 years. I forget a lot of this. I was in finance when I left. In planning I was in economic planning. How to best provide a service. Finance is a continuation of that. I worked with a Ph.D. on a lot of strange things. I was his joe-boy. He was from [another company] and would come up with some real theoretically possible ideas that were not at all practical. I was there to bring him back down to earth. He was more of a research guy. I wrote some computer programs. He could come up with relationships about anything, but I would keep him in line. When I went to finance, we were working on a thing called [project name with description]. Things like revenue splitting and cost provision of services. Like how much does something cost for each company.*

C.7 The Boring Aspects of the Engineer's Job

- *I think it seemed that there was some promise with the large corporations at the beginning, but it turned out to be just a lot of boring work. I went out on my own in order to at least be in control of what I was doing.*

- *I do not think that my feelings really impacted the way the work was approached because no matter how boring, I felt that there was a need for the work to be done right.*

- *I worked two years and didn't really like it. I didn't like sitting in the office and using those rulers, so I didn't like it.*

- *I would consider going back into engineering if there was a job offer that paid well and it clearly had societal benefits. As an example, if someone was trying to develop an alternative fuel that would reduce pollution and improve the environment, that would interest me. The job would have to involve using the application of the technical stuff I took at University and be at the conceptual level so as to not get bogged down in the boring little details. I cannot think of a situation where this type of job may actually exist. I have never actually heard of anyone having a job like this. Therefore I think it is very unlikely that I would return to engineering and the money alone would not be enough. I guess if it was enough money for me to gain independence and not have to work at all. But then I guess I would not be doing engineering at that point either.*

C.8 Learning on the Job

- *I expected to be in charge of projects and I guess university led us to believe that if you're sitting on a drafting board that you're a failure as an engineer. But I found out afterwards that my first boss in engineering was very quick to put me in my place and*

I did end up spending quite a bit of time on the drafting board. And I felt that after it was done it was a very significant contribution to the work I was going to do in the future. You're putting ideas on paper, you have to be able to do that. The drafting floor at [company] had two hundred drafting boards not two hundred computers.

- *I started right out of school and I had a lot to learn. I did not really understand the nature of business and the management aspects and I read books about business but I did not know. It is just kind of growth.*

- *I expected to get experience in many areas and then make a determination later whether, all I wanted to do was get experience, so I went out in the field a lot and that made me happy. I learned a lot on the ground. I moved myself around both there and even in government later. I found jobs that interested me and then after that, I guess I really had no expectations.*

- *[Company] was pretty good about training when I was there. They would let you take pretty much any courses you wanted. Anything from technical courses to things like public speaking. Some speaker that came to give public speaking. Sometimes even report writing. When I was in economics, I got sent on courses put on by [competitor]. I even wrote a manual on how to do economic evaluations. I wrote a computer program on how to do quick economic evaluations. When I was in finance I got to go to meetings in Toronto and Ottawa... Actually, when I was in [department], I got to visit [vendor] in Holland*

C.9 Five Years Experience

- Participant *I just think that experience helps you develop your own personal approach to work that well, for myself it's more efficient, there's hundreds of reasons why it's more efficient. Generally speaking, younger engineers haven't figured out all that stuff, so they struggle with the simple things, you know things that they haven't seen,*

run into a problem. The experienced guys have seen that problem ten different ways already and solved it, so yeah far more efficient.

Interviewer: *So how long do you think it would take to build this efficiency?*

Participant: *I don't know, in some industries maybe a long time, but in mine maybe about 5 years.*

- Interviewer:*How long do you think it will take the junior engineers to feel that they know it?*

  Participant: *That would depend on the individual but I would say five years.*

- *When the engineer has less than 5 years experience, they require a lot of coaching on projects. Then after that 5 year period they become much more independent.*

- *For an oil company, like a standard exploration and producing oil company, five years is generally the sort of the time it would take to get comfortable in the industry to the point that you could be now assigned to a specific task and you're going to stay there for a few years.*

C.10 Management Positions

- *I guess the promotion to the supervisory level in 1999 brought great change. Things that required a different type of skills and I thought I was ready for it and overall I think I did a pretty good job but I think certainly there was some growth and development that had to happen in that time.*

- *Every time I was in too large a company for too long, I would be forced out of that type of work. I had to keep changing companies to get back into the engineering type work*

- *If the money gets short, I will just go back to the corporate grind. The executive positions may pay more, but I enjoy the technical work. I am trading less money for enjoying my work.*

- *I will work until I am 65 [currently 63]. I cannot imagine not working. I just will not be happy as a manager if I am forced into it again.*

- *My plans for the future are very short term. It would be nice to be able to sit down and figure out a long term strategic plan for the organization, but the daily supervision of people prevents too much thinking. I just take the job a day at a time. I have no real vision of where I will be a few years down the road, or who I will be working for. I may keep in engineering or do something else, I do not know.*

