The Design and Implementation of an Ethics Module within an Undergraduate Engineering Studies Curriculum

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A thesis submitted to the Auckland University of Technology in partial fulfilment of the requirements for the degree of

Doctor of Education

by

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed ……………………………………………………..

Dedication

I dedicate this thesis to my wife and best friend Gillian Reid; thank you for your example, advice, love, support and understanding during my years of study;

Acknowledgements

I would like to thank the following people for their contributions to the research and subsequent production of this thesis:

- To my supervisors, Andy Begg and Roy Nates; thank you both for your supervision, guidance, patience, encouragement and assistance with my work, and my most sincere thanks for your inspiration;
- To School of Education staff and colleagues in this EdD programme; thank you for your professional assistance, guidance and friendship during my six years of study.

This research study would not have been possible without the co-operation, example, encouragement and patience of all of you.

Abstract

This thesis documents the development of an ethics curriculum which is incorporated as a module within the Engineering Studies paper at the Auckland University of Technology (AUT) in New Zealand. The module is a compulsory component in the final year of the Bachelor of Engineering (BE) and Bachelor of Engineering Technology (BEngTech) degrees in the School of Engineering and was designed to meet the ethical and societal requirements of the Washington and Sydney Accords.

The thesis reviews the shift in global attitudes, ideology and world opinion towards engineering practice with respect to engineering ethics. It follows the changes in attitudes towards ethics and values within education that led to the requirement to include ethics in university undergraduate engineering programmes. The literature review was an interpretive enquiry into:

1. Professional ethics in engineering.
2. Philosophy of ethics education.
3. Pedagogy of ethics education.
4. Assessment of ethics education.

The research method used to review, design and evaluate this curriculum was a combination of interpretive, autobiographical and action research.

The overall goal was to develop an appropriate and effective curriculum relevant to engineering to meet the programme objectives related to expected student outcomes. These outcomes were a requirement of the engineering degree programme and highlight the importance of critical thinking in situations where students cannot always rely on routine or tradition when making decisions. The concern here was that the curriculum design should contribute to an overall programme where students graduate with the capability of intelligent, independent, and ethical thought. This thesis not only describes the design and development process, but also the means by which the module was implemented. In the process a number of research foci arose concerning the

requirements for an effective ethics teacher and the curriculum development process within the following framework:

1. Diagnosis of the learner's needs and the expectations of larger society.
2. Formulation of learning objectives.
3. Selection of learning content.
4. Organisation of learning content.
5. Selection of learning/teaching experiences.
6. Organisation of learning/teaching experiences.
7. Determinations of what to evaluate and the means to do it.

This thesis is a reflective documentation of literature reviews, curriculum development options, and the rationale for the options chosen. What has evolved at AUT is a *stand-alone* ethics module which is part of the Engineering Studies paper for students in their final undergraduate year.

This research is intended to make a contribution to engineering education by providing information and guidance for any university engineering staff member who may wish to, or may be required to, introduce ethics into an undergraduate engineering programme. For those academics already offering ethics papers, this work may provide a stimulus for further thought. Hopefully this work may become a useful resource to others.

CHAPTER 1
Introduction

1.1 Background to this thesis

The respect which society and business accords the profession of engineering is enhanced by its members demonstrating a strong commitment to ethics. In recent decades there has been a significant global change in engineering and societal attitudes, together with shifts in ideology and world opinion towards engineering practice with respect to engineering ethics (McGregor, Johnson, & Bagia, 2002). These changes have led to the requirement for the inclusion of ethics and sustainability education in university undergraduate engineering programmes.

In 2005 there was an existing Engineering Studies paper incorporating ethics in the Auckland University of Technology (AUT) School of Engineering. The paper was conducted from 2001 to 2005 on an elective basis before it became a requirement for accreditation for the AUT engineering degrees (detailed in chapter 4). These degrees are accredited under the Washington and Sydney Accords and it should be noted that the accreditation requirement (chapter 4) is for ethics to be contained in the degrees. Whether ethics education is placed in one or several papers was not of concern to the accreditation panels.

The objectives of the paper up until 2005 were to introduce students to ethics and sustainability in engineering during the undergraduate degree. Upon examination of the existing paper's student appraisal, the important indicators in the summative and formative evaluations revealed that this paper was unpopular with the majority of engineering students. The content and the delivery mode were somewhat unacceptable to the staff and students (personal conversations with Dr R. Nates, 2005).

Furthermore, during the School of Engineering degree accreditation process in 2005 it became evident that the Engineering Studies paper at AUT did not meet the requirements of the Washington and Sydney Accords (described in chapter 4).

I have been a part of an evolution of attitudes and related compliance issues at AUT, particularly after we were granted university status in 2000. My growing interest in engineering undergraduate ethics education was such that I was asked to take over the responsibility for the Engineering Studies paper, which would be compulsory in 2006 for all undergraduates within the AUT School of Engineering. The new curriculum development was intended to meet the requirements to receive accreditation for AUT engineering degrees (both three-year and four-year degrees) by the Institute of Professional Engineers of New Zealand (IPENZ). The guidelines are explained in more detail in chapter 4, but essentially the requirement was to include several responsibilities relevant to engineering practice (International Engineering Meetings, 2005):

1. Teamwork.
2. Communication.
3. Societal, health, safety, legal and cultural issues.
4. Professional ethics.
5. Sustainable development.

A further requirement stipulated by IPENZ clearly states that the students will understand the relationship between engineering and society (IPENZ, 2002).

To organise the new 2006 Engineering Studies paper effectively, the School of Engineering management divided the paper into two main components, ethics and sustainability modules, with both of these components also expected to cover and support items 1, 2 and 3. To achieve these goals I conducted educational research into the area over a period of time.

The theoretical assumption that underpinned this research was that successful teaching relies on good curriculum which includes pedagogy appropriate for the curriculum level and the number of students (Dreyfus & Geddes, 2001). There is no standard education blueprint for a curriculum in ethics in New Zealand universities, as is the case with most university papers (Deans, 1999). Thus, it was up to lecturers to interpret the requirements for the curriculum, and any curriculum design can be significantly influenced by the personal life experience, education and culture of the lecturer.

Having studied the existing paper, it appeared reasonable to research, design, develop and implement a new engineering ethics curriculum which would include student outcomes that related to the Washington and Sydney Accords. The underpinning theoretical perspectives for grounding the curriculum research for the AUT ethics in engineering paper were essentially an interpretive enquiry into:

1. Professional ethics in engineering.
2. Philosophy of ethics education.
3. Pedagogy of ethics education.
4. Assessment of ethics education.

The resulting AUT ethics in engineering module introduces participants to the ethical values that underpin the profession and their obligations that flow from these values. Familiarity with governing codes of ethics is particularly emphasised within the provisions contained in the IPENZ Code of Ethics (IPENZ, 2005). Participants are expected to improve their skills in ethical reasoning and judgement and develop an increased sensitivity to the ethical dimension of the engineering profession. This intellectual development is intended to strengthen their knowledge of best practice and dedication to excellence, which goes beyond simply understanding engineering ethics. It is intended to foster the development of problem-solving skills through the process of enquiry and discovery.

In the course of the development of this engineering ethics curriculum I wrote the text book *The Social Responsibilities of Engineering* (Reid, 2006). This book is the main reference for the ethics section of the Engineering Studies paper I present that includes ethics and sustainability education for all final year students of both the Bachelor of Engineering (four-year programme), and the Bachelor of Engineering Technology (three-year programme). The book is attached to this thesis as appendix 2.

From the beginning my main challenge was to find an effective platform to reach the goals of the module; one that would not only be accepted by AUT students but would also actually interest them. As a result, over the four years I have taught this ethics module I have repeatedly reviewed the curriculum, analysing problems with content, teaching style, coursework and assessment, which has resulted in cycles of review and intervention that has been described as action research (McNiff, 2002).

1.2 Objective of this thesis

This thesis describes and reviews the four-year research and development process of the Engineering Studies curriculum intervention. It includes reflections on the cycle of action research that took place throughout the four years of the process, (July 2005 – July 2009) and the outcomes of that process.

The documentation of this development process is intended to make a contribution to engineering education, providing information and guidance for any university engineering staff member who may wish to, or may be required to, introduce ethics education into an undergraduate engineering programme. It may also contribute to academic discussion amongst those already doing so.

In such an exercise there are many options from which to choose. What options do we have for a teacher appointment, curriculum content, teaching method, delivery timing and assessment? This thesis is a reflective documentation of the literature that was reviewed and the development processes undertaken. These options are explored and the rationale for the particular options chosen for this engineering curriculum intervention are explained. Sometimes the choice was simply through necessity, and sometimes a quest for improved teaching practice.

The thesis reports not only the actions of the researcher, but also the learning involved in the process. The research method of chapter 2 precedes the literature reviews because the literature reviews in chapters 3, and 4 that examine the background to professional ethics in education were part of the research approach; they provided the background that influenced the design and development of the curriculum. The autobiographical review of chapter 5 examines the influences in my education and life experience that engaged my interest in ethics education and my growth in curriculum development leading to my involvement as the curriculum developer.

The focus with the review chapters was to understand the changing attitudes, and their effect on the field of engineering education over time. These perspectives focused on the current engineering view of ethics and, in the process, tracked the shifts in ideology with professional attitudes in the engineering industry that have led to a change of direction by scientists and engineers towards *post-positivist* and *postmodern* thinking (Crotty, 1998), which is reviewed in chapter 6. These reviews investigate the changes of world opinion regarding the concerns for our planet and how these attitudes may be relevant to ethical engineering practice. The reviews include the current focus on decision-making about social well-being, conservation of physical resources, maintenance of the integrity of our ecosystems, and avoiding the transfer of costs onto future generations (Swearengen & Woodhouse, 2002).

There have also been general changes in attitudes towards engineering ethics education. The positivist knowledge assumptions in education are being gradually supplanted and there is now world-wide expectation that educational institutions should effectively prepare people for the ethical decision-making that will be encountered when developing and applying modern technology in practice (Buckeridge, 2000; Davis, 1999; Singleton, 1991). These aspects of education are reviewed in chapters 6 and 7.

The cyclic development of the ethics curriculum at AUT is outlined in chapters 8 to 11. These chapters contain some literature which influenced the action research cycles that led to changes and improvements to the ethics module as the paper progressed.

Finally, the thesis considers the reasons for the design of this curriculum, and the ways in which values and ethics might evolve in the engineering curriculum in the future.

1.3 Ethics curriculum overview

1.3.1 Programme objectives

The graduate attributes of the Washington and Sydney Accords (International Engineering Alliance, 2005) required at that time in 2005 for the degree programmes may be summarised:

1. Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
2. Communicate effectively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
3. Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
4. Understand and commit to professional ethics and responsibilities and norms of engineering practice.
5. Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.

Essentially, to meet the programme objectives of expected student outcomes, a curriculum design was necessary which would provide for the students to have more than just knowledge, but to be able to understand and apply knowledge. The curriculum development goal was to research the most appropriate and effective design and delivery to enable the students to reach the desired attributes of the programme objectives.

1.3.2 Foundations of Curriculum design

The term curriculum actually refers to, and is used here to describe the entire process required to reach the desired student outcomes (Smith, 2000). These outcomes are a requirement of the engineering degree programme that highlights the importance of critical thinking in which students cannot always rely on routine or tradition when decision-making. The concern here with the curriculum design should contribute to an overall programme where students graduate with the capability of intelligent and independent thought. It is not only important for our graduates, but a desirable feature of all educational outcomes in a democratic society. These educational objectives were the criteria for the entire curriculum design, which included selecting materials, content, instructional methods, and assessment. It not only describes the process, but also the means by which an educational proposal is put into practice (Stenhouse, 1975). From the late 1940s in the United States, the research of Ralph Tyler has had an enduring influence on international curriculum theory and practice to present day education (Smith, 1996, 2006). Tyler's rationale for curriculum design was based on simplicity which incorporated four fundamental questions (Tyler, 1949):

1. What educational purpose should the paper attain?
2. What educational experiences can be provided to attain these purposes?
3. How should these educational experiences be effectively organised?
4. How can we determine whether these purposes are being attained or not? (p. 1)

To implement Tyler's questions Taba (1962) believed that teachers who teach or implement the curriculum should be involved in developing it – what she calls a grass root approach and suggests seven steps which lead to a coherent method of formulating, organising, and evaluating the educational objectives that have been chosen for the curriculum to reach the required student outcome.

1. Diagnose learner's needs and expectations of larger society.
2. Formulation of learning objectives.

3. Selection of learning content.
4. Organisation of learning content.
5. Selection of learning experiences.
6. Organisation of learning experiences.
7. Determinations of what to evaluate and the means to do it. (p. 44)

To develop the full potential of AUT students and provide them with the necessary knowledge expected of them by the Washington and Sydney Accords in engineering ethics, these seven steps of the curriculum development became the research focus for this research thesis.

The concept of *curriculum* can sometimes be misinterpreted as a list of contents to be covered (Smith, 2000). Smith sees the curriculum as the entire educational process “where objectives are set, plans drawn up, then applied, and the outcomes measured” (p. 3). Although the works of Tyler (1949) and Taba (1962) are still currently accepted standards of curriculum development (Smith, 2006), further developments in curriculum design have taken place. For example, Felder and Brent (2003, p. 9) represent the complexities and interrelatedness of curriculum design in figure 1.

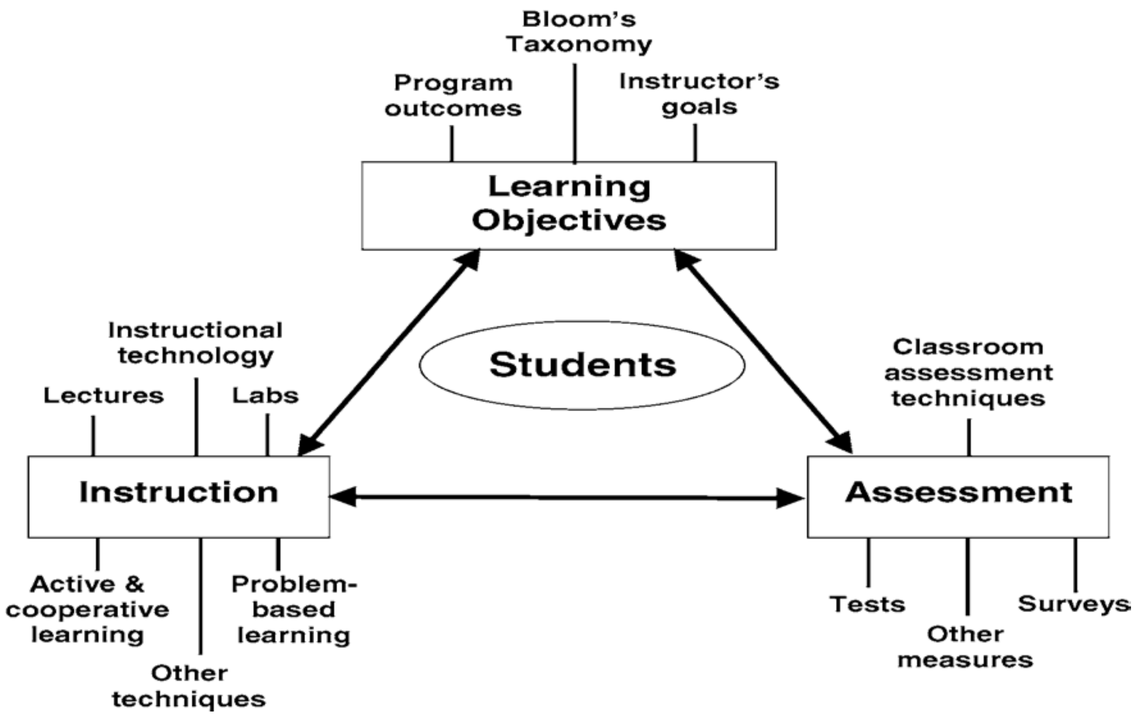

Figure 1. Elements of curriculum design.