- *I am paid a lot more than when I started and I don't have any second thoughts about that, and I think I contribute that to that degree. Skills have developed and I think I have made the contribution. The management stream, every company has to have management and that is maybe easier to assess. On the technical side, if you are a senior engineer on the technical side, it is a little harder to evaluate.*

- *My boss stated that he wanted my [manager] position to be one that dealt with strategic goal setting and it turns out that supervision consumes almost all my time. It is complicated with the baggage that my boss left me when he was in my position... If I could make the changes, I would be a lot happier and feel that I was doing something meaningful and my personal job satisfaction would definitely go up.*

- *Any of the good engineers were promoted to management and then they are not doing the engineering. They may or may not be good at management, but their good technical skills are gone. And then the so-called professional managers like the MBA's may not be any good, because they may know management, but they do not know anything about the business. Maybe after they work for a few years, they can learn how the business runs, but out of school they quickly learn that things don't always work the way they are supposed to. I do not think that keeping the old people in the system longer would do much. There will always be the few people that are technically*

inclined that can manage to stay on the technical side. But not the majority. These are still insignificant compared to new graduates in numbers.

- *Basically, the problem with engineers, all the managers they come from engineering... So they leave as engineers. Other problem, managers get paid more than engineers, I noticed...Even if you don't like it, you go there because it's a natural progression. I'm making 50 now; I will not go anywhere, that's where you are. But I can see an engineer that goes into management making 75, so it's a natural progression because people are like that.*

- *The thing is that when I went to senior project manager, I went to client service director, now it was completely human issues, there was no engineering in it at all. For about two years. I didn't like that. So I said "That's it, that can't go anywhere." And I am getting out and on my own.*

- *But now certainly in a leadership position, I have to be more careful about what I say and so when I was younger I could joke around and be more carefree. But now everything I say and do has an impact and I have to be more careful about that. I have to present things and when I was younger if I did not agree with something I might have openly said so without thinking about it but now if I do not agree with something and I want to say something about it, I phrase it carefully and I have to at times put on the management hat and say here it is and this is the way it is and whether I agree with it or not I have to present it a certain way. So that is the way things have changed.*

- *Constantly dealing with human cries and babysitting people, supervising and everybody wants to go on a holiday. So I said that's not for me as an engineer, I got to find something where I can use my background, my engineering, my common sense. I guess it depends on how you think, so that's why I changed jobs.*

- *I have always resisted the desire of my superiors for me to get into management. In my current job, I am able to stay out. I find I suffer at the stress of fighting the wave to put me into a job I know I will be unhappy in. My current job has the monetary reward without the need to do management.*

- *You want to grow on the job. But so long as it [a V.P. position] was still involved with product planning and machine design I would have enjoyed doing that... [but] You're more in charge of numbers. Vice president of engineering, maybe that would have appealed to me...[but] they just do budgets. Basically. I would have liked to stay with the hands on profession.*

- *The output of an engineer is far more than words depending on what kind of work knowledge workers do. But I am getting to the point where I am just supervising, directing and managing people right now.*

- *At first, as I moved up the organization I was forced to do more intangible things, and some will think that is positive. HR types would think that to do intangible things, that it is very very positive and it results in a stronger career development to do things that are less tangible. Because it is bigger picture. I do not understand it and I guess that I is why I am not doing it [management] that well*

- *I never liked being a boss and even now I see myself as a mentor to the people on my team. I do not do the HR type of managing. I help and I mentor. I do not supervise.*

- *I would like to see me take a more more direct role in project management, the execution, conceptualization, and such kind of things, to do that. I mean that is not really a part of the job description of the supervisor.*

C.11 The Engineer's Career - Early Stage

- *What I found coming out of university and based on some of the comments I received at work is that I could design things but I could not make a decision.*
- *When you're right out of school, you've always got the idea that you're dealing with absolutes and there's absolute wrong and right ways to do things.*
- *Well, specifically in the courses you take, there are right and wrong answers.*
- *It is like that joke when I first came here [sewage treatment facility], a fellow said, "you would never think you could get this excited about shit!"*
- *I was originally very gung ho about APEGGA and belonging to the whole engineering community.*
- *It was a long stretch of hours, on call for many hours of the day. We had to travel a lot. To where ever the well site was and you had to stay there the whole time the data logging was going on. That could be a couple hours or a whole day, or if the tool got stuck it could be a couple of days. I ended up getting no sleep a few of the times, but that was part of the job. That was one reason why I wanted to get out of that and I was looking for something more stable, like [utility]. We would end up sitting there for a long time, really and usually without any break.*
- *I guess I was proud. I had to put my two years in to become the professional. My father had passed away and I was the surrogate father for the family. It was sort of like I had to make my mark. I had to do it without help from my father or the government. They had pulled my student loans, it does not make sense, my father died and my loans were yanked.*
- *I saw the ideas of the big boys and I had to record it and it gave me the opportunity to ask questions. And they would actually answer my questions. They saw that I was*

green behind the ears. I don't know if they liked doing it, but they answered my questions. I got in trouble a few times but ... they answered my questions.

- Participant: *To begin with, right out of school, you're in a system of engineers, you're helping older hands doing the type of work they do. And I did a lot of field work then, because I was the new guy, and that really was one of the best ways to get the experience and understanding of the industry was to get out in the field and see how it's done which I don't think a lot of young guys now do, probably because it just can't be done anymore.*

  Interviewer: *Can't be done?*

  Participant: *Well, I think that people that hire professionals now, they got specific tasks in mind for them and they get parked in an office, they really don't get anywhere. Seeing young engineers out of school in the field today is pretty rare.*

- *Although I was basically just working and getting paid as a rodman on the survey crew, I could tell that it was becoming apparent that the drawings were wrong. In one case it was because they showed an installation where there was already an existing storm sewer line where our line was going. So I needed to come in early in the mornings before anyone else was there to draw up corrections for that day's scope so that the work would progress on schedule.*

- *I was basically a glorified secretary.*

- *The way the world is going, there will probably be a point where the system will suffer. They can let old people go, but the young people that just agree with whatever they are told to agree to will probably find they paint themselves into a corner.*

- *Well, I guess when I started I was sort of very authoritarian: "That's not the way you do it."*

- *When I started out, there was the focus on developing a technical solution to a problem.*

C.12 The Engineer's Career - Middle Stage

- On reporting to upper management: *It is just the information, not making any decisions. Just this is what we are doing and this is when we are doing it and this is the cost impact or whatever if there is a cost impact so that it is complete and concise and management knows what we are doing in what area and by all means if there are questions they can ask, but very seldom in those communications to senior management do I ask for a decision or what direction should I take.*

- *I think in general I work to please myself and in my current role as a sort of a manager I do a lot of mentoring. I find myself more of a cheerleader than actually doing the work and I find that has a lot of value.*

- *When I was in planning we often had to present plans to something like a Board of Directors. About once a month or so... I had to put on slide presentations to these people.*

- Participant: *I guess we had a discussion at the performance review and I said I had to decide what my options were and I made it clear that I did not see things progressing well for me and I left it at that. And what else could I do?*
  Interviewer: *So what were the consequences?*
  Participant: *There were no consequences.*

- *Where do all the engineers go? Do you know this? Where do they actually go? Do they go and work for APEGGA? [laughs]*

- *You know, we were structured pretty lean over the past few years and there some challenges the past few years and we got the numbers to back it up and we delivered*

on our targets and that sort of thing there are always some challenges and sometimes they are tougher but lots of things can get in the way.

- *If the client gives you a hard time, you may decide not to push the advantages or benefits of what you are recommending. The quality of the work done is likely no different. It is not ethical to put in less that the full effort in your work. You still deliver the best product possible. But if you do not feel like helping the client very much because of the trouble they are causing you, you may decide to just leave him to do whatever they want.*

- *Now, after 20 years or more, I look at the global picture. I have meetings to determine if the project should even be done. Then I would do a literature review to see what has already been done by others.*

- *Not every day is roses. I have had some disappointments in getting passed over for promotions that I thought I was ready for. Those have an effect on you. But I pretty much did the same job anyways and certainly engineering professionally at a professional level nothing ever changes, you know, you do your design, you execute your projects, and you do the best you can. I would not say that that it had an impact, but not everyone will be all smiles. It may make you less efficient, but I would say that is a pretty minor thing in the scheme of things. You know, I am accepting employment here and if I am working under these terms I have a job to do so I do it. I have to ride out a few disappointments but that is life.*

- *Everyone here is in a pretty positive frame of mind because of the changes. I have enjoyed what I have done. Some of the times are tougher than others, but overall it has been good for me.*

C.13 The Engineer's Career - End Stage

- *Seniors are more honest about when they do not know an answer. But the senior person usually has a good idea about what the answer is. The junior person has to go back and check. If you are in a hurry for the answer, and everyone seems to be in a hurry these days, the senior person generally is the one to go to.*

- *The way a problem is structured and the approach. The senior engineer focuses on gathering facts before starting the solution.*

- *I am civil, I got a little bit of exposure to everything, man. But hopefully, I can recognize bullshit. That is what I like. I got to be not bad at the nuances of the job. I did one thing for a while, oh I did quite a few drainage designs, water - one pipe. But once I got here, I just pushed paper. I did one design of many things, but then the pushing of paper became my job. I stamped two drawings. I did them so that I could say I did them.*

- *The senior person is more results oriented. Looking at getting things done and what the objective is.*

- Interviewer:*So do you have a lot of contacts there still? Do you keep in touch? [after 33 years with company]*
  Participant: *No, anyone that I may have known has pretty much left. I do not talk to anyone there.*

- *I am almost there. Just need to be 55 and I get the company pension. ...I guess I may keep working if there was something I liked to do. If not I will just get out.*

- *I was originally very willing to make accommodations to fit my work to match the wishes of supervisors or clients. Now I rely on my experience to determine what I think is the best way to do something. Others can either accept that or get someone*

else to do what they want done. I am asked to do something, and if they know the better way, why ask me? I am no longer willing to play along with the wrong solution.