The diagram represents many possible aspect of curriculum design as was referred to during this thesis. Some of the aspects were not relevant and, for example, Problem-based learning is referred to as team projects involving case studies. The principles of Bloom's Taxonomy are used in the curriculum development, although Bloom is not specifically referred to.

Defining student needs or learning outcomes depends on the educational perspective of the curriculum developer/lecturer. To researchers such as Smith (2006) the term student learning outcome is similar to constructs such as *educational objectives*, *competencies, skills* or *achievement,* and the similarity of these key terms has led to confusion among lecturers as they focus on such reform initiatives as *outcomes-driven assessment, competency-based curriculum,* and *ability-based learning*. As a result, Smith suggests that engineering educators have initiated reform actions assuming the notion of learning outcomes without really exploring its underlying meaning. There are two issues to address when defining student learning outcomes: the breadth of the constructs and the level of specificity.

Consequently, the provision of student outcomes required by the Accords provided the guidelines towards the development of a curriculum to meet these objectives.

1.3.3 Intended student learning objectives

As a result of literature reviews, the content of the AUT ethics module in 2006 included a study of the following issues and concepts that are intended to lead towards an understanding of modern engineering ethics.

1. The importance of the role of a university, and subsequently its graduates, as an effective critic and conscience of society.
2. The relationship between society and engineering.
3. The subsequent relationship between society and technology.
4. An awareness and understanding of the way in which engineering practice contributes to global social, environmental and economic issues

so that we are able to make responsible choices for the benefit and safety of society.

5. An introduction to values, moral and ethical theory in engineering education.
6. An understanding of engineering ethics which includes how it should be used to contribute to social contexts in the western world and in developing countries.
7. A guide to ethical (and values-based) decision-making in engineering.
8. An examination of the current responsibility of engineers in ethical decision-making, with the opportunity to learn from the past to enhance understanding and take appropriate action related to contemporary industrial development and globalisation.
9. An understanding of engineering codes of ethics.
10. The encouragement of the students' ability to critique engineering issues.
11. A guide to the university, industry and societal expectations of high standards when conducting engineering research.

The review during this research, revealed a guide to the process of school-level curriculum construction by Stenhouse (1975), who suggests that a curriculum should comprise three phases, as a basis for planning the course, studying it empirically and considering grounds for its justification:

A. In planning:

1. Principle for the selection of content – what is to be learned and taught.
2. Principles for the development of a teaching strategy – how it is to be learned and taught.
3. Principles for making decisions about sequence.
4. Principles on which to diagnose the strengths and weaknesses of individual students and differentiate the general principles 1, 2 and 3.

B. In empirical study:

1. Principles on which to study and evaluate the progress of students.
2. Principles on which to evaluate the progress of teachers.
3. Guidance as to the feasibility of implementing the curriculum in varying school contexts, pupil contexts, environments and peer-group situations.

4. Information about the variability of effects in differing contexts and on different pupils and an understanding of the causes of the variation.

C. In relation to justification:

A formulation of the intention or aim of the curriculum which is accessible to scrutiny. (p. 5)

Based loosely on these principles of curriculum design, the thesis documents the process and subsequent alterations and improvements, related to figure 1 in terms of learning objectives, instruction and assessment to meet the desired student outcome. During this research process it was expected that in the search for teaching methods to reach the student outcome, these methods would be suited to the content in a manner that would interest engineering undergraduates. This led to one further question pondered in this research; what are the requirements for an effective ethics teacher.

1.4 Background to the development of the ethics in engineering curriculum

This section provides an introduction to the background of AUT to provide an understanding of the environment in which I developed the ethics curriculum.

New Zealand

New Zealand is a small former British colony in the South Pacific with a population of about 4.5 million people. As it has matured as a nation, New Zealand has progressively grown away from the traditional colonial influence of England (Department of Statistics, 1999). Its economy once depended on exports of agricultural products to the United Kingdom, and it is still dependent on overseas trade, but the once traditional dependence on dairy, meat and wool exports is now supplemented with the establishment of newer industries of forestry, horticulture, fishing, manufacturing and tourism (Department of Statistics, 1999).

However, as remote and small as New Zealand might be compared to other developed countries, we have always kept abreast of modern engineering, particularly with the global changes in attitudes towards engineering education and the increasing awareness of the delicate balance between our ecology and technology. AUT has been part of this growing change in attitudes and engineering practice.

AUT

AUT University is New Zealand's newest university, of a total of eight. It gained university status on 1st January 2000, having originally been a Technical School. In 1895 it began as the Auckland Technical School for the purpose of educating Auckland's so-called underprivileged class of children (Auckland Institute of Technology, 1995), progressing to a technical high school in 1910, before being renamed Seddon Memorial Technical College. The secondary school system at that time followed the British tradition where middle class and academically strong students went to a public or grammar school and the children of the working class went to technical high schools (McKenzie, 1992). New Zealand's technical high schools typically offered boys pre-vocational streams of engineering, building, and agricultural courses to give them practical skills to prepare them for the non-professional workforce (Lee, 1992). Female students were offered subjects such as typing and bookkeeping to prepare them for jobs in commerce or, alternatively, learn "needlework, cooking and domestic economy" (Gibbons 1977, p. 164). In rural districts the post-primary schools were a mixture of the two types and the *pre-vocational* or *pre-university* concept was similar to the European secondary school system on which New Zealand's was modelled (de Vries, 1992; McKenzie, 1992). For more than half the twentieth century, night classes were conducted by Seddon Memorial Technical College for trade apprenticeship training (Auckland Institute of Technology, 1995).

The decline of trade training

In the 1960's Seddon Memorial High School was relocated and renamed as Western Springs College, and the original city site became the Auckland Technical Institute for the provision of tertiary trade training. For decades the institution was considered one of the nation's leaders in arranging and overseeing apprenticeships (Auckland Institute of Technology, 1995). However, during the economically difficult times of the 1970's and 1980's some apprenticeship schemes were abandoned while others were placed in the hands of private training providers which significantly reduced the requirement for the provision of skills-based training in the region by the Auckland Technical Institute.

Following the government's white paper *Learning for Life*, in 1989 the Auckland Technical Institute was renamed to become the Auckland Institute of Technology with the authority to confer degrees (Reidy, 2004). This shift to degree and post-graduate level education in the 1990's was seen as essential for survival (Auckland Institute of Technology, 1995; Reidy, 2004).

A period of extensive growth followed in the 1990's, which was a time when many tertiary institutions in Australia and the United Kingdom were gaining university status. The Auckland Institute of Technology became a university in 2000 and was renamed the Auckland University of Technology (AUT). "The rationale behind it was identical to that of wanting to offer degrees in the first place; the globalisation of education and the need for international recognition" (Reidy, 2004, p. 64).

The new focus of AUT as a university

This new status brought a new focus and responsibility to AUT, as the principal function of any university is to advance knowledge by research, and to maintain and disseminate such knowledge by teaching. As a university there is also the obligation to develop intellectual independence (Blakey, 2002; Braukman & Pedras, 1990; Hinchcliff, 1997; Kerr, 1998; van der Vorst, 1998); this includes understanding, rational thinking and judgement over an increasingly unpredictable future. Ideally, as the students progress through their chosen course of tuition, a university course needs to take them beyond knowledge, to wisdom (Garrison, 1997). From this perspective it is no longer sufficient to teach engineers about the past, or even the present; we need to have them anticipate the future, and their place within it (Toffler, 1970). What kind of structures and organisations will they have to contend with? What sort of ethical issues must they contend with in the process? It is only by generating such hypotheses, trying to define what might be and debating and continually updating this, that we can give students the effective and cognitive skills required to survive in a rapidly changing workforce environment (Herkert, 1997; Toffler, 1970).

1.4.1 The shift in relationship between technology and education

The concept of a university of technology has grown out of the changes that occurred in the application of technology as far back as the industrial revolution. Since that time technology progressively became less skills-based and so it followed that it was no longer the exclusive domain of the artisan. The trades were no longer the manual-labour-based careers they once were (Industry in the classroom, 2009). Much of technology is now knowledge-based, in that the technologist must very often build an intellectual base before any artisan skills can be applied (Braukman & Pedras, 1990). For example, such is the computerisation of modern construction and assembly that one simply doesn't have time to learn everything. In modern society, with intellectual aspects of technology becoming increasingly important, there is a compelling requirement for intellectual understanding before technology can be applied in practice (Braukman & Pedras, 1990). Unlike the original concept of the trade training in a polytechnic, a university of technology is not an educational centre for vocational training (Reidy, 2004). While a polytechnic may invest much of its time and energy into skills-based training, the shifts in technology and the migration of workers may make such training quite useless in another place or time (Iacocca, 1985). Hutchings, (undated, cited in Hinchcliff, 1997) distinguishes the necessary transition from polytechnic trade training to the requirements of undergraduate and post-graduate degrees (emphasis in original):

> The power we want our graduates to have is power in and over the unpredictable future … . It is the power of understanding and judgement. Its contribution to the moral, physical and spiritual natures of its students and to their 'success' in the world are made by way of this power. No other agency in the community has the responsibility of supplying the intellectual power that the community requires. The progress and even the safety of a democratic community depend in part upon the intelligence of the citizens. (p. 338)

This shift to the intellectual aspect of technology is particularly relevant in engineering education. In this respect, Bereiter (1992) observed: “Higher-order conceptual knowledge … may be better organised around problems than referents” (p. 342). Similarly, van der Vorst (1998) argued that the changes in modern engineering education should include:

> 1. A decreased emphasis in factual learning.
> 2. An increased emphasis on life-long learning and continued professional development. (p. 172)

1.4.2 The new expectation as the critic and conscience of society

A further obligation of AUT in the adaptation to a university is the expectation that, as a university, it should take a responsible role in the community as a *critic and conscience of society*, words which are in the New Zealand tertiary education policy as specified in the Education Act 1989 (Education Act, 1989). The Ministry of Education states that the government should use the Crown’s ownership interest in tertiary education institutions to ensure, among other things, “protection of academic freedom” (Kerr, 1998, p. 2). The Act defines academic freedom as: “the role of academic staff to act as critic and conscience of society under which they question and test received wisdom, put forward new ideas and challenge orthodox, or state unpopular decisions” (Kerr, 1998, p. 2).

The *Initial Report of the Tertiary Education Advisory Commission* (Maharey, 2001) also makes mention of the role of a university as “encouraging staff and learners to serve as informed critics of society and contribute, as active citizens, to the formation of public values and policies” (p. 3). I see this critic and conscience concept as related to ethics education, which will empower graduates with the ability to judge and deal with situations in which their conscience is alerted. Such responsible actions may also include changes in their social behaviour as a result of the values their university has helped them develop. At times it is expected that they will challenge, rather than passively accept, the social, economic, commercial and industrial realities that are defined for them by others (Kerr, 1998). However, such actions should be tempered with a social conscience that balances the profit motive with an ethical and responsible approach to serving the community’s needs (Randerson, 1991).

The university input to social critique and improvement can contribute to positive social change, playing a role that properly stimulates reflection, provokes new thinking and leads positively towards the future. However, because universities have such an enormous influence in society, they need to be held accountable for that influence, which calls for an ongoing two-way relationship between universities and society (Dick & Stimpson, 1999). This important relationship is addressed in the AUT ethics module, along with the responsibilities of academic freedom. Having examined the background of AUT and the new responsibilities and expectations of the institution, I now briefly examine some of the expectations within its two engineering degrees.

1.5 The new engineering bachelor programmes

The AUT engineering degree programmes were designed according to the requirements of a degree programme defined by the New Zealand Qualifications Authority. AUT offers two engineering bachelor degrees and the graduate profile and outcome of both programmes is based on IPENZ (2002), which expect graduates to:

1. Communicate effectively on engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
2. Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
3. Understand and commit to professional ethics and responsibilities and norms of engineering practice.
4. Understand the impact of engineering solutions in a societal context and demonstrate knowledge of, and need for sustainable development.
5. Recognise the need for, and have the ability to engage in independent and life-long learning. (para. 3)

In chapters 3 and 4, I show how the understanding of the societal context, professional and ethical practice principles as applied to engineering is considered by many to be an important part of this life-long learning and continued professional development, and is now a requirement by the major stakeholder in engineering standards, IPENZ. Engineering ethics has become a compulsory feature of undergraduate education in countries that are signatories to global agreements (or accords) on engineering academic standards (Coates, 2000). To gain accreditation for its engineering degrees IPENZ required AUT to meet the criteria laid down for engineering educational standards by the Washington and Sydney Accords of which IPENZ is a signatory.

1.6 Overview of the thesis

Having stated the significance of the study, and the background and expectations of AUT where the research took place, the research design is now explained. This is followed by four review chapters which were conducted while designing the ethics module. The first two comprise literature reviews of engineering ethics, engineering ethics in education, followed by an autobiographical review of my growing development and interest in the subject and values in education. Next, the field of values, morality and ethics and values-based decision-making are investigated. These chapters provide the background for the development of this research project which led to the final development and delivery of an undergraduate programme of ethics in engineering at AUT. This development is presented and discussed in the remainder of the thesis. To document this development cohesively the action research is categorised as four distinct areas comprising curriculum content, teaching organisation, teaching approach and assessment. The thesis concludes with discussion on the findings of this research, and a projection of possible trends in the future. Figure 2 shows the thesis structure.

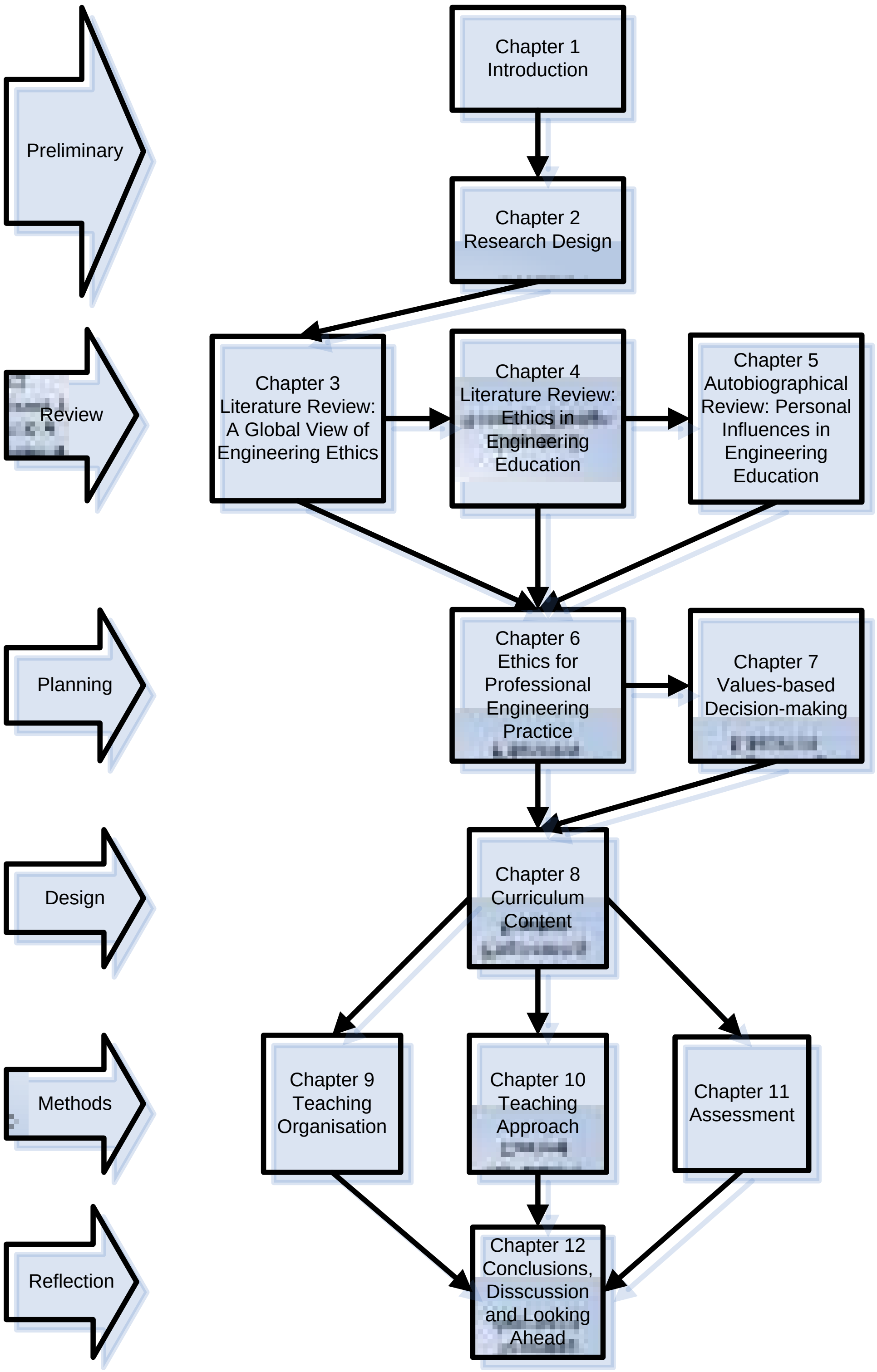

Figure 2. The thesis structure.