- Interviewer: *So you took this package that they offered 10 years ago[at age 55], and you did not work anywhere else?*
  Participant: *No I retired. I retired in the sense that I did not work for anyone for money. The kids went out and got new houses and there was a lot of work. Never a dull moment. I have a couple of friends that also worked at [company], and they have done some outside jobs with me. Nothing technical. Putting up fences, reflooring a basement, that sort of thing.... it was nothing that made any money. Just something to keep from going insane. And then there is hunting and fishing. And I can go when it is a good time to go, not when I am allowed to go. Go on a few cruises. No problem keeping busy.*

- *I will likely never stop working, or at least up to the age of 65. I may take on less work and pick my work more carefully, but I will not stop.*

- *My wife wants me to retire, but I do not know what I would do. I could have retired a long time ago. But then what? Arizona? We are going to be talking about it on holidays, and I do not know what will be decided.*

C.14 Engineering in Government Organizations

- *Engineering is weird, I thought APEGGA finally got it right about ten years ago when they split the technical and the management and they recognized that some people are going to be more in the technical stream. When I was in government this was when the stream happened. I rated myself on the technical thing because I wasn't supervising anybody but the value that the technical people provided at a more mature level was finally recognized and the government set their pay scale based on that, so managers are making the same amount as the technical people with the same amount of*

experience. Now APEGGA recognized that value, I don't think the industry recognizes that enough, the managers are paid far far greater than the workers. Maybe that's another reason why you don't see a lot of working engineers, they all want to graduate to management to make more money. Or they may get into a situation like myself where you don't like the job and then when you're 50, 60 you go "why do I need the money? I'ld rather have a job I like. I'm out of here."

- *I have only ever worked for the [government branch]. I am an old war horse. I am always swimming upstream.*

- *The Department of [provincial government] is good because they will find a place for the dissidents. One older engineer was making drawings for buildings that sort of became unnecessary when clients could find their own on the Internet. His service paralleled that provided by many commercial outfits, and the government did not want to compete with industry. The older engineer did not want to learn anything new in terms of a new role. He was moved out of the organization, but he was allowed to continue producing drawings for another branch of the government. He was 'put out to pasture' with no subordinates and a lot less responsibility. But he was able to maintain his paycheck.*

C.15 Comparing Young Versus Mature Engineers

- *An older engineer knows more how to approach a project, but may lack the enthusiasm of a younger guy. In my opinion the experience likely outweighs the drop in enthusiasm.*

- *The biggest thing that I do quite a differently now is that when faced with some kind of task I try to find an individual, people that really know how to do this stuff and can do that. And you either get them to do it or at least get a lot of their input into how to do it. And of course when you are younger, you are a lot of "I can think of that",*

"I can figure this one out", "I can try that", "I will really look at it and figure that out all by myself, because that is the challenge, right?" To do it yourself, to do all by yourself, you can say "I did this entirely" so that's a great challenge. Now I say it is a little bit changed because I guess I am looking for more overall efficiency and try to solicit a lot more help and expertise to do things, to try and access that kind of knowledge and I guess I now focus more on just getting the job done right, correctly, and the most efficiently than I focus on personally growing.

- *Somebody once described the various stages of a project and I think panic is one of them. That's definitely the case for when you first start, getting into projects, that seems to always be the way to do it and this becomes lesser the more you do it. Getting older you begin to understand that all these things are manageable, you just have to think of all the things that have to happen what might occur, and break them down into manageable pieces and get everyone working on them.*

- *If I was hiring someone, I would avoid the older people. They are set in their ways. The set ways of the older ones upsets team performance. We may have a less efficient way of doing things than the new hire, but we also have older people that are set in our way. It would just disrupt the whole process. I have no idea what would be the motivation behind being inflexible, I have just seen it many times. You have a lot more influence over the younger engineers and they will just do things the certain way we do them.*

- *Is there an economic worth of mature engineers? If you are looking at our case, it is my opinion that there has been a stretch where we have not valued that, you know as a company, that is my opinion. Personally.*

Appendix D

The What Study - Forms and Applications

Telephone survey letter and question guide

REQUEST FOR PARTICIPATION IN AN ENGINEERING RESEARCH STUDY

Title: The Value of Experience: The Engineer's Career.

Investigator: Donald Kennedy, P.Eng., M.Sc. (Ag. Eng)

Ph.D. Student, Graduate of Mech. Eng. Class of 1982

Department of Mechanical Engineering

University of Alberta

ph. (780) 420-5264

Purpose of Project: This project is part of the Ph.D. requirements for Donald Kennedy.

Requested Participation: A telephone interview lasting approximately 5 minutes.

Dear: (graduate),

You are one of the 30 names randomly selected from the graduating class of (year), Department of (department). I am researching the careers of engineers and I would like to use your career as part of the data for my research. I, or one of my team, will be contacting you by phone in the near future and at that time your participation will be requested in the study. This letter is being sent now so that you will know the purpose of the call when you are contacted. The questions are not of a private nature and the current ethics standards at the University require such a letter for any contact with human participants, regardless of the nature of the research.

The University of Alberta holds the ethical implications of research with human participants in the highest regard. Both this letter and the questions I hope to ask you by telephone have been approved by the Faculty of Engineering Research Board.

At the time of the call, you can choose to simply withhold any consent and nothing more will happen regarding yourself and this study. Even if you initially choose to participate and listen to the questions, you are still free to refuse to answer any of the questions or to contact me in the future and have your answers withdrawn from the data in the study. All answers will be held in the highest confidence and no information that would make it possible to identify the individual participants will be used.

Other than the questions regarding the ethical implications of the study and the assurance that you have given informed consent to participate in the study, the actual telephone interview will be very short and it is for this reason that a more formal in person interviewing process is not being followed. The nature of the questions will center on where you have been working since graduation and what your current job and duties are. If you consent to the telephone survey and your answers are representative of a group of engineering graduates that are of particular interest to the study as a whole, you may be asked if you would be willing to participate in a more in-depth interview. It is expected at this time that the majority of telephone surveys will not result in a follow-up interview.

Background: Data from professional associations and Statistics Canada suggests that engineers may have different career paths than other professions. Engineers that are currently practicing and those that have left the system are being recruited for participation in this study. The hope is that they can provide key insights into reasons behind these observations.

Benefits: Your participation in this study will provide you with the opportunity to directly contribute to the advancement of knowledge in the field of the management of engineers. The information obtained in this study has the potential to enhance the management of engineers and could provide better forecasting and control of the required numbers of future engineers.

Risks, Anonymity and Confidentiality: Your participation in this study will be known only to the researcher and his supervisor. : To ensure confidentiality and anonymity, personal

information will be stored in a locked cabinet and destroyed at the end of the study. Any data used will be stripped of any identifiable characteristics.

Freedom to Withdraw: Your participation in this study is entirely voluntary. You have the freedom to not participate, or to withdraw at any time. You can also request at any time that all information you provided be withdrawn from the study and this information will not form any part of the final results.

Third Party Contact: If you have concerns about this study, you may contact Dr. James Miller of the Engineering Faculty Research Ethics Board, at (780) 492-5580. Dr. Miller has no direct involvement with this project.

Sincerely,

Donald Kennedy

Telephone Survey Guideline (used by interviewer)

Questions:

-Do you consent to me recording your consent to participate in the study being conducted at the University of Alberta entitled: The Value of Experience: the Study of the Second Half of an Engineer's Career?

- (tape recorder on)– I have turned on a tape recorder to capture your consent to participate in the study being conducted at the University of Alberta entitled: The Value of Experience: the Study of the Second Half of an Engineer's Career. You are aware that the tape recorder is now on?

Could you please state your name, age and year you graduated?-

Have you received and reviewed the letter of notification of the intent requesting your participation in a short telephone interview regarding your career following graduation from the University?

Where do you currently work?-

What is the title of your current position?-

- Do you consider your work to be engineering?

– (if the answer is no, then ask:) What year did you last practice engineering?-

- If your answers put you in a group of particular interest to the study, would you be willing to participate in a follow-up interview?-

- Do you have any questions or comments regarding this survey?-

- Thank you for your time. (end of call).

Example of one data point:

CLASS OF 19XX, XXX Engineering

Person's name	**Address**	**Phone no.**	**Age**	**Employer**	**Job Title**	**Consider it Engineering? (if no, last year of doing engineering)**
John Engineer	1256-89 ave Edmonton	458-87968	56	Jo Jo Corp.	Power Engineer	No, 1995

Appendix E

Ethics Application - The Why Study

Following is a copy of the application to the University of Alberta, Faculty of Engineering, Research Ethics Board for approval of the research. The approval was given on July 27, 2004. REQUEST FOR ETHICAL REVIEW OF ACTIVITIES INVOLVING HUMAN SUBJECTS

Project Type: Ph.D. Thesis

Project Title: The value of experience: the study of the economic worth of mature engineers

Principal Investigator(s) and Degree(s): Donald Kennedy, M.Sc. (Ag. Eng.)