CHAPTER 2
Research Design

2.1 Introduction

It had been my intention at the beginning of the AUT EdD programme in February 2005 to research how I could introduce ethics across the board into the engineering programmes at AUT. However, in mid-2005 I was unexpectedly requested to take over the teaching of the ethics module of the existing AUT Engineering Studies paper, beginning in 2006. Following investigation, I decided to redesign the ethics module and implement the planned intervention in 2006. This meant that the curriculum development had to be done in 2005, and as this thesis began in 2007, the research topic changed to documenting my reflections on the initial development of the ethics module and the cycles of reflection and adjustment in a further three cycles of action research. The five research questions relating to curriculum development listed in section 1.3 comprised: requirements for appropriate curriculum content; effective ethics teacher; teaching method; delivery options and assessment.

The approach taken in the investigation and design of the initial curriculum can be broadly described within the interpretive (or interpretivist) paradigm (Cohen, Manion, & Morrison, 2000).

Research is often based on objective logical deductive views of knowledge in which data can be derived by hypothesis testing and statistical analysis incorporating measurement by positivist and quantitative research methods such as rating scales, surveys and observation (Muchmore, 2000).

Such a positivist approach, which claims that social life can be understood through the examination of observable regularities, is usually without any reference to the subjective (Bullock & Trombley, 2000).

However, teaching is a personal and complex endeavour which is shaped by subjective influences that are beyond a positivist outlook. Thus, while many engineering research projects tend to be positivist, questing for quantitative and provable empirical data, this project, being education-based, used a qualitative approach in which the emergent themes revealed by the data were considered "subjective, humanistic and interpretive" (Hussey & Hussey, 1997, p. 47). Crotty (1998) distinguishes between interpretive and positivist enquiry:

> A positivist approach would follow the methods of the natural sciences and, by way of allegedly value-free, detached observation, seek to identify universal features of manhood, society and history that offer explanation and hence control and predictability. The interpretivist approach, to the contrary, looks for culturally derived and historically situated interpretations of the social life-world. (p. 67)

According to Hussey and Hussey (1997), some researchers use the term phenomenological rather than interpretive; however, in this research I used interpretive for ease of comprehension. Such a research paradigm is described by Hussey and Hussey (1997) as "an approach which assumes that the social world is constantly changing, and the researcher and the research itself are part of this change" (p. 64).

There are many terms used in association with the interpretive type of enquiry. Crotty (1998) explained that, historically, what we now understand as an interpretive approach to human enquiry has already appeared in many guises, including hermeneutics and phenomenology, and that it may be seen as an attempt to develop a natural science of the social by understanding and explaining human and social reality.

The interpretive analysis of data is an attempt to place specific encounters, events and understandings into a fuller, more meaningful context (Tetlock, 2000) in order to derive a useful philosophy – in this case of engineering ethics education – of an international standard for the critique and edification of other academics.

The approach of this thesis evolved with three distinct phases, although they overlapped to some extent time-wise. The phases were:

1. *Literature reviews*: An interpretive enquiry detailing the global shift in opinion regarding ethical education in engineering, and a review focusing on appropriate curriculum design.
2. *Self-reflective or autobiographical review*: Identifying the influences on me that in turn influenced the development, practicalities and delivery of the new curriculum.
3. *Action research*: The planning of the intervention and the cycles of implementation, review, evaluation and adjustment designed to improve the curriculum implementation and to solve problems that arose as the paper progressed over a four-year period.

The combination of these provided a methodological approach to investigating the education of ethics within an interpretive framework. It resulted in the acquisition of data that also related to the global perceptions and experiences of other academics within their immediate field and engineering infrastructure. Although the autobiographical approach used was a small feature of the study, it was a useful analytical tool, yielding data of a greater breadth and depth for understanding my own values and ethical approach to my work and teaching that were pertinent to the subject of engineering ethics.

The thesis structure/research plan in figure 2 (section 1.6) shows the literature and autobiographical reviews as chapters 3 to 5 which formed the background to this research. However, chapters 6 to 11 rely on further literature review and on some aspects of autobiographical review as the basis for the development process, as I solved problems during the cycles of planning, designing and action research. Chapters 6 and 7 record my investigations into understanding ethics, and the action research chapters 8 to 11 are presented in the order that I addressed the curriculum issues, namely: curriculum content, teaching organisation, teaching philosophy and assessment – these issues often overlapped, however.

2.2 Literature review

The review of relevant literature as the starting point for designing curriculum is routinely used by people designing courses in any number of disciplines. The literature review process involved examining the experience of other academics, researchers and practitioners. In chapters 3 to 7 the reviewing was addressed specifically, and in chapters 8 to 11 reviewing further literature influenced the modification and the natural evolvement and improvement of the study.

The literature review sought opinions related to the following areas of curriculum design:

1. Understanding ethics.
2. The influences affecting the development of curriculum content.
3. The teaching approaches.
4. The influences affecting the learning methods and assessment.
5. The criteria laid down in the Washington and Sydney Accords of the required graduate profiles.
6. The choice of *across-the-board* and *stand-alone* formats of papers.
7. The two options of delivery for stand-alone solutions as a block course or a weekly session (referred to by some academics as total immersion or drip feed).

From the reviews, emerging themes arose which were interpreted and documented, thus building up a picture of the general philosophy of curriculum design. Many conclusions were drawn, some of which influenced the initial curriculum design, and the review file was also used in conjunction with the further review, ongoing development and evolution of the curriculum.

2.3 Autobiographical review

The autobiographical review in chapter 5 reflected the changes in my life and circumstances, and how these influenced the ethics curriculum design. The addition of this autobiographical review grounded this research very firmly in the New Zealand historical and cultural context.

The autobiographical component used an interpretive enquiry approach. I analysed data relating to selected aspects of my lived experience that seemed relevant to learning and teaching engineering ethics. This approach is a branch of the ethnography; it is gaining in popularity with researchers for understanding the lives of teachers, and the way they think about their subject matter and curriculum in general (Muchmore, 2000). Collins and Hussey (2003) describe ethnography as a “methodology derived from anthropology whereby the researcher uses socially acquired and shared knowledge to understand the observed patterns of human activities” (p. 347). Whereas the research into the acquisition of knowledge is that of the researcher, the chapter regarding my own experiences, meanings and interpretations for the structured text of chapter 5 of this thesis could be viewed as autoethnography (Collins & Hussey, 2003; Tetlock, 2000).

The research of Ellis and Bochner (2000) defines the autobiographical form of autoethnography as:

> An autobiographical genre of writing and research that displays multiple layers of consciousness, connecting the personal to the cultural. Back and forth autoethnographers gaze through a wide-angle lens, focusing outward on social and cultural aspects of their personal experience. (p. 739)

Such an approach, together with interpretive analysis, allowed me to come to an understanding of my own experiences and growth (Moustakas, 1990). Jankowicz (2005) is positive about the methodology, believing “the importance of an issue is due as much to its provenance as to its content and a longitudinal approach can be very revealing” (p. 230). Tetlock (2000) gives a similar view, that it: "involves an ongoing attempt to place specific encounters, events, and understandings into a fuller, more meaningful context" (p. 455).

The data from the autobiographical review were assembled as a structured table of incidents that I considered to have influenced thinking about ethics and my teaching; they were organised in the following four categories:

1. *Life experience*: A biographical recall of incidents or periods of my life.
2. *Community/education perspectives at the time*: An analysis of the social and historical context of the action.
3. *Effect on my personal values*: An interpretation which traces the construction and adaptation of my values.
4. *Effect on me as an educationalist*: Examining the effect of the incident on the construction of my knowledge base and changes to my philosophy as an educator.

2.4 Action research

A systematic approach to curriculum design based on the works of Tyler (1949) Taba (1962) later works by Shuman et al. (2000) was used in this research for a preliminary paper in 2006. However, Tyler emphasises the fact that curriculum planning is a continuous cyclical process, involving constant replanning, redevelopment, and reappraisal, which describes the process of improvement in 2007-2009. This suggested that the integrated assembly and review process of this instructional program could be related to action research which features such a cyclic process.

The decision to use this approach is strengthened with the precedent in the USA where, with the introduction of the EC-2000 accreditation criteria in the USA in 1995, there is now requirement for engineering programs to develop and implement systems for continuous improvement. Faculty must now demonstrate that the outcomes important to the mission of the institution and the objectives of the program are being met via sound measurement, and must give evidence that these results are applied to the further development and improvement of the program. Hence, outcome assessment and continuous curriculum improvement have now come to the forefront of engineering education (Shuman et al. 2000).

Consequently, efforts to improve the ethics module at AUT were similar in aspiration to the efforts in the USA. This research entailed this continuous improvement; it could have been described as a case study methodology, as it appeared to relate well to Tyler's (1949) theories of a cyclic process of improvement. However, considering the structured cycles that took place, the action research model was chosen which involved reporting the intervention that has been practised, tested and reviewed and offering some discussion on possible ways to improve the curriculum and how best to serve the needs of the students and the industry in the future. From these notions of action research, and being a teacher in practice, the aspects of the action research approach were not as formal or systematic as some theorists believe desirable – it was practice-based.

Action research is a reflective practice of problem-solving which was conceptualised and introduced by Kurt Lewin in 1948 (Hopkins, 1985). Action research is often used to encourage social change, particularly within a work environment, and Lewin believed that the people who were subject of the change would be more conducive to accepting change and adopting new methods and procedures if they were directly involved in the decision-making process as participants of the research. The concept has since been elaborated and expanded and is now often undertaken by large companies, organisations and institutions to improve their organisational strategies and practices. In such a research mode the organisations often depend on the assistance of professional researchers, with the aim to improve their strategies, practices, and knowledge of the environments within which they practise.

The salient feature of action research is the cyclic process for the purpose of fostering a deeper understanding of a problem. The research cycle is conducted in a series of steps consisting of a cycle of planning, action, and review of the change brought about as a result of the action (Elliot, 1991;

Hopkins, 1985). This conceptualising and itemising process moves through several cycles of interventions and evaluations. The cycle of action research has four main components:

1. The exploration into understanding and defining the problem, and designing an intervention as a solution.
2. Implementing an intervention.
3. Observing the effectiveness of the intervention.
4. The following cycle begins with further intervention design.

Kemmis (Kemmis & McTaggart, 1981, p. 9) illustrated the cyclic nature in figure 3 below. Action research is designed to find an "effective way of bringing about a conscious change in a partly controlled environment" (Hussey & Hussey, 1997, p. 65).

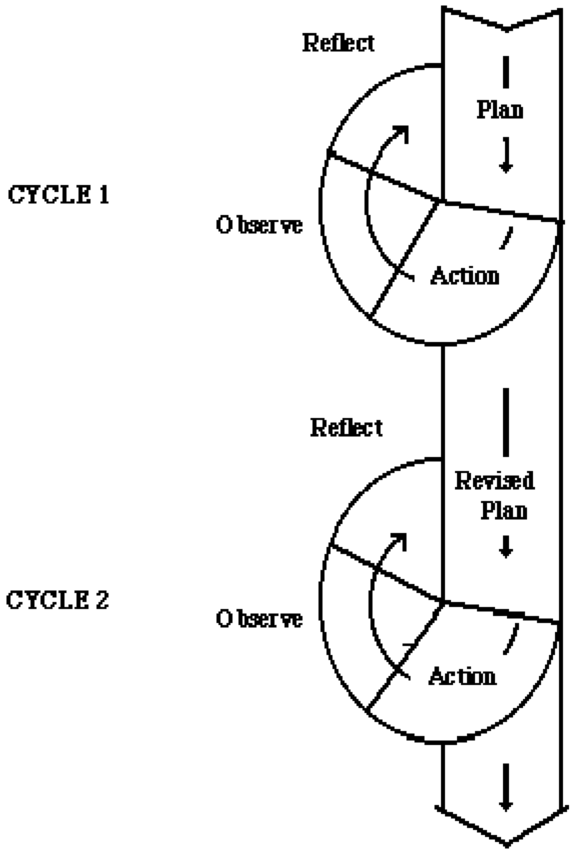

Figure 3. The Kemmis action research protocol.

Kemmis and McTaggart (1981) state "action research is concerned equally with changing individuals, on one hand, and, on the other, the culture of groups, institutions and societies to which they belong" (p. 16).

While I have described the common use of applying action research to improve practice within organisations, Cohen, Manion, and Morrison (2000) consider action research useful as a small-scale intervention where a "combination of action and research renders that action a form of disciplined enquiry, in which a personal attempt is made to understand, improve and reform practice" (p. 226).

Furthermore, Cohen et al. (2000) suggest that action research may be used in education research for many reasons, of which the following particularly applied to this curriculum development:

1. *Teaching methods*: Replacing a traditional teaching method by a discovery method.
2. *Learning strategies*: Adopting an integrated approach to learning in preference to a single subject style of teaching and learning.
3. *Attitudes and values*: Encouraging more positive attitudes to work, or modifying students' value systems with regard to some aspect of life.
4. *Continuing professional development of lecturers*: Improving teaching skills, developing new methods of learning, increasing powers of analysis, of heightening self-awareness.
5. *Administration*: Increasing the efficiency of some aspect of the administrative side of school life. (p. 226)

Avison, Lau, Myers and Nielson (1994) categorise action research as a research method into four groups:

1. Action research focusing on change and reflection.
2. Action science trying to resolve conflicts between espoused and applied theories.
3. Participatory research emphasising participant collaboration.

4. Action learning for programmed instruction and experiential learning. (p. 96)

I see this research as category 1, and my surmise is supported by McNiff (2002), who promotes the action research method for use by individual educators to improve their own practice in teaching as a regular cycle of self-reflection and course appraisal. McNiff explains how action research may be used by the individual teacher to reflect on their own practice:

> In traditional forms of research – empirical research – researchers do research on other people. In action research, researchers do research on themselves. Empirical researchers enquire into other people's lives. Action researchers enquire into their own. Action research is an enquiry conducted by the self into the self. You, a practitioner, think about your own life and work, and this involves you asking yourself why you do the things that you do, and why you are the way that you are. When you produce your research report, it shows how you have carried out a systematic investigation into your own behaviour, and the reasons for that behaviour. The report shows the process you have gone through in order to achieve a better understanding of yourself, so that you can continue developing yourself and your work. (p. 1)

Action research, as the name suggests, is research through action, and concerns those people who are carrying out professional actions on a daily basis. Waters-Adams (2006) explains:

> The aim of an action researcher is to bring about development in his or her practice by analysing existing practice and identifying elements for change. The process is founded on the gathering of evidence on which to make informed rather than intuitive judgements and decisions. Perhaps the most important aspect of action research is that the process enhances teachers' professional development through the fostering of their capability as professional knowledge makers, rather than simply as professional knowledge users. In an age of centralisation and the proliferation of national guidelines and strategies, action research can help teachers feel in control of their own professional situation. (p. 2)

Action research can thus be used to:

1. Understand one's own practice;
2. Understand how to make one's practice better;
3. Understand how to accommodate outside change in one's practice;
4. Understand how to change the outside in order to make one's practice better.