Advisor (if applicable): Dr. John Whittaker

Status or Rank: Professor Office Phone: 780-492-4443

Department: Mechanical Engineering Faculty: Engineering

Building and Room: 4-8J, Mech Eng Edmonton, Alberta Canada, T6G 2G8

Sponsoring Agency: N/A Project Period: Fall 2004/ Winter 2005

PURPOSE AND OBJECTIVES

1) What are you doing?

I am studying the career paths of engineers, and especially mature engineers. An initial review of publicly available data reveals that fewer engineers over the age of 45 are working compared to people with other University degrees. In addition, publicly available data from Association of Professional Engineers Geologists and Geophysicists of Alberta (APEGGA), shows that the salary of engineers within a given job description is independent of years of experience. In addition, data from the APEGGA website indicates that the number of engineers working in the profession drops off rapidly once the engineers

turn 43 years of age. To explore these phenomena, interviews with engineers will provide a depth of information that would be difficult to obtain in any indirect way. I will conduct a qualitative research study with the involved individuals.

2) Why? What benefits are there to the participants, to society, or to further research? What are you trying to find out?

The benefit to the participants is in the opportunity to contribute to the field and is outlined in detail in the benefits subsection below. It is expected that there will be significant ramifications of the results once formulated for individuals that are at the various stages of career development in the field of engineering. The findings will also be of considerable significance for the employers, educators, customers and funders of engineers and engineering activities. There is considerable concern expressed by researchers in management of the impact of the demographic profile of the baby boomers as they advance in age. This study will provide great insight into the potential mitigating policies regarding the stemming of a potential shortage of engineering talent resulting from any shift in the general aging of the population. The findings will be a part of a larger goal of better understanding the factors affecting the management of engineers.

3) Where will the study take place?

Edmonton, Alberta 4)How are you going to do it (e.g., interviews, physical testing, videotaping, etc.)?

The portion of the study that involves the participation of human subjects will be performed utilizing semi-structured interviews involving open ended questions. The methodology will follow the grounded theory procedures more closely aligned with the later works of sociologist Barney Glaser. The interviews will be taped for potential full transcription at the discretion of the researcher. All participants will be advised that the interviews will be taped and that they should assume that their interview will be transcribed fully as this is a likely scenario. Detailed notes will be taken during and immediately after the interview. The interviews will follow a sequential pattern of

development in keeping with the grounded theory methodology. The submitted list of open ended questions will be used for an initial sample of participants in order to perform an exploratory evaluation of the potential phenomenon to cover in subsequent rounds of interviews. Based upon our anticipated results, the supplied questions should be adequate. However, if the results of any round of interviewing suggest that the direction of the study should be modified to further explore any rich points encountered during follow-up analysis, the interview format will be changed to properly address the suggested shift in questioning. If the interview format is altered in any way that impacts the nature of the questioning, a follow-up application to the ethics board will be made at that juncture and prior to the implementation of the proposed changes.

5) How long will it take (each part of the study; total time required of participants)?

Ethics approval was obtained by the researcher as a part of the fulfillment of credit in the winter 2004 session of H ECOL 603 to perform one interview with a mature engineer on the nature of leadership. This interview took a total of 27 minutes. Using this interview as a general guide and making an extrapolation based on the nature of the subject matter to be discussed, it seems reasonable to conclude that any one participant will be involved in the interviewing process for between 30 and 90 minutes. There is a potential for subsequent involvement regarding follow-up clarifications or expansions which should take an estimated five or ten minutes. It is foreseen that these potential follow-up sessions would be the exception as opposed to a regular occurrence.

DESCRIPTION OF METHODOLOGY AND PROCEDURES

1) Where will the project be conducted (room number or area; if not U of A location, site authorization allowing this research must be provided)?

In order to not produce undue hardship upon the participants and thereby increase the probability of informed consent to participate and thereby reduce the potential bias by unduly limiting the selected population of participants, it is deemed reasonable to conduct the interviews in neutral settings in a location convenient for the participants and agreed

to between the researcher and the participant. If feasible and agreeable to the parties involved, it may be deemed appropriate to use a small conference room within the Mechanical Engineering Building on the University of Alberta Campus. To reduce the potential for placing the researcher or participant at physical risk, no interviews will be held in private residences or secluded areas. As noted above, the interviews will not be held within the workplace of the researcher or participant. An example of a public location proposed to conduct an interview would be the rotunda area of Commerce Place, 10155 102 street, Edmonton, Alberta. In such instances care will be taken to reduce the potential for unintended overhearing by individuals not associated with the project. 2)How will the project be explained to the subjects?

The participants will first receive an explanatory letter at the initiation of their participation. The subjects will be informed that the purpose of the investigation is to determine the typical career path of graduates of engineering programs from accredited Universities. It will be explained that they were selected as a representative of a particular segment of the engineering population and their insights into their particular career objectives are being sought.

3) If the subjects are minors, how will assent be secured:

This question is not applicable to this particular study.

4) How will you make it clear to the subjects that their participation is voluntary and that they may withdraw from the study at any time they wish to discontinue participation?

The attached consent form will be provided and explained to them and they will be informed that participation is wholly voluntary and can be discontinued at any time. No question will be asked that will be required to be answered by them if such a decision is made by them at any time in the interview. They will be given the option to retroactively rescind any information provided and all such records of conversations will be destroyed prior to analysis or removed from the final analysis at their request. It will be explained that decision to terminate participation at any time will not be tied to any foreseeable

future consequence and since their anonymity is ensured, there will be no pressure on them to withdraw participation.

5) Method: Semi-structured interviews following the attached sample outline.

PERSONNEL

1) Describe the qualifications of research personnel if special conditions exist within the research that could cause physical or psychological harm, or if participants require special attention because of physical or psychological characteristics, or if made advisable by other exigencies

All research related interviews will be conducted by Donald Kennedy. As a professional engineer, Donald was required to pass the APEGGA ethics exam as a part of registration. Donald was a chair of several sessions at the recent 2004 International Institute of Qualitative Methods Conference at Banff, Alberta. One of the sessions was specifically geared towards issues in the ethics of interviewing for research purposes. Donald attended a workshop lead by American author and ethnographer, Michael Agar which devoted a significant portion of the program to issues around interviewing and ethical approaches. Donald has been trained to work as a volunteer on the suicide prevention hot line in Edmonton.

DESCRIPTION OF POPULATION

1) Number of subjects to be involved:

The number of subjects expected to be interviewed in the initial round of research is approximately 6 individuals. If the results obtained suggest a shift in questioning for further data collection, subsequent ethical approval will be sought. It is expected, based on an empirical review of literature on qualitative research, that the maximum number of subjects will be less than 30. If the results of the data obtained suggest an enhancement of the scope of the project of a significant value, subsequent approval will be also be sought for that condition.

2) Description of population to be recruited and rationale for their participation (indicate age range):

It is expected that the age of the participants will be from 24 to 65 years of age. Although there may be an age group that warrants particular attention, it is expected that there should be sampling of at least some individuals from all age ranges with a 5 year window. The population will only consist of practicing engineers or former practicing engineers who have subsequently advanced into other areas of employment or activity.

3) How are the subjects being recruited?

A number of participants will be selected at random from the publicly available database of APEGGA members. A random number generator will be used that ranges between 1 and the number of members in the database at the time of selection (approximately 30,000). Upon the generation of the random number, that member will be located on the database. The information contained within the publicly accessible data is sufficient to determine suitability based on the requirements outlined below. If the member listed does not meet all the criteria listed below that individual will be dropped from consideration. The member listed next sequentially will then be considered for meeting the requirements. Once a potential participant is identified, contact will be made via telephone. Only if the potential participant provides fully informed consent for further contact will further action be taken towards that participant. Arrangements will then be made for an interview. At the beginning of the interview, the nature of the study will be further explained and informed consent will be requested of the individual. If the participant is not comfortable with participation in the research, they will be removed from the study and the next sequential member that fulfills the requirements will be approached. Once the interview process is underway, theoretical sampling will augment the random sampling in order to ensure coverage of sectors of the population that may represent individuals with characteristics of interest to the research.

4) What are the criteria for their selection?

The potential participant selected through the random number based methods should: - be a Professional Engineer - listed as working within a 20 km radius of Edmonton (arrangements may be made to pursue participants in other geographical areas, but these would be on a prearranged non-random basis). - have sufficient contact information available on the publicly accessible data on the APEGGA website to allow for reasonable ease of access

DATA

1) Who will have access to the gathered data?

Donald Kennedy and the supervisor

2) How will confidentiality of the data be maintained?

All information that has the potential to identify the individual will be omitted from any descriptions of the interviews or compiled results.

3) How will the data be recorded (instruments, notes, etc.)?

The data will be recorded using an audio recording device, handwritten notes taken at the time of the interview, and post interview notes taken immediately after the interview.

4) What are the plans for retention of data?

The data will be stored in collected notes, audio tapes and transcriptions of the interviews. The data will be retained in a file cabinet that will be locked when unattended. The data will only be retained until the project is completed as signified by acceptance by the thesis examination committee.

5) What are the plans for future use of data beyond this study?

The data will be destroyed, negating any potential use beyond this study.