At its heart, action research involves the careful monitoring of planned change in practice. A decision is taken that a particular action may either yield improvements or provide information as to the nature of the teaching situation. The action is thus used as a research tool. To design, test and improve a curriculum can be seen as action research (Waters-Adams, 2006). The initial design of the curriculum was the first cycle, where I identified the problems with the existing paper offered before I took responsibility for the paper, and began the process of intervention. Later I reflected on the changes I initially made to the curriculum. Subsequently I have taught the module four times, and each time I again reflected and refined the programme. These changes are documented and discussed in chapters 8 to 11. The feedback used to stimulate further reflection each year included the annual student appraisals, personal student feedback, and my reflections on difficulties with the programme.

Carr and Kemmis describe it as a self-reflective enquiry "in order to improve the rationality and justice of their own practices" (p. 162). However, in this research it began as a reflection of AUT practice, but continued through several cycles in reflection of my own subsequent practice.

The Kemmis Action Research Protocol described by Kemmis and McTaggart (1981, p. 9) suggests a cycle of plan, action, observation and reflection, followed by a revised plan, where the second cycle begins the process again.

Carr and Kemmis's (1986) reflective spiral is shown in figure 4.

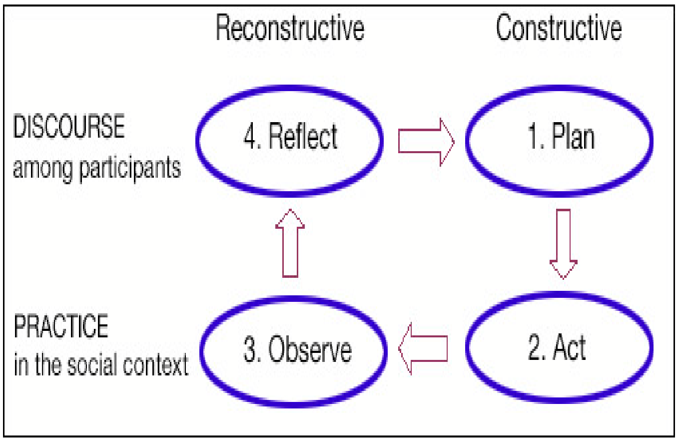

Figure 4. The Carr and Kemmis reflective spiral.

(Carr & Kemmis, 1986, p. 183).

This reflective spiral, in its very simplest form, suggests an action plan follows the order of plan/act/observe/reflect (1, 2, 3, and 4). However, this was a case of inheriting an existing paper, so my reflective spiral began with an observation of the existing paper. Hence, my action plan evolved as four cycles in the sequence 3, 4, 1 and 2, where:

3. Observation: Used to observe and identify a problem that needed attention in the paper I was taking over.

4. Reflecting: Considering alternatives to revise the plan. This reflection included the process of logically considering a range of alternatives, deciding on one, and explaining the reason for the choice.

1. Planning: To give the detail to support an alternative solution to the problem found in the reflection.

2. Action: To put the plan into action.

However, *observe, reflect, planning and action* are not used in describing the process, as to some extent they overlapped and merged into each other. Each plan and action was followed by review in the succeeding cycles. Each year it has been a process of:

1. Determining whether the material is being understood and deciding if an alternate strategy might enhance students' comprehension of the material.
2. Managing the learning environment with increasing numbers of students. (The numbers went from 30 to 154 over a five-year period).
3. Reviewing and improving the assessment.
4. Reviewing and streamlining the administration of the paper.

Some of the changes made in curriculum content and case-study updates were what I consider normal evolutionary change with the modifying of resources, teaching method, presentation techniques and assessment after reflecting on my practice. Minor changes only receive a brief mention in the thesis, and the action research concentrates more on the major changes in the direction and philosophy of the ethics module.

The study was always exploratory in nature. Hence, the development of theory as the research progressed could be likened to the *Grounded theory* of research described by Glaser and Straus (1967). Grounded theories are developed incrementally from empirical observation; however, the research did not use the deep analytic strategies that make grounded theory quite complex.

2.5 Research data quality criteria

2.5.1 Quality criteria for existing literature enquiry

In tracing the global and local events in engineering for this literature review, the data required an accurate interpretation and portrayal of past events, including the achievements and contributions of various groups and individuals (Gutek, 2004). However, such a review presents a construct validity issue concerning the relevance of both the assembled data and the analysis of that data. This validity issue presented the question of whether my construction of the review was the same as others would have constructed it, and whether my interpretation was either too narrow, under-represented common opinion, or suffered from the inclusion of irrelevancies (Cohen et al., 2000). Content validity was sought by ensuring that the content of any material gathered through literature review used a fair sample of opinion in the subject matter in question (Cohen et al., 2000).

However, my interpretation of some events, issues and the required curriculum content – where reliability and validity were not always an issue – was subjective. The curriculum development research revealed data that was not only historical, but also of a social and cultural nature, and I understand that other researchers' opinions and experiences in this field of education are equally as valid as my own. However, to ensure the validity of any assembled data I had to be careful to understand other researchers' and educators' meanings, interpretations, terms and intentions as their data was documented and interpreted. I kept in mind that, on a global basis, many ideologies in education are contextual, arising from particular times and places, and are based on given historical political and economic situations (Gutek, 2004). Different cultures and countries may have their own ideologies which can influence the content of their degree programmes. When attempting to ensure the validity of the research, I strove to avoid ideologies with a narrow focus. By considering the international and multi-cultural nature of the AUT students, the research sought a philosophy (rather than an ideology) in ethics education that would be relevant to all AUT engineering undergraduates in this country.

2.5.2 Quality criteria for autobiographical enquiry

Critics of the autobiographical research methodology point out that although individuals are creators of meanings which form the basis of their understandings of their everyday lives, individuals act according to meanings through which they make sense of their social existence. The interpretation of those meanings is thus the qualitative approach to the study of a life which itself is subjective and interpretive (Roberts, 2002). Hence, in autobiographical enquiry, concerns often arise as to the adequacy and quality of accounts (Mills, 2003) and, in particular, how far a life story should follow the recognised methodological standards of qualitative research (Roberts, 2002). Cohen et al. (2000) state that "the reliability in life history research hinges upon the identification of sources of bias and the application of techniques to reduce them" (p. 133). Ideally, the autobiography should be based on journals containing notes that have been documented over a period of years (Begg, 2006). In the absence of such notes for the years before 1999 (when I began my PGDipEd and MSc studies), I relied on biographical recall. In terms of quality, the interpretation of these selections was subjective but was also referenced whenever possible.

The data in the autobiographical section was analysed using a mapping (or chart) technique, giving my interpretations of events and how they affected me personally, as well as how they affected the evolution of the curriculum design and delivery. I was aware at all times during the curriculum delivery research of the need for sensitivity in my assumptions and interpretations (Jankowicz, 2005). Tenni, Smyth and Boucher (2003) offer good advice in this respect, in that an autobiographical analysis:

> is not about presenting ourselves in a good light – in charge, competent, controlled, organised and so on, or how we might like to be seen. Rather, it is about writing rich, full accounts that include the messy stuff – the self doubts, the mistakes, the embarrassments, the inconsistencies, the projections and that which is distasteful. It is about writing all of it. (p. 3)

As in any normal research report, the accuracy of statements routinely needed checking with other authors and reports. My own biographical recall would at times be difficult for readers to validate, and in view of this concern, I followed Riessman (1993) in giving particular attention to all data regarding authenticity, credibility, coherence, plausibility and trustworthiness. Consequently, I checked my recollection of childhood culture with others who had shared the experience of living in Pukekohe. The authenticity of other childhood prejudices was verified where possible by literature review.

Maintaining quality in a naturalist type of enquiry can be quite different to the normal positivist type of quantitative enquiry, which requires reliability, generalisability and validity in data. Lincoln and Guba (1985) suggest that trustworthiness in data can be established using credibility, transferability, dependability and confirmability. Begg (2006) in his autobiography on curriculum in mathematics interpreted these as:

> Credibility (comparable to internal validity) requires the researcher to show that the subject of enquiry was accurately identified and described. Transferability (instead of generalisability) is the ability for another to recognise the interpretation as speaking to their own situation. Dependability links with credibility and is usually achieved by triangulation to ensure that bias is limited. Confirmability (as opposed to objectivity) is ensured by providing enough evidence to justify the approach and the connections with the data and conclusions. (p. 64)

These criteria might be sound advice for the qualitative researcher in general, but we all have different perspectives and influences that may contribute to one's complete education and holistic view of life. I hope that assessors of the developed curriculum would understand how my perspectives on education may vary from another's views. Furthermore, an incident or event that shaped my values and ethical views would not necessarily transfer to someone else.

My autobiographical interpretation of the events and experiences that had developed my values and attitudes to ethics was interpretive and qualitative. These are my interpretations of those contextually related experiences and events that were pertinent to the ethics in engineering curriculum development. It was an exercise in making sense, or interpreting my experiences and, in the process, growing in self-understanding (Ellis & Bochner, 2000; Riessman, 1993; Settelmaier, 2007; von Glasersfeld, 1990). However, they are my recollections of past events and influences that changed my understanding and attitudes. In the chapter containing autobiographical reflection the curriculum design research objective was to reflect, establish and understand what influenced me in the design of this curriculum.

2.6 Reflective critique of the research design

The interpretation of all data presented challenges with respect to quality. Seedhouse (2005) explains that human understanding and interpretations of the external world are "filtered through human perceptions and interpretations" (p. 51). Seedhouse infers that quite often we find it difficult to step outside our own culture or comfort zone to comprehend truth or reality. Consequently the influence of one's personal or cultural relativism may skew interpretations and belief in what is right or wrong (Cohen et al., 2000; Rachels & Rachels, 2007; Seedhouse, 2005).

Furthermore, a researcher needs to be cautious as it can be argued that there is no such thing as absolute truth, and to construe a constructivist view of the interpretation of lived experience as a reality or empirical truth is considered a biographical illusion (Denzin, 1989). Alternatively, a researcher can be accused of emotional interpretation and, unlike the fictional character Mr Spock who believed that all decisions should be made with logic, it is quite difficult for human beings to act in value-free ways (Seedhouse, 2005).

To avoid such skewed interpretations, I attempted to separate my personal ethics from ethics for engineers, regardless of their cultural relativism. The literature review in chapter 3 showed that one of the objectives of a commercial or professional code of ethics is to stipulate the values of the profession. This in effect decontextualises personal ethics, which may vary within cultures. However, the autobiographical review in chapter 5 clearly shows that my personal ethics and values have influenced the way I see professional ethics.

CHAPTER 3
Literature Review:
A Global View of Engineering Ethics

3.1 Introduction to modern engineering

3.1.1 Defining engineering

Modern engineering as it is understood today is the consideration and application of aspects of technology to everyday problems. Engineering involves the design, planning, problem-solving, decision-making, communication, and application of technology, for the purpose of fulfilling the needs or desires (actual or created) in society (van der Vorst, 1998). Essentially, such a definition considers an engineer to be a technologist, albeit in specialised areas of technology. Van der Vorst (1998) further defined an engineer as a person who deals with "technological systems using them for the best of society" (p. 172). He defined the goals of engineering with the statement "the ultimate aim of engineering is to modify the natural world to further human purposes through the wise application of technical knowledge, skills and judgement" (p. 172).

3.1.2 The modern professional engineer

Modern science and engineering industries are staffed by professionals with high levels of skills, attitudes and personal qualities, and "it is the area of attitudes and values where corporations are making a dramatic shift in their expectations" (Vasilica, 1994, p. 396). A high standard of personal integrity is now expected of any such professional in a position with responsibility where "high standards of personal integrity not only have intrinsically high moral value, but their possession makes a substantial contribution to successful operations in practice" (van der Vorst, 1998, p. 172).

Such a working environment in engineering requires people who are technically qualified, have the ability to make critical judgements, and who can work in challenging environments and working relationships (Stephan, 1999). As Stephan pointed out: "engineering work is now more complex than ever and its ethical, social and cultural effects can no longer be dealt with by a seat-of-the-pants decision-making process that sufficed when engineering systems were simpler" (p. 7). The consequences of a poor decision-making process in engineering can be far-reaching and sometimes catastrophic.

3.1.3 Responsible decision-making

Ilic (2002) is a practising engineering university educator in Australia. He describes the evolution of modern engineering, from an occupation that provided employers and clients with competent technical advice into a profession that serves the community in a socially and environmentally responsible manner. Ilic explained this further:

> There is also an increasing need for engineers to choose technological solutions that are appropriate to their social context and give consideration of the long term impacts of their work, if only because the work of engineers can have wide-ranging effects. Today's technologies can impact on the whole globe and on future generations. Never before has there been such a moral imperative to consider what may have been thought of as unintended consequences in the past. (p. 145)

There are environmental, cultural and social aspects of any engineering decision, which an engineer has a responsibility to consider when making an engineering decision. In respect of this, and also the wise application referred to by van der Vorst (1998), engineers will be required in future to meet societal needs without endangering the Earth's natural systems and resources.

Consequently, values and ethics have now become an area of concern for the field of science and engineering (Davis, 2002).

3.1.4 Ethical behavioural expectations in the engineering industry

The essence of engineering is to improve society and its environment. Modern engineering embraces issues such as sanitation, health, sustenance, transportation, education and defence (Buckeridge, 2001b). The lifestyle of the world's industrialised nations requires a high use of energy. The heavy use of fossil fuels together with the careless disposal of industrial waste products has been such that the environment has gradually deteriorated – a deterioration which is evidenced by the recent increases in water pollution, air pollution, acid rain and global warming (Chandler, 1995; Ilic, 2002; Lim, 2006; Kroll, 2006). For example, IPENZ (2001) state that:

> Although scientific debate continues about whether or not climate change and global warming are occurring, there is general agreement that the concentration of greenhouse gases in the atmosphere is increasing. In particular the concentration of carbon dioxide, a by-product of the combustion of fossil fuels, has increased by about 50 percent since the time of the industrial revolution. (p. 1)

In a similar vein Hinchcliff (1997) and Buckeridge (2001a) stated that wise engineering must, for the good of society and the sustainability of our resources, include a global perspective on issues such as resource limitations, cultural contexts, environmental and social impacts.

3.2 Global changes in attitudes towards engineering

In terms of the social context, engineering decision-making is now expected to consider the safety and welfare of society. In this respect a significant example is the *Titanic* disaster of 1912, which resulted from a series of poor decision-making and operational failures. The world was shocked at the resulting disaster, and some of its unethical aspects, including some of the ship design and construction, were condemned at the time. The enquiries and recriminations resulted in many improvements to operational procedures and the safety of ships on the high seas. However, interestingly, despite Hollywood's continual fascination with this disaster and the innumerable media reports, documentaries, films and books on the subject, the term ethics is not used in most accounts of the tragedy.

The engineering world's attention was again drawn to the need for a formalised engineering code of ethics after the 1986 *Challenger* space shuttle disaster. This incident highlighted the pressure that a professional engineer can face in decision-making and involved the deaths of seven astronauts when *Challenger* exploded just over a minute into the flight (Pritchard, 1992). This explosion arose as a consequence of what is now considered as unethical decisions made by the engineers and management and galvanised the quest by professional engineering societies for the promotion of improved risk management and an effective ethical decision-making process in engineering (Davis, 1991).

In the aftermath to the Challenger disaster, the global engineering fraternity showed a growing awareness of unethical decision-making and promoted ethical decision-making in engineering which included the societal aspects of engineering decision-making (Davis, 1991; Pritchard, 1992; Texas A & M University, 2002).

What is interesting is that some eighty years after the *Titanic* disaster the term ethics was being applied to the engineering decision-making that preceded the *Challenger* disaster. In recent decades publicity has been given to engineering decisions that have had adverse effects on society, resulting in an increasing requirement for engineers to accept accountability for their actions (Dick & Stimpson, 1999; Didier, 2000; McGregor et al., 2002).

Buckeridge (2000) extends this accountability and responsibility "beyond the traditional professional-client relationship to one encompassing society and the environment" (p. 12). Similarly, the wide ranging research of McGregor et al. (2002) refers to several issues:

> Ethical behaviour underpins successful long-term global engineering practice. Ethical sensitivity is central to professional moves towards sustainability. Indeed, ethics is becoming a matter of central importance for engineering practitioners and their organisations. (p. 255)

So, the three main issues that surfaced in this review were society, environment and sustainability. Sustainability is not specifically covered in this thesis, but sustainable decision-making is very much part of our values and ethical decision-making, and it is often referred to.

The growing consensus among engineers and scientists of the societal and environmental issues is reviewed separately, with the environmental aspects of ethical engineering decision-making reviewed first.

3.3 Engineering and the environment

3.3.1 The fragility of our environment

The current awareness of our environmental fragility has seen a refocusing of our value system to include society's obligations to future generations. The work of an engineer is now considered to include social responsibilities to humanity and engineers should consider questions to which there is no clear-cut answer, such as the short-term benefits and the long-term disadvantages of professional decisions (Thring, 1992).

Lim (2006) quoted the German philosopher Buber, who believed the world faces an ongoing environmental crisis through the perceived failure of humanity to relate with and accommodate nature (that which is not constructed by humankind). Buber (cited in Lim, 2006) wrote of this post-industrial revolution crisis in his research on environmental ethics:

> The ongoing environmental crisis … has been characterised by the massive industrial-scale exploitation and the concurrent destruction of natural entities such as individuals, species, and ecosystems. (chapter 1, para. 1)

The approach to environmental ethics outlined in Lim (2006) is that the environmental ethical approach must:

1. Be able to explain how humankind's relationship with nature has degraded to the environmental crisis we face today.
2. Explain how humankind's relationship with nature can be improved to one of respect. (chapter 1, para. 9)

Another important ethical challenge facing technological civilisation is excessive consumption in the affluent nations. The research of Swearengen and Woodhouse (2002) showed that the average consumer in the USA "directly or indirectly is using an average of 125 pounds of material every day or about 23 tons per year" (p. 15).

An early example of the awareness of the Earth's fragility was the book *Silent Spring* by Carson (1962). According to Kroll (2006) the title was meant to describe a spring season of the future in which no bird song would be heard, because they had all vanished through the pesticide abuse at the time. Carson wrote that DDT had been found to cause thinner egg shells which had resulted in reproductive problems and death. The final paragraph of the book sums up Carson's criticism of materialism, scientism, and the technologically engineered control of nature at the time (emphasis added):

> The *control of nature* is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man … . It is our alarming misfortune that so primitive a science has armed itself with the most modern and terrible weapons, and that in turning them against the insects it has also turned them against the earth. (p. 297)

Carson's accusations included the spreading of disinformation by the chemical industry and the uncritical acceptance of such claims by public officials. Carson drew world attention to society's obligations to future generations with her documentation of the detrimental effects of pesticides on the environment, particularly on birds, and she ignited the first great wave of concern over our planet's deteriorating environment. Carson's accusations were followed by coordinated and vicious attacks on her, launched by chemical manufacturers and their allies after she exposed what was in her view the flagrant abuse of pesticides (Seideman, 2007). These attacks on her opinions by scientists and chemical manufacturers in America were such that President John F Kennedy asked the USA Science Advisory Committee to investigate Carson's claims. Their investigation vindicated Carson's accusations, and this resulted in a revision and strengthening of regulations on the use of chemical pesticides in the United States (Kroll, 2006).

Carson died in 1964, and although DDT was banned in the 1970's as a direct result of her research, she receives criticism to this day for creating a climate of fear and hysteria about DDT, as some believe that DDT would have saved the lives of thousands of malaria sufferers through the possible eradication of mosquitoes (Seideman, 2007). However, her courage to speak out has left an indelible mark on the scientific community and Kroll (2006) was to pay her a tribute for being the prime mover of modern scientific accountability:

> So if the ecological revolution never materialised in the way that Carson had hoped, what was her legacy to the history of science and society? Over the past thirty years green philosophies like eco-feminism, social ecology, and deep ecology have illustrated increasingly sophisticated systems of thought that attempt to reconfigure the relationships between humans, environment, and the role of science and technology in mediating the human-nature dialectic. The growth of sociology and ethics programs that scrutinise science, technology, and society is especially impressive. While it is doubtful that scientific authorities ever had free reign to do whatever they wished, today they are held to a high degree of accountability. The press actively keeps the public wary with news of genetically engineered organisms, terminator seed manipulations, irradiated food, and new pesticides. While we might question the efficacy of such initiatives in creating real and widespread changes in values, we have come a long way in questioning the epistemic sovereignty of science. Carson was not the first to do this; but she was among the first to bring the debate into the public sphere. (para. 9)

Following Carson's concerns on the damage done to the environment by pesticides, scientific concern for the environment adopted a wider perspective when, in April 1970, the Santa Clara Declaration appeared in the periodical *Technology and Culture.* It reported how a group of engineers and scientists attending the National Science Foundation Conference on Engineering and the Technological Society at the University of Santa Clara, California, expressed concern over the harmful impact of technology on environments, culture and values (Thring, 1992). In 1970, Abelson (1970), in an editorial in the journal *Science*, stated (bracket added):

> One important function [of science] is that of watchdog. In exploiting scientific discoveries humanity will squander resources and unwittingly conduct profoundly important experiments on it and on the environment … thus, academic scientists and the scientific societies have responsibilities that they cannot escape. (p. 241)

The Santa Clara Declaration signalled an awakening of opinion amongst scientists and engineers that they could not divorce themselves from the social, environmental and sustainability aspects of their work (Abelson, 1970). The work of Carson, Abelson and Thring shows that this concern has been gathering momentum for several decades. Further early campaigns on ethics can be found in work by writers such as Guy (1985), and while Abelson talked of scientists having such a responsibility, Thring (1992) included engineering in these responsibilities. He did not differentiate between a scientist and engineer, and used the word *engineer* to represent an all-encompassing group including "all applied scientists, architects and technologists who apply the experimental and theoretical knowledge of science to the solution of practical human problems by the development of hardware ranging from a drug to an aeroplane" (p. 222).

Thring (1992) maintained that even if the pure scientist is disconnected from societal applications of this work, "it is becoming increasingly difficult for any branch of pure science to be separated from its practical consequences for humanity" (p. 222). He pointed out that the work of an engineer affects all aspects of human life, particularly its:

> bi-products and side effects, such as noise and pollution; effects on the destruction of the environment and wild life; effects on future generations – particularly in using up scarce resources so that they are not available in the next century. (p. 224)

Nearly two decades later, these concerns are even more salient when it is widely thought that 80% of the world's resources are being consumed by 20% of the world's population. It is believed that 30% of world's population suffer from poor sanitation, malnutrition and air pollution, and these remain major causes of illness and death (Buckeridge, 2000).

As a result, by the 1990's there was a growing movement (and demand) for change, with some critics clearly laying some of the social responsibility on university educators, who should, they argued, examine, question and attempt to institute ethical and sustainability education for engineering students (Buckeridge, 2000; Davis, 1999; Herkert, 1997; Singleton, 1991).

3.3.2 The engineering relationship with the environment

To become professionally responsible citizens, engineers must understand that the technical excellence involved in building a structure, chemical or device should not compromise society. The work of an engineer can have an effect on all aspects of society. The destruction of wildlife, pollution of the atmosphere, the effects of harmful by-products, and the effect on future generations – particularly where valuable resources are being used at an unsustainable rate by the current generation (Buckeridge, 2001b; Ilic, 2002; Thring, 1992) – must be considered. Engineers in the past have been criticised for their failure to consider the long-term impacts of their work and to show sufficient responsibility for the social consequences of technology. There is now a global opinion that engineers must choose technological solutions that are appropriate to their social context. They must consider the impact of technology on environments, culture and values, and take professional responsibility for designing and managing clean technology (Thring, 1992; van der Vorst, 1998).

But, where does the engineer fit in society? We have scientists, engineers and technologists: what are the differences between them?

3.3.3 Scientists, engineers and technologists

There can be some confusion between the terms scientist, engineer and technologist. As I have previously stated, Thring (1992) used the word engineer quite loosely and in an all-encompassing way when referring to technology. Reviewing the modernist era, the *Concise Oxford Dictionary* (1964) stated that scientists accumulate knowledge and general principles "based mainly on observation, experiment and induction" (p. 1128), whereas the work of an engineer is to "design, construct, manage, arrange, contrive, bring about" (p. 402). It appears the difference was generalised as follows: scientists study and discover whilst engineers use this scientific knowledge to design and build. This could be viewed as a broad simplification, as there are engineers who discover new materials, procedures and principles and scientists who design and build. Collins (1986) defines a scientist as "a person who studies or practises any of the sciences or who uses scientific methods" (p. 1032) and an engineer as "a person trained in any branch of engineering" (p. 368). In my view the later Collins definition of a scientist could easily be applied to an engineer.

So where does the technologist fit in? According to IPENZ (2002) a technologist is a specialist who is trained to perform work in a field of technology. This means that the term technologist suggests a description of some aspects of technical work by anybody, from a professionally educated engineer to a trained technician, a science technician, or even a skilled worker. Herschbach (1995) wrote (emphasis added):

> The term *technology* acquired limited use in the 19th century as a way to refer to the application of science (knowledge) to the making and use of artifacts. In our century, formal knowledge is inextricably linked with the development of science and technology. More recent scholars emphasise the importance of knowledge in defining technology. (p. 90)

The term *professional engineer* is defined by the Washington Accord as a person who has a four-year engineering degree (BE) with appropriate work experience, whereas the Sydney Accord defines an engineering technologist as one who has a three-year engineering degree (BEngTech) with appropriate work experience (IPENZ, 2002). However, I interpret from Herschbach (1995) that both be generally regarded as *technologists*, although the professional engineers might be reluctant to identify themselves as such, because a professional engineer with a BE has a much greater engineering capability than an engineering technologist with a lower-level BEngTech.

3.4 Technology and society

3.4.1 Technology

Technology is the human process of applying resources to fulfil human needs to survive, and subsequently the process of solving problems and extending our capabilities to satisfy our wants and needs (Chandler, 1995). Chandler maintains that the term technology is variously used to “refer to tools, instruments, machines, organisations, media, methods, techniques and systems” (p. 1). Ellul (1964) defined technology by adopting the broad umbrella of *technique* by which he referred to “the totality of methods rationally arrived at and having absolute efficiency … in every field of human activity” (p. 5).

Bush (1983) related technology to activity with this definition: “technology refers to the organised systems of interactions that utilise tools and involve techniques for the performance of tasks and the accomplishment of objectives” (p. 155). Bush includes in her definition of technology “all the norms, values, myths, aspirations, laws, and interactions of the society of which the tool or technique is part” (p. 157).

Adams (1993) explained that the ancient Greek attitude to the activities associated with technology was that they were considered the work of slaves and foreigners, while the “citizens involved themselves with the more disembodied mental activities” (p. 12). Adams observes that even though technology has changed radically through the centuries, this attitude seems to have been passed down through western intellectual tradition, to continue this influence on our modern society up until the last century. Now, “Technology has come to represent our dream of progress” (Daugherty, 2003, p. 33) and is no longer the exclusive skills-based domain of the artisan.

It is also said that we have moved from a *skills-based society* (e.g. in ancient Greece where the technical work was done by slaves), to a *knowledge-based society*, where intellectual learning is a greater part of any technological endeavour (Blakey, 2002). It is said that that we are now immersed in an *information revolution*, sometimes referred to as the *knowledge wave* or *knowledge society* (Blakey, 2002; Ministry of Education, 1995). As the knowledge-based complexity of technology increases at an exponential rate, so have the education structures needed to support it, such that most universities have moved away from the original exclusively intellectual concept of a university.

3.4.2 The evolution of technology and society

As our needs change, new technologies replace old ones, which in turn change the culture behind the technology. As technology changes, so does the culture of society (Cowan, 1997). Cultural evolution is the progression of human lifestyle and customs as culture adapts itself to new technologies. This cultural evolution of lifestyle and customs as our culture adapts itself to new technologies has pushed engineering to a position of greater prominence than ever before**.** In fact, the socio-cultural pressures of the development of technology often depend on the economic, political, ideological and social interests of a nation, and may have a direct effect on the rate of technology development (Daugherty, 2003).

Technology and society have historically fuelled each other, and McGinn (1978) credited the cold war “with affecting the increased funds into research into energy and automative technologies, and the international politics on weapons technology” (p. 188). In this respect, the development of aerospace technology during this time could have been justified by the claims of ideological superiority, and that the fear of losing prestige had direct effects on both protagonists in the so-called space race.

In terms of wants and necessities, while technology gives society cause for change, "the acceptance by a society or culture can shape new designs, or continue the momentum of existing designs" (Staudenmaier, 1989, p. 158). In effect, if society does not accept a new artefact into its culture, then that piece of technology will not succeed (examples are the satellite telephone and the Ford Edsel). Alternatively, a technology adopted by society can unexpectedly change our lives dramatically (Staudenmaier, 1989). A more recent example than 1989 is the advent of cell phones and the Internet. Advances in technology can also give society new moral problems; a current example is the problem amongst young people concerning text bullying. Another example, on a recent national scale, is how the improvements in surveillance and detection have reduced the illegal importation of heroin and cocaine; as a consequence, however, there has been an increase in both the importation and the local manufacturing of methamphetamine, which is harder to detect.

Technology traditionally provided solutions for survival by creating more efficient ways to get food and energy, and it has given humans a certain amount of mastery over resources and sources of energy. Technology has enabled us to have fewer people involved in food production, which in turn enables a larger part of the population to work on other areas of technology (Iacocca, 1985). Iacocca pointed out that not all redundancies of older technologies result in re-employment in the new technologies, and Toffler (1970) questioned the wisdom of these new technologies, in that the ideology of growth is essentially backwards thinking if we use more of what we have less of (natural capital) to use less of what we have more of (people).

As technology improves our quality of life, the threshold between survival and comfort becomes unclear, and in some of the affluent economies the human focus on technology has moved from survival to fulfilling luxurious wants. Furthermore, Taylor (1995) questions the wisdom of engineering decisions in terms of equality or our needs and luxurious wants, that is, decisions that give further choice to those who already have an abundance of choices, whilst further denying choice to those who have limited choices or none. Taylor suggests that our professional responsibility should also include "ethical behaviour, equality of opportunity and ecological sustainability" (p. 4).

3.4.3 Engineering and technology

The introduction of technology has sometimes been disastrous on our environment, and the sense that technology may be out of control is influenced by the way in which technical developments can lead to unforeseen side-effects (Chandler, 1995). Consequently, in recent decades engineers and academics have argued that many applications of engineering have ethical implications of varying degrees and it is important that engineers recognise the larger ethical context of their work (Davis, 1999; Ilic, 2002; Kline, 2001; McGregor et al., 2002; Nichols, 1999; Soudek, 1999; Stephan, 1999).

These mounting global concerns for engineering standards and engineering ethics imply the need for guidelines that set and maintain the standards expected of engineering practice and cover an engineer's obligation to the profession, society, and clients. Kiepas (1997) held the view that ethical considerations should regulate the applications of technology. Such changing attitudes and concerns of society to problems caused by technology have created new expectations of the engineering profession and a new role of responsibility with respect to their relationship with technology. Naturally there have been mistakes in the past and Buckeridge (2001a) was almost apologetic as he stated:

> There may well have been engineers who have behaved unethically, but engineers are none-the-less human, and err as such. The very nature of engineering ensures that it will attract individuals who wish to improve the lot of humanity, not degrade it. (p. 3)

However, the traditional commercial imperative that seeks to shorten the time between discovery and profit has brought about a less idealistic relationship between engineering and society, who pays for the final product. Unfortunately, in a commercial or industrial environment, accountability to the management usually outweighs the moral convictions of accountability to society and the consumers (Randerson, 1991). Similarly, there can sometimes be a commercial competitive fear that “we will miss the wagon of progress if we hesitate to think about the difficult questions” (Kedgley, 2000, p. 1).