6) How will the data be destroyed and at what point in time:

The raw data will only be kept until the thesis is accepted by the thesis examination committee. At that time, any information that could potentially identify any of the participants will be destroyed. Any notes or transcripts of the interviews will be shredded.

The tapes of the interviews will be erased and then physically destroyed to ensure there is no possibility of data reconstruction.

7) Where will the signed consent forms be stored (list administrative office and room number)?

The signed consent forms will be stored in a lockable file cabinet in the office of Dr. Whittaker at the University of Alberta. The cabinet will be locked when unattended.

BENEFITS, COSTS, RISKS

1) What are the potential benefits to the subjects?

The benefits to the subjects will likely be limited to the satisfaction that a professional usually gains from the active contribution to knowledge in their field. Under the requirement from APEGGA for its members to engage in continuous professional development, the participation in this study will allow them to take a small allowance under the Participation category.

2) What may be revealed that is not currently known?

The reason behind the apparent decrease in the numbers of engineers following the attainment of what should be a mid-career milestone. What are the factors contributing to this attrition? Are there mitigating strategies that could be potentially employed if this trend is not desired within a particular organization?

3) Will monetary or other compensation be offered to the subjects? No.

4) What are the costs to the subjects? Approximately one hour of time.

5) What risks to the subject are most likely to be encountered (physical, psychological, sociological)?

In consultation with seasoned researchers, such as Michael Agar, it was deemed that a project of this nature was considered to be very low in terms of risks to the participants. It was the informed opinion of the consulted seasoned researchers that negative impacts resulting from freely expressed information revealed during interviews in general was a very low frequency occurrence. Professional engineers would likely have a lower potential risk

associated with negative impacts from interviews about their work activities than many other research areas.

6) What approach will you make to minimize the risks?

Reliance upon voluntary participation coupled with ensuring the confidentiality of the information obtained. In addition, the contact with the participants will be limited to public places with a low chance for any physical harm to come to the researcher or participant. In addition, the line of questioning will build around the framework of the well publicized 1959 study of motivation led by Frederick Herzberg. A review of follow-up publications indicates no reported problems arising from the participation in this study, or the numerous replications of the study by others.

PARTICIPANT INFORMATION LETTER

Title: The Value of Experience: the Study of the Economic Worth of Mature Engineers

Investigator: Donald Kennedy, P.Eng., M.Sc.

Ph.D. Student

Department of Mechanical Engineering

University of Alberta

ph. (780) 420-5264

Purpose of Project: This project is part of the requirements for the attainment of a Ph.D. degree for Donald Kennedy. This project is investigating the typical career development of engineers and how employers value engineers.

Background: Data from professional associations and Statistics Canada suggests that engineers may have different career paths than other professions. Engineers that are currently practicing and those that have left the system are being recruited for participation in this study. The hope is that they can provide key insights into reasons behind these observations.

Benefits: Your participation in this study will provide you with the opportunity to directly contribute to the advancement of knowledge in the field of the management of engineers.

The information obtained in this study has the potential to enhance the management of engineers and could provide better forecasting and control of the required numbers of future engineers.

Risks: Your participation in this study will require about an hour of your time. This will consist of an interview and the potential for brief follow-up clarification by telephone.

Anonymity and Confidentiality: To ensure confidentiality and anonymity, personal information will be stored in a locked cabinet and destroyed at the end of the study. Any data used will be stripped of any identifiable characteristics.

Freedom to Withdraw: Your participation in this study is entirely voluntary. You have the freedom to not participate, or to withdraw at any time. You can also request at any time that all information you provided be withdrawn from the study and this information will not form any part of the final results.

Third Party Contact: If you have concerns about this study, you may contact Dr. James Miller of the Engineering Faculty Research Ethics Board, at (780) 492-5580. Dr. Miller has no direct involvement with this project.

Appendix F

Themes of the Interviews

During the coding of the interview transcripts, 30 themes were identified and used to parse the comments of the participants. Some of these themes were almost universal between the participants and others arose infrequently. In the analysis of the data, seeing a theme repeated by a new participant led to the inclusion of this theme for subsequent analysis, including re-examining previously coded transcripts for this new theme. These themes are as follows:

Career Planning

Job Satisfaction

Learning on the Job

Management Positions

Mentoring

Recognition for Performance / Performance Evaluation

Serendipity

Terminations

The Employer / Employee Implied Contract

The Importance of This Study

The Work of an Engineer

Travel

Value of Experience

Security

Boring

Changes in Engineering

Current Situation

Dealing with Management

Duty

Effect of Attitude on Performance

Engineering Community / Self Identity

Engineering Formal Education

Expectations at Beginning of Career

Five Years Experience

Freelance Consulting

Going Back into Engineering

Early Career

Mid Career

End Career

Government vs. private