My interpretation of this comment is that ultimately scientists and engineers fear for their jobs – an egoistic concern for self-preservation. (Kedgley, 2000) referred to science when expressing her concern that:

> Many scientists are unwilling to voice these concerns, for fear that they will lose their research, or their jobs, or both. In the present climate, to make a stand is to take a great personal risk, which is why those scientists who speak out about genetic engineering tend to be people whose jobs are not on the line. (p. 1)

Technology influences society and, in turn, society influences technology. They fuel each other and Basalla (1988) observed that the selecting agents who determine whether a technology is accepted by society could be influenced by economic and military requirements and restraints, as well as by social and cultural forces.

Daugherty (2003) wrote of this relationship that:

> Technology is a driving force in society. It can be viewed as an oddity, feared and given unrealistic assumptions of power by the uninitiated, but in the end, it is a powerful force. Social institutions, values and cultures are forever altered as a result of the introduction of technology. On the other hand, society is the impetus for almost all new technological developments and adaptations. In that capacity, society is the driving force behind technological development. Without human demands for new technological products and systems that make life easier, technology would never have been granted that power. (p. 32)

In terms of security and control, technology and society are inexplicably enmeshed to such an extent that Mitcham (1994b) stated "if power or the ability to act increases, then so must intelligent control" (p. 260). At times we must make choices and Winner (1990) sees this as part of our ethical responsibility in this relationship between technology and society:

> Ethical responsibility … involves more than leading a decent honest, truthful life … and it involves something much more than making wise choices when such choices suddenly, unexpectedly present themselves. Our moral obligations must … include a willingness to engage others in the difficult work of defining what the crucial choices are that confront technological society. (p. 62)

3.4.4 Assuming responsibility

There are now suggestions that technology has become *autonomous*, meaning that technology changes in accordance with its own needs rather than the needs, desires, or wants of society. Asimov (1981) wrote "the whole trend of technology has been to devise machines that are less and less under direct control and more and more seem to have a will of their own" (p. 130).

Adams (1993) states: "we also have technology to thank for an unprecedented ability to exploit others and destroy ourselves" (p. 1), and as technology increasingly influences our lives and the way we live there are times when we must consider its effects on our lives and our planet, and ask who has the responsibility to control it. As new technological artefacts and practices become part of our daily life, the effect of technology on our society is such that strict controls are required and, regardless of how technology is used, society must be its conscience.

Technology and society have a fragile relationship and it is easy for a technologist to argue that technology is neutral and follow neutrality theorists who absolve themselves from responsibility for this relationship. Neutralists argue that irrespective of whether the technologist has designed an artefact with good or evil intent, it is how society chooses to use technology that determines and varies its intent (Ellul, 1964). For example, the technologist makes a knife for the purpose of catering, but is detached from any responsibility when it is used in a homicide. The neutral position is to argue that it is up to society how they use technology.

Alternatively, the non-neutral argument may be illustrated by a nuclear bomb that has only one purpose – a neutralist might counter-argue that it was built as a deterrent. Jacques Ellul (1964) was a prominent non-neutral theorist who locates the responsibility for the effect on our society and environment by the indiscriminate use of technology directly with the technologists. He argues that technological tools are human tools, and while undoubtedly they are used by some against the will of others, they also shape and design the way we live. He challenges the technologists, stating "technique has become autonomous; it has fashioned an omnivorous world which obeys its own laws and which has renounced all tradition" (p. 14).

Ellul (1990) later stated that "technical development is neither good, bad nor neutral" (p. 35). Instead Ellul argued that its resulting positive and negative consequences shape our lives and environment: "we become conditioned by our technological systems or environments" (p. 37). Singleton (1991) signalled his alarm at this suggestion and argued that it is our responsibility to control technology, “as society becomes increasingly dependent on technology, it is more and more incumbent on the masters of technology to assume the responsibility for protecting the public from technology gone awry” (p. 145).

The advancement of technology is not always deemed to be progress, and any given use of tools, techniques or technology can have both beneficial and detrimental effects at the same time. There are examples like the Chernobyl nuclear power station disaster, when the consequences of technology can be catastrophically beyond the community’s control, and any society input is sought only with hindsight. In this respect society is gradually changing its views, realising that it must strive to control and influence technology with foresight, and that often it is necessary for governments to embody responses to existing technology in its laws.

3.4.5 An example of the social responsibilities of engineering

In Auckland, New Zealand, a local example of the lack of consideration of the effect of engineering on society was the Orakei sewerage pipeline which shut off the Orakei Basin's access to the Auckland Harbour in 1914. This in turn denied access to fishing grounds of the local Māori residents as the harbour aspect was lost, along with ready access for their fishing craft. In addition, the drainage was insufficient and in heavy rain the surrounding land turned into a swampy quagmire with associated pollution of shell beds (Waitangi Tribunal, 2007). One could argue that the engineers of the time were considering society in their planning by minimising the cost to the ratepayers of the time. Now they would have to consider the impact on all of society, and in recent years we have seen engineering move from ill-planned structures such as the Orakei Basin sewerage pipeline, to a global concern for improved technological solutions, which includes the emergence of ethical concern (Ilic, 2002).

3.5 Control of technology

There is a delicate relationship between society and technology in which technology can have consequences. These consequences are not necessarily identical to the original means or intent of that technology. Bush (1983) recommended that societal consideration of either the introduction or the adoption of a new technology must consider "the ecological impact of accepting the technology versus the impact of continuing current techniques" (p. 165).

Such is the impact of technology on our environment that New Zealand now has waste management procedures; water authorities; pollution acts; land, sea and air traffic planning and controls; and resource management acts to maintain some control over technology.

As a consequence of the scientific and social concerns about the impact of technology, there have been attempts to control technology for the good of our planet and its inhabitants. Recent attempts include the Kyoto Protocol, and here in New Zealand, the Resource Management Act.

The Kyoto Protocol – named after the Japanese city where it was drafted in 1997 – is an international agreement to address issues related to global warming and further climate change. Over 180 nations have agreed to the pact in an attempt to cut emissions of gases blamed for global warming. The aim is to address the challenges of climate change, energy security and air pollution without limiting economic development. The Kyoto Protocol sets legally binding targets and timetables for cutting the greenhouse gas emissions of industrialised countries (Ministry for the Environment, 2005).

In New Zealand, the Resource Management Act came into force on 1st October 1991 to promote the sustainable management of natural and physical resources. This act requires all people who use and develop natural resources to do so in a sustainable way to mitigate or avoid any adverse environmental effects of such activity (Ministry for the Environment, 1991).

Another recently developing area of ethical concern in controlling the impact of technology is in the field of engineering robotics, where it is now widely accepted that when these devices reach their full potential, robots may in future be mass marketed for assistive capabilities to humans in a wide range of applications. This has precipitated an investigation into the standardisation of robots by the International Standards Organisation (Dogramadzi, Virk & Harper, 2010). Dogramadzi et al. (2010) explain the current concern as to whether they should be encouraged or not (bracket added):

> This has started an ethical debate on what should be encouraged and if there are robot applications that should be discouraged. It is accepted that robot applications that genetically improve the quality of life for humans should be encouraged but areas which promote unethical areas of human activities should be looked at more closely to determine if robots should be allowed to enter these sectors or not; this includes applications such as military applications, sex robots, fully autonomous robots, etc. In view of these developments, discussions have commenced within ISO [International Standards Organisation] so that internationally accepted views can be formulated and accepted. (Abstract)

3.6 Engineering codes of ethics

An improvement in engineering behaviour emerged with the establishment of engineering professional associations early in the twentieth century. Members of the profession organised themselves into professional associations and adopted codes of ethics relevant to the profession. Most professional societies have codes of ethics and these codes formalise the expectations of the professional in decision-making (Coates, 2000). Unger (1994) justified this establishment:

> Engineers, particularly those who are employees, sometimes find out that doing the wrong thing may result in career damage. This can lead to behaviour detrimental to society. Mechanisms for helping ethical engineers in such situations can be based on professional engineering societies, on improvements in our legal system, and on the adoption of procedures within employing organisations for dealing with controversy. (p. 13)

This move towards ethical guidance within the profession was a gradual process which is now briefly reviewed.

3.6.1 Early codes of ethics

Many cultures have developed codes of behaviour and an early example of such a code is the Old Testament's Ten Commandments. Professional codes of ethics or codes of professional conduct have evolved in various formats ever since the original Hippocratic Oath was laid down for physicians in the fifth century BC. The Hippocratic Oath was a code of conduct for a high level of professional honour, responsibility to the patient, and respect for the patient's private life (Haden-Guest, 1951).

While the medical and the engineering professions have codes of ethics, such codes are differentially binding. Doctors are required to take a modern version of the previously mentioned Hippocratic Oath (personal conversation, Dr Phillip Polkinghorne, 29th January 2008), but engineers are not bound by such a formal oath (IPENZ, 2005). Concerning this latter aspect, Thring (1992) maintained "we need a Hippocratic Oath for all engineers and applied scientists which will refer to their responsibilities for all the consequences of their work" (p. 224).

In the last century various professions regulated their own affairs with various amounts of public scrutiny (Coates, 2000). Perlman and Varma (2002) traced engineering codes of ethics back to the USA-based Institute of Electrical and Electronic Engineers, a professional organisation which prepared a code of ethics soon after its foundation in 1912, coincidentally (or not) the year of the *Titanic* disaster.

According to Perlman and Varma this code of ethics was to stress gentlemanly conduct rather than concern for the public welfare: "traditionally the engineer was to be honest, impartial, avoid conflict of interest, not criticise a fellow professional, and not compete for commissions on the basis of price" (p. 41).

This appears to be concerned with the self-preservation of the professional group or company as a whole, and Mitcham (1994a) believes that what is missing from early codes is reference to the altruistic idea that engineers should have a responsibility for public health, safety, and welfare of society. Herkert (2001) disagreed, and dismissed Mitcham's claims as a popular myth. Herkert surmised that the use of the phrase "avoiding conflict of interest" (p. 10) is consistent with, and may be interpreted as serving the public interest. Coates (2000) agreed with Mitcham, stating ethics was often viewed by the public as:

> A matter of etiquette as well as a code of professional conduct. However, beginning in the 60s and 70s there was a move to codify professional behaviour and expand its scope and to eliminate the paternalistic views of the public … this process of social transformation has probably been more pronounced in the engineering profession than any other. (p. 11)

The pressures and responsibilities on a modern engineer require a knowledge of ethics in terms of value judgements where the decisions of practising engineers may not always be the same (Frazer & Kornhauser, 1986). Decision-making policy may vary from one company to another by way of company policy, or by individual attitude. Quite often different views and opinions contrast idealism and realism (Frazer & Kornhauser, 1986), and in industry and commerce compromises and tradeoffs between the two are often made (Randerson, 2002).

3.6.2 Modern codes of ethics

The recent shift in emphasis in codes of ethics reflects a movement from the original concept of gentlemanly behaviour and company loyalty to the realisation that engineering decision-making affects the Earth's inhabitants, the environment and the sustainability of the Earth's resources (Herkert, 2001). Modern codes of ethics have now moved their focus to include these issues and to "emphasise the public interest as a criterion for professional responsibility" (Coates, 2000, p. 11).

It is probably impossible to unite all ethical theories and beliefs into a single coherent theory that will be accepted by everybody, such as the Hippocratic Oath (Texas A & M University, 2002), and in practice a decision may suit some people, but not all. Consequently, to ensure that decision-making is in the best interests of the public that professionals serve, judgements based on values need guidelines for good decision-making and professional organisations lay down these descriptive guidelines in *codes of ethics*. These codes of ethics are not always perfect or free from self-interest, but the objective is to define strategies that best serve every person's wishes to achieve and be an accepted member of society (International Statistical Institute, 1985).

Davis (2001) has the view that a code of ethics is not a set of laws inscribed with divine wisdom in a stone tablet to be obeyed by all. A professional code of engineering ethics is a set of rules that is supposed to win the support of engineers. No law binds engineers to abide by the code of ethics of their professional organisation, such as the legally binding expectation of professional conduct in the practice of law (Davis, 1991). Nor do the obligations of an engineer rest on anything tangible such as a promise, vow or oath. The convention between professionals is not a contract, and Davis (2002) saw it more as (emphasis added):

> What lawyers call a *quasi-contract* or a *contract implied in law*: that is, an obligation resting not on an actual agreement (whether express or tacit) but on what is fair to require of someone given what he has voluntarily done, such as the benefits that go with claiming to be an engineer. (p. 4)

However, in terms of responsibility, it is common practice that whenever a party, including an engineer, enters into a contract, the legal responsibility appears in any contract signed, and his or her rights and responsibilities are defined with reference to the language of the contract (Davis, 2001).

As such, modern codes of ethics provide us with a *guide*, rather than hard-and-fast rules on what to do. Luegenbiehl, (1991, cited in Davis, 2001) complains that “there are no rules at all … the guides provide almost no guidance. All they do is remind engineers to look for some things” (p. 12). Such an interpretation (made back in 1991) would make a code of ethics a matter for one’s private conscience. Despite the claims of Davis and Luegenbiehl, engineers currently practising in New Zealand could find themselves deregistered from IPENZ if they followed such an outmoded doctrine.

Nevertheless, some engineers would rather not take the risk and responsibility of becoming a member. The codes have been rewritten and modern engineering codes of ethics give precedence to public health, safety and welfare; when a conflict of interest arises, the decision-maker is to interpret the rules so that “the conflict disappears” (Davis, 2001, p. 14).

To be a useful guide to the profession’s members, Davis (2001) suggests that the codes should not be so complex that they are difficult to interpret; they require a clear set of priorities. But clear priorities also have costs, including rigidity and complexity. In terms of rigidity, Davis uses the United States Army, where the decision-making rules are usually quite clear, as an example. But the complexity issue is difficult, and to write a code of engineering ethics with enough detail to cover every eventuality in a decision-making process would result in a lengthy and complex document.

Consequently, even long codes of ethics are relatively short compared with legal documents, which attempt to cover every possibility that may arise. Instead, a code of ethics deliberately tries to remove the influence of context by providing broad, generic and widely applicable guiding principles for professional behaviour or practice, regardless of the context of the particular issue facing the decision-maker (Davis, 2001).

3.7 Institute of Professional Engineers New Zealand

In New Zealand the formal body for professional engineering is IPENZ. IPENZ (2002) maintains that the respect which New Zealand society accords the engineering and technology professions in this country must be earned and maintained by its members through the constant demonstration of a strong and consistent commitment to ethical values. They provide the profession with guidance of these expectations in the form of a code of ethics (IPENZ, 2005).

The IPENZ Code of Ethics was first written in 1964 and at the time tended to be self-protective and inward looking. On reflection, critics argue that "it was organised to shield the professions from outsiders' view; rather than to advocate professional responsibility to clients or society" (Coates, 2000, p. 11). In 1996 the code was refocused with the removal of gender-specific language, and the addition of the clause "in all their work (professional engineers) shall recognise their responsibility to the public interest as paramount" (IPENZ, 2005, para. 3). Thus the economic benefit of engineering is not the sole criteria for good decision-making; the code requires engineers to use resources sparingly and wisely, minimise environmental impacts and give due consideration to the social impact of these decisions (Coates, 2000; IPENZ, 2005). IPENZ later reinforced this stance as a founding signatory of the Washington and Sydney Accords (see chapter 4, p. 67).

This code is believed by IPENZ to be appropriate and responsive to the changing expectations of both society and the engineering profession and the global standards to which the Institution subscribes. IPENZ states that they enforce the code of ethics impartially. The IPENZ Code of Ethics gives clear guidance in terms of the expectations of the professional conduct of its members (Coates, 2000).

In my view the values (or canons) in the IPENZ Code of Ethics of key interest for an engineering ethics paper are:

> **1. Protection of life and safeguarding people:**
>
> Members have a duty of care to protect life and to safeguard people.
>
> **2. Society and community well-being:**
>
> Members shall actively contribute to the well-being of society and, when involved in any engineering project or application of technology, shall, where appropriate, recognise the need to identify, inform and consult affected parties.
>
> **3. Sustainable management and care of the environment:**
>
> Members shall be committed to the need for sustainable management of the planet's resources and seek to minimise adverse environmental impacts of their engineering works or applications of technology for both present and future generations. (IPENZ, 2005, para. 3)

Vesilind and Rooke (2001) maintain that with "the use of the word *shall* in the IPENZ canon, the item is enforceable by IPENZ" (p. 162).

Having reviewed some of the global concerns regarding ethics, I now consider the literature in the field of education concerned with teaching for an understanding of ethics in engineering; this is the basis of chapter 4.

CHAPTER 4
Literature Review:
Ethics in Engineering Education

4.1 Introduction

The literature review in chapter 3 showed that in the latter part of the twentieth century engineers and scientists in some countries became concerned with the growing threat to our environment. It also surveyed the growing global body of opinion that engineers must take responsibility for the quality of modern-day engineering, and that they must not divorce themselves from the social, environmental and sustainability aspects of their work.

These views of engineering have placed demands on university engineering education, where science and engineering knowledge was once considered to be completely objective and absolute (Crotty, 1998; Gutek, 2004; McGinn, 1978). Hinchcliff (1997) studied philosophy at the University of Canterbury, New Zealand, in the late 1950s and commented with hindsight that during the time of his studies "it was argued that education should teach only definitive answers to tangible problems, using scientific methods. Ethics had a poor image" (p. 229). Buckeridge (2001b) agreed, claiming that the expansion of knowledge has resulted in a reduced focus on the environmental issues in university education. Buckeridge claimed that at that time environmental education and the associated ethical issues were not always taught in New Zealand universities, and he stressed the importance of such education. He explained the problem at that time:

> In the second half of the twentieth century, increasing technological demands within science and engineering degrees

> have somewhat marginalised ethics and other liberal arts subjects. They became targets for deletion from technologically oriented curricula and have suffered accordingly in many programmes. Today's business, ecological and social environments however require much more from scientists and engineers than previously, although many curricula now pay little more than lip service to issues ethical. (p. 57)

Positivist attitudes are being surpassed by a variety of critical developments to the point where professional attitudes are moving towards *post-positivist* or *postmodern* thinking (Crotty, 1998; Gutek, 2004; Kuhn, 1996; McGinn, 1978). In the last fifteen to twenty years there has been a growing western world expectation that educational institutions should prepare people for the ethical decision-making that will be encountered when developing and applying modern technology in practice. Swearengen and Woodhouse (2002) believe that "schools of engineering arguably have a special obligation in this regard, as do professional organisations of engineers" (p. 30) and an understanding is considered important for any practising or prospective scientist or engineer. The consensus emerging here is that the ethical and technical aspects should both be regarded as essential in education; and, if one considers that ethical values can determine a course of events, then ethics should be regarded as an essential part of a science or engineering curriculum.

Hinchcliff (1997) commented that fortunately in educational institutions the pendulum has recently swung in favour of ethics and there is also a growing demand world-wide for a set of principles to which members of a profession can be held accountable. Hence Hinchcliff argued that ethics should be taught in universities, the crucial reason being "that it challenges students to gain the ability to respond in a disciplined, rigorous and sensitive way to the various crises and ethical challenges that they may encounter in their profession" (p. 233).

There is now a requirement in most western countries, and in New Zealand by IPENZ, that educational engineering programmes must include a consideration of the societal, environmental and sustainability aspects of engineering (Davis, 1999; Dick & Stimpson, 1999; Didier, 2000; Keirl, 2003; McGregor et al., 2002). These embrace problem-framing and problem-solving in ways that reduce the risk to the planet and society of predictable environmental, social and economic failure (Davis, 2002). Mehlinger (1986) considered this growing requirement for accountability important to all students, and he stressed the importance of communicating issues of responsibility and ethics to school and university students as part of an important life-long education. He gave three reasons for this:

> 1. So many decisions, which have to be made today, whether in developing or developed countries, involve some aspects of science and technology. All these decisions in some way effect people, and most of the decisions involve making judgements balancing positive (socially desirable) and negative (socially undesirable) effects.
> 2. Public opinion is a powerful force. If the general population has knowledge and understanding of the social ethical issues of science and technology, then it can much better be involved in decision-making.
> 3. There is a real danger of society becoming divided into a minority having some knowledge and understanding of science and its social issues, and the majority who feels that science is too difficult to understand. (p. 32)

4.2 Interest in ethics education in New Zealand

While some courses on ethics had been established in university engineering schools in the 1990's, they were irregular, and experimental (Hinchcliff, 1997). Furthermore, these ideas were not always received well by university staff and their integration into engineering curricula at that time generally remained poor (Deans, 1999).

Davis (1999) has pursued a long crusade in the USA promoting engineering ethics, and has been an avid campaigner for the education of engineers in the consideration of environmental, cultural and social aspects of decision-making. He considered the events of the space shuttle *Challenger* disaster in terms of the Institute of Electrical and Electronic Engineers Code of Ethics and revealed that this code was not widely implemented in the engineering workplace. It was further noted that, although the total quality management movement had helped by creating a corporate atmosphere of openness, it was up to the engineering schools to empower their graduates with the skills and the determination to live up to the Institute of Electrical and Electronic Engineers Code of Ethics. Singleton (1991) suggested that proposals for engineering ethics education should include:

1. Establishing an engineering oath modelled on the Hippocratic Oath.
2. Increasing requirements for courses in ethical engineering and effective communications, and provide on-the-job training for practising engineers. (p. 145)

The Davis (1999) campaign for engineering ethics education in USA universities aimed to achieve four outcomes:

1. Increased ethical sensitivity.
2. Increased knowledge of relevant standards of conduct.
3. Improved ethical judgement.
4. Improved ethical willpower, that is, a greater ability to act ethically when one wants to. (p. 1)

Herkert (1997) placed the responsibility for ethics education with the universities, stressing its importance as a part of the engineering curricula to bridge the gap between technology and society. Herkert pointed out that this should "include the ethical implications of public policy issues of relevance to engineering, like risk, product liability, sustainable development, globalisation, health care and information technology" (p. 175).

Herkert (2001) showed that there had been an increasing amount of interest in engineering ethics over the latter part of the twentieth century with regard to the scope and magnitude of the social implications of engineering technology and the ethical responsibility of engineers. These early views of ethics contributed to a wider body of opinion (Weil, 2000; Zandvoort, De Poel, & Brumsen, 2000) and over the last two decades engineering ethics has been developed into an established interdisciplinary academic field in many English-speaking countries. Early efforts at inclusion were voluntary but there has been an awakening of opinion (Davis, 1999; Dick & Stimpson, 1999; Didier, 2000; Keirl, 2003; McGregor et al., 2002; Stephan, 2001). According to Stephan (2001):

> In the engineering world of the future, a sound understanding of the theoretical and practical side of engineering ethics will be necessary to the proper education of engineers as a knowledge of differential equations is today, if not more so. While there may have been reasons to neglect engineering ethics or treat it superficially in the past, those reasons are no longer valid. (p. 7)

4.3 Engineering ethics: four case-studies

The following four case-studies were reviewed in 2005 and influenced the design of this ethics curriculum. The purpose of these reviews is to investigate and learn from fellow university practitioners and the experimentation and of work many university academics like me from the USA, Canada, Australia and New Zealand are noted. They are presented to illustrate how ethics in engineering was approached at that time.

4.3.1 The United States of America

The call for the introduction of ethics in university engineering curricula was initially manifested in the USA, and later in other countries, to ensure that due attention was paid to the ethical aspects of engineering and technology (Zandvoort et al., 2000).

Zandvoort et al. (2000) noted the rising tide of opinion:

> In recent years political and advisory bodies in several countries have stimulated the engineering schools to incorporate ethical issues into their curricula. During the 1999 Annual SEFI Conference held in Zurich, there was hardly a single keynote speaker who did not, at least in passing, stress that engineering curricula should pay attention to the ethical aspects of technology and the engineering profession. (p. 291)

In 1995, the Accreditation Board for Engineering and Technology (ABET) in the USA related to the Washington Accord with the proposed new criteria in the form of the Engineering Criteria, 2000 (EC-2000) for engineering education. The proposal concerned engineering education outcomes, complete with a minimum set of 11 student learning outcomes to assure that engineering students in the USA receive a quality education that would enable them to make important contributions as professionals and citizens. Their recommendations comprised a set of five *hard skills* incorporating the engineering skills including (Shuman, Besterfield-Sacre, Wolfe, Atman, McCourtney, Miller, & Rogers, 2000):

1. An ability to apply knowledge of mathematics, science and engineering.
2. The ability to design, and conduct experiments, as well as to analyse and interpret data.
3. The ability to a system, component or process to meet desired needs within realistic constraints such as economic, environmental, political social, ethical, health and safety, manufacturability and sustainability.
4. An ability to identify, formulate and solve engineering problems.
5. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice. (p. 101)

A further set of six outcomes, the professional skills were stipulated, and caused some controversy amongst universities (Shuman et al. 2000):

1. An ability to function on multi-disciplinary teams.
2. An understanding of professional and ethical responsibility.
3. An ability to communicate effectively.
4. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
5. Recognition of the need for, and an ability to engage in lifelong learning.
6. Knowledge of contemporary issues. (p. 101)

A considerable discussion followed between institutions as the substantial changes set forth by ABET left the expected outcomes unspecified. Each institution was left to their own interpretation as how best to meet to each outcome which caused concern among engineering educators.

Dick and Stimpson (1999) claimed that as a result of the Accreditation Board's statement the exposure of engineering students to relationships between technology and society had become an accepted component of undergraduate engineering curricula in the USA.

Bugliarello (1987) had earlier advocated the social aspects of engineering education. He espoused the theory that to become fully professional employers and employees, and fully responsible citizens of society, engineering graduates should understand a code of professional ethics. Bugliarello's view is that the quest for technical excellence when building or using a structure, chemical, or device should not compromise society:

> We have to cover a certain amount of subject matter in engineering. But I'd rather they be able to ask ten questions that affect our survival as a society than learn one more higher-order differential equation. (p. 37)

However, a decade later a survey by Stephan (1999) suggested that ethics education was not widespread in the USA at that time. He noted (emphasis in original):

> A survey I conducted which appeared in the October 1999 issue of the *Journal of Engineering Education* indicates that only about 27% of all educational institutions in the U.S. which grant an undergraduate degree require all of their engineering students to take even one course which mentions ethics in its catalogue description. (p. 1)

Zandvoort et al. (2000) agreed with Stephan and quoted an even lower figure at that time in the USA (10–20%), stating that "in spite of numerous developments, there was still resistance from students, scientific educators, school directors and from the profession itself or sometimes from employers" (p. 300).

In contrast, the research of Haws (2001) analysed the *interest* in ethical education in the USA. The mounting interest was such that Haws found that in the four years (1996 – 1999) the American Society for Engineering Education annual conference proceedings contained some 42 papers that treat engineering ethics as a coherent educational objective. Haws' analysis indicated that "while some of these papers disclose small components of a larger ethics commitment, others discussed a university department's major commitment to ethics education" (p. 223).

In the early part this twenty-first century the USA Accreditation Board for Engineering and Technology activated a more firm requirement. Swearegen and Woodhouse (2002) note that "engineering educators are wrestling with means to fulfil the Accreditation Board requirements for contemporary, global, corporate context, including social, economic, legal, ethical and environmental issues" (p. 24).

In 2000 A team of researchers (Shuman et al. 2000) addressed the problem of how best to meet these outcomes with the following objectives:

1. Evaluate a comprehensive set of methodologies for assessing engineering education undergraduate program outcomes, and hence,
2. Provide engineering educators with well documented, alternative methods, including protocols and instruments, for assessing specific outcomes.

In doing this, their objective was to work with colleagues at partner institutions to:

1. Identify existing instruments for each method to assess student achievement outcomes.
2. Develop instruments when none can be found.
3. Compare the effectiveness of multiple methods to assess the same outcomes.
4. Implement these methods and their instruments to assess innovations at multiple institutions.
5. Document these methods so that they can be adapted by other institutions.

6. Utilize the worldwide web to facilitate adoption by other engineering programs.

The purpose was to assist faculty by presenting a framework with supporting documentation that will enable individual programs to achieve specificity in an informed, systematic manner. In particular, as part of a large research study funded by the National Science Foundation (NSF), each outcome has been characterised by a set of attributes whose organization is based in

Their NSF sponsored project (Shuman et al. 2000) used Bloom's Taxonomy to develop learning objectives for all six levels of learning in Bloom's taxonomy (a clearly defined process for the analysis of problems) for four outcome elements:

1. Demonstrate an ability to make informed ethical choice.
2. Demonstrate knowledge of a professional code of ethics.
3. Evaluate the ethical dimensions of professional engineering and scientific practice.
4. Demonstrate ethical practice.

The review team focus was on assessment through an integrated effort, and the team represented experienced engineering education researchers from six universities. This multi-disciplinary team of principal investigators became collectively involved in engineering curricula innovation, assessment, and educational research. They assessed the individual outcomes of their respective education to evaluate engineering education programs, both for accreditation and to assess the increasing number of innovations that have resulted from almost a decade of NSF and private foundation funding (Shuma et al. 2000).

This project resulted in the provision of a series case of studies to provide engineering educators with a cost-effective means for outcome assessment. These case studies are expected to be of value to engineering educators who are preparing for or who are actively engaged in outcomes assessment, but who may lack the background knowledge or resources to conduct rigorous evaluations of their programs (Shuman et al. 2000). Although I was not aware of this work at the beginning of the AUT curriculum design in 2005, I have included this information because I was following a similar path of curriculum development. As an example of this commitment to ethics education at the time, Stanford University (2002) offered an Ethics in Society Program. Stanford considered that the programme encouraged students to reflect on fundamental issues of ethical and political philosophy. These issues include: the nature and implications of treating people with equal dignity and respect; the scope of liberty; the legitimacy of government; and the meaning of responsibility. The course web page stated that the programme posed these issues, and others, in the context of debates which have arisen in normal public life. It extended ethical concern and reflection across disciplines such as medicine, law, economics, international relations, and public policy (Stanford University, 2002).4.3.2 Canada – Manitoba

Late in the twentieth century in Canada, undergraduate engineering students were required by the Canadian Engineering Accreditation Board to be exposed to the impact of technology on society (Dick & Stimpson, 1999).

As an example of the implementation of this board's curriculum requirement, the University of Manitoba implemented a separate paper for second-year engineering students. Dick and Stimpson (1999) outlined the delivery of this paper in technology for engineering students, and commented that it was an interesting challenge to develop a curriculum content and format to which junior students would respond with enthusiasm and interest. They explained that they achieved this desired level of interest by establishing an immediate connection in the first section of the course in civil engineering, where they provided numerous examples of the role and impact of technology on society. The course incorporated historical, current and future perspectives, and the examples ranged from the historical, such as the impact of pyramids and gothic cathedral construction, through to an interest in the future, and how students viewed their possible roles as engineers.

This Manitoba paper titled Technology and Society used a blend of formal instruction, small-group discussion and full-class plenary discussion to provide a stimulating classroom environment. The students had the opportunity to debate issues involving values and ethics, and to practise writing and research, both individually and as groups. Interestingly, Dick and Stimpson (1999) did not deem it necessary to try and measure any degree of mastery in the subject through formal testing or examination. The paper was designed with the deliberate intention of active student participation, encouraging the students to learn for themselves through research, discussion and the sharing of ideas. The aims of the paper carry an expectation and conviction that students would gain (and take ownership of) new insights and perspectives in the relationship between technology and society. The paper received "uniform commendation by students based on a post-course written evaluation" (Dick & Stimpson, 1999, p. 113).

4.3.3 Australia – New South Wales

In the latter part of the twentieth century there was a growing interest in ethics in Australian education. Preston (1996) gave an Australian perspective on this development of ethics education (emphasis in original):

> The establishment of ethics education programmes in schools and universities, ethics research and consultancy centres, and the formation of an *Australian Association of Professional and Applied Ethics* are all testimony to the growing interest in ethics. (p. 7)

Simcock (1998) talked of Australian university engineering education in general terms of training engineers to meet the needs of society:

> It is no longer sufficient to consider only the technical content of students' education. We must prepare our students to fulfill a lifelong, meaningful role in society. Furthermore, in order to claim that our students are educated rather than just 'trained' we must consider their broader preparation to meet the needs of society. (p. 173)

The research of Johnston, McGregor and Taylor (2000) showed that ethics was taught in the engineering courses at the University of Technology, Sydney and the University of New South Wales. At these universities, the subject of ethics was introduced in the first year, and taught throughout the course, requiring the students to attend sessions each week. In the opinion of Johnston et al. (2000), these approaches are typical of Australian universities. According to the Institute of Engineers Australia (IEAUS; cited in Johnston et al. 2000) the approach:

> is not to separate out ethical issues, but to deliberately interleave them through the programme. This model of interleaving, of threading these issues through other material has been adopted by the IEAUS in its most recent approach to competency certification of Chartered Professional Engineers. (p. 318)

An alternative approach was adopted by Ilic (2002) of the University of Western Sydney, which involved giving first-year engineering students a *foretaste* of formal engineering ethics. The word foretaste was used because it was a voluntary three-hour paper as part of a larger paper called Introduction to Professional Practice.

Ilic (2002) described this paper as a presentation to draw the students' attention towards consequences of their future engineering activity on the society and environment. The full subject of Engineering Ethics was at that time only an elective subject in the senior years of study. The class feedback indicated interest from the students, which the university hoped would be pursued in the senior elective part of the engineering course. Ilic outlined the problems with this paper as being a lack of time to cover any useful material, and the students' lack of interest in a non-compulsory paper. Interestingly, the research report noted that when the paper was offered a second and third time during the same semester, more interest was expressed by students, resulting in greater attendances. It appeared that even though the paper was voluntary, the students thought it was worthwhile attending.

4.3.4 New Zealand – Auckland

Professor Dreyfus was commissioned by AUT to conduct a survey on successful teaching within AUT's Faculty of Science and Engineering. Dreyfus and Geddes (2001) reported the results of Dreyfus' investigation and although they were generally complementary about the standard of teaching in the engineering courses, they commented: "Social relevance, i.e., relevance to the relations between technology and society, is seldom explicitly mentioned" (p. 16). My recommendation at the time was that any improvement to the students' understanding of the relationship between technology and society such as Dreyfus and Geddes (2001) suggest needs to be a structured and systematic approach to the modernisation of courses, not a haphazard one. This research is a direct consequence of this view.

To gain accreditation for the Bachelor of Engineering degree, it was not necessary in 2001 to show that AUT was incorporating ethics issues into its courses (personal communication, Professor Geddes, AUT Dean of Science and Engineering, 1 August, 2002). However, Buckeridge (2001b) introduced ethics into the Bachelor of Engineering programme in 2001 on a voluntary basis. Early campaigners in New Zealand like Buckeridge and Deans at the University of Auckland experienced difficulty in trying to squeeze more material into an already full engineering programme driven by increasing technological demands within engineering programmes. The advance of technology in the field of engineering has been responsible for an increasing amount of technical data needing to be included in the four-year undergraduate engineering curriculum (Deans, 1999). This resulted in the marginalisation of ethics and other liberal arts subjects which became targets for deletion from technologically oriented curricula (Buckeridge, 2001b; Deans, 1999; Hinchcliff, 1997). Deans (1999), in the context of the same difficulties being experienced at the University of Auckland, thought it was ironic that the New Zealand government introduced legislation making universities more accountable to society! Yet an early reluctance of universities to accept this change in curriculum and to include ethics was evident (Deans, 1999; Zandvoort et al., 2000).

4.4 The Washington and Sydney Accords

In 1988 the Washington Accord was drawn up as an agreement between the professional engineering bodies of the USA, Great Britain, Australia, Canada and New Zealand to serve as a benchmark for Bachelor of Engineering degrees and a path to professional registration between the signatory countries. This served as a partial internationalisation of the profession, such that when applying for admission to another signatory's professional organisation, a member would proceed without further examination (Buckeridge, 2000). Hong Kong, South Africa and China were later admitted to the agreement. The objective was to develop a uniform standard for professional engineering practice, which included standards for the four-year engineering degree. The Washington Accord was followed by the Sydney Accord for engineering technologists, which included the three-year BEngTech degree (International Engineering Meeting, 2007). Williams (2004) noted that both of these Accords require the provision of "an insight to the role of engineers and the responsibility to society" (p. 15).

Subsequently, professional and advisory bodies in the signatory countries expected the incorporation of ethics into engineering curricula. In 2005 IPENZ insisted that AUT meet the graduate profiles of the two Accords to receive IPENZ accreditation of its undergraduate engineering programmes. The Accord offers guidelines representing how things may be done, but which are not mandatory – these guidelines are changeable according to a defined procedure at any time by the signatories (International Educational Accords, 2007).

The distinction between the Washington and Sydney Accords is the difference between the skills, abilities and engineering functions performed by professional engineers and engineering technologists. These distinctions are reflected in the differences between the two undergraduate programmes leading to these professions. The BE programmes are geared towards development of conceptual skills, and consist of a sequence of engineering fundamentals and design courses, built on a foundation of complex mathematics and science courses. The BEngTech programmes are oriented towards application, and provide their students introductory mathematics and science courses, with only a qualitative introduction to engineering fundamentals.

To summarise AUT's aims for the two types of graduate:

1. The AUT BE programmes provide their graduates a breadth and depth of knowledge that prepares AUT graduates to function as designers.
2. The AUT BEngTech programmes prepare the graduates to design less complex systems, and to have the ability to apply others' complex designs.

Figure 5 compares the two Accords and shows there is little difference between the two degrees in the requirement for ethics and sustainability instruction.

During the 2005 IPENZ accreditation process it was made clear to AUT engineering staff that the Accords' standards were mandatory for accreditation. Of the many standards provided, only those shown in figure 5 (7–11) were to be met by the AUT Engineering Studies paper. The paper is divided into two sections, ethics and sustainability modules (sections 10 and 11). Both modules are intended to support the requirements itemised in standards 7, 8 and 9, as does the whole engineering programme. My task with this project was to address the curriculum requirements of the international Accords' standards (figure 5) at AUT by designing and introducing an ethics section for the Engineering Studies paper.

		Differentiating characteristic	For Washington Accord graduate	For Sydney Accord graduate
7.	**Individual and team work**	Role in and diversity of team.	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	Function effectively as an individual, and as a member or leader in diverse technical teams.
8.	**Communication**	Level of communication according to type of activities performed.	Communicate effectively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Communicate effectively on *broadly-defined* engineering activities with the engineering community and with society at large, by being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
9.	**The engineer and society**	Level of knowledge and responsibility.	Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.	Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering technology practice.
10.	**Ethics**	No differentiation in this characteristic.	Understand and commit to professional ethics and responsibilities and norms of engineering practice.	Understand and commit to professional ethics and responsibilities and norms of engineering technology practice.
11.	**Environment and sustainability**	No differentiation in this characteristic.	Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.	Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.

Figure 5. International Accords standards 7–11.

(International Engineering Alliance, 2005, p. 6)

In the next chapter I investigate the development of my ethical attitudes over much of my life.

CHAPTER 5
Autobiographical Review: Personal Influences on Engineering Education

5.1 Introduction

This chapter is a brief autobiographical exploration of my development in the areas of values, engineering and cultural relationships with society, and of my growth in commitment to professional ethics education. I explain issues and incidents that were going on in New Zealand as I was growing up and working that influenced my views on the engineering ethics curriculum. I explore the meaning of these experiences to gain a deeper understanding of the evolution in my attitudes, and the interpretations I now place on those experiences that have influenced my work on the development of AUT's Engineering Studies paper. In the process, I have tried not to present trivia or to "trouble the reader with the purely private facticities of one's life" (van Manen, 1990, p. 54).

5.2 Development of values

My immediate family consisted of my mother my three siblings, and myself. My grandparents were initially the dominant influence on my values as a child. Schools, church, scouting, Air Training Corps, Volunteer Fire service, Army service and social groups also had an influence as I grew and developed. These influences fit with the theories of Bandura (1989b) who sees social learning as a continuous process in which acquired standards are elaborated, modified and new ones are adopted. Driver (1992) described this as *context* *dependent situated cognition*, a broadly constructivist process involving social influence, value issues, social etiquette, cultural laws and ethical views.

5.3 Early societal and cultural attitudes

I now perceive some of my early experiences and values as strongly founded and enduringly influential. For example, the frugality with which my childhood family lived affected me positively later as an academic. It affected my attitudes towards the difficulties that some students experience, particularly in terms of understanding and appreciating the enormous expectations and social pressures some of them may experience in education due to their low socio-economic background.

However, there were other attitudes, conditionings and humanitarian values that were to change later in life, because I was ill-prepared during childhood for the issues I would have to deal with as a university lecturer in the field of engineering ethics. On reflection I was indoctrinated into racist and sexist attitudes which I now view as prejudices.

As a child I lived in the small South Auckland town of Pukekohe. In the town during the 1940s and 1950s the treatment of the Māori people was such that on reflection I am appalled at what I was brought up to believe as normal. Māori had a separate designated primary school and they were not allowed to sit upstairs or in the back stalls downstairs in the cinema. Their use of the public swimming pool was limited. Despite the modest economic circumstances of my own family, we were conditioned to look upon Māori as being of lower status.

In this socially divisive community I accepted without question that Māori interests were, in many respects, deliberately separated from European interests. I have been unable to find any racially motivated national legislation to enforce this division which leaves me with the assumption that it was simply a locally enforced custom, with the exception of separate Māori and European schools, which was required by the Department of Education.

This division in social status and privilege in Pukekohe is described by Bryjak and Soroka (1994) as a form of social stratification, where the dominant ideology represented the power and wealth of the community based on the dominant group in NZ and that group's access to wealth, prestige and power. However, what was unjust and unethical was that the structure of the stratification was based on racial division.

My childhood and youth provided little experience or contact with other cultures such as Asian, Indian or Middle Eastern cultures. Unlike Māori, a few of them attended the Pukekohe Primary School, but they faced similar discrimination in seating arrangements at the local cinema. I had little contact with them outside the school and as an academic in the future I would have a lot to learn about the multi-cultural society I now live and work in.

Within my primary school experience, first in Pukekohe and later in Hamilton, it was quite noticeable that most teachers were female, but the positions of higher responsibility always seemed to be held by males, with the sole exception of senior teacher in junior classes. It was also accepted as normal practice for a female teacher to leave teaching when she got married (although that had ceased to be compulsory before the 1950s).

King (2003) was to remark in his history of New Zealand that the prevailing attitude during the 1940's and 1950's was that a women's place was in the home. The percentages he gives below (citing work to mean paid-work) were pre-war:

> Mothers were taught to be professional child carers, and girls learnt home craft in the schools. Women, especially working class women, were given limited scope for fulfillment outside the family life ... the proportion of female school leaver designating home as their destination was high and very few women worked after marriage. The fraction of all women actively engaged in the

> workforce remained around 17% from the turn of the century until the 1930s. (p. 375)

My secondary schooling at Hamilton Technical College was another experience in gender inequality. The programmes and subjects offered followed sex-role stereotyping (Gibbons, 1977). I now reflect on the narrow gender prescriptions as an impediment to personal development and growth, locking people into stereotyped life roles via a gender-differentiated curriculum both in subjects and treatment.

Over the years my attitudes towards sexism have changed. During my post-graduate studies at the University of Waikato, which began in 1999, we were challenged to remove all sexist statements from our work. I now reflect on this requirement as an important milestone for me on my journey towards teaching ethics in engineering.

From the perspective of the multi-cultural society that I currently live and work in, it is interesting to reflect on the history I learnt at primary school. This was in the post-war period and pro-British attitudes influenced the history we were taught about New Zealand; much of which has proven to be inaccurate (King, 2003). Those attitudes and the pro-British bias I now look back on as unethical.

On reflection, my childhood indoctrination was centred on the attitude that *might is right*. This attitude was also reinforced by Hollywood producers in the type of movies we watched as children, which often portrayed the John Wayne attitude that all problems are resolved with violence.

I later questioned the value of this indoctrination and approach to history, and its influence on my conduct. This may have influenced my teaching in ethics, where I pay particular attention to injustice, to our commitment to the Treaty of Waitangi, and to a commitment to education for all cultures within our society. Of particular importance to engineering ethics is the peaceful and constructive resolution of ethical issues.

My changes were a gradual result of living through the 1960's and 1970's, during which my ingrained childhood attitudes were transformed. Thompson (2005) remembers this as a time of radical changes in social and political attitudes, when the vivid horrors of the Vietnam War were brought daily to our television screens. This was a time for protests, peace movements, challenging the establishment, alternative lifestyles, and a growing awareness of our threatened environment. A decade later we experienced the Springbok tour protests. Such incidents and experiences in these decades gave me ample opportunity to reflect on my values and attitudes towards injustice, and on my growing interest in the need for new approaches to ethics. On reflection, the biggest changes in my attitudes stemmed from the recognition of other people's rights during a time of major reform in the treatment of minority groups and the underprivileged in the community and workforce. I don't see these changes in attitude as an about-turn of my beliefs; they represented my emergence from the comfortable cocoon of my own social world, a shedding of some naivety, and a growing awareness of injustices and other people's rights.

I view this understanding and the development of my own standards and values as important to my development, both as a person and as a professional. However, quite apart from the changes in societal attitudes, my work environment was also a prominent feature in the development of my views, attitudes, moral judgement and ethical behaviour. I briefly review these influences next.

5.4 Early career

In any organisation there is a social structure with expectations of certain behavioural norms. I began working in 1962 with the status of a Post Office technician. The Post Office working environment seemed to have a class structure defined by job descriptions. Bandura (1999a) comments that it is quite normal to behave in a group as we would in practice under the contextual influence of status and background of our own social environment, and this was the case in the Post Office.

At the Post Office I learnt particular work ethics, and on reflection, observed some rather poor attitudes which appeared to be considered normal at that time. Later in life, I found that social cognitive theory, which posits that behaviour is developed by observation and imitation, could be applied to that situation (Bandura, 1989a; Schunk, 1987; Zimmerman & Schunk, 2003). Some behaviour by staff was unethical; sick leave, for example, was used to play golf. Later in life, as an academic, this experience had far reaching effects on my work ethic; to take sick leave would mean somebody else having to work extra time to teach my class. Hence, it is not a system that gets noticeably abused in the academic circles and I try to set a good example to students, particularly as I teach them engineering ethics.

Also, my industrial experience in ethical situations prepared me well for my current leadership role at AUT. I learned through observation when working for others that unethical behaviour is detrimental to effective management. The lesson in professional leadership here is that unethical behaviour by management results in managers, peers and/or workers losing respect for their management. The lesson in values is that if you are dishonest, you cannot expect those you supervise to either respect you or be honest themselves. The overall understanding of ethics is an important feature when teaching engineering ethics and in Rachels and Rachels' (2007) view, "being a moral agent ... means guiding one's conduct by universal laws, as moral rules that hold, without exception" (p. 122).

In 1974 I was a tutor at Waikato Technical Institute, where the lower social status of technicians was reinforced in both a social and professional sense by some staff. I had moved from a quite senior position for my age in a government organisation in 1974 to a junior tutor in an academic one; but my confidence was affected because I perceived that people with qualifications were better than me. Without formal academic qualifications and coming with a low-level technician qualification into the academic world, I was now working with university educated engineers. My feeling of inferiority affected me socially within this environment. In this hierarchical structure the implication was that I had lower social and professional status than those who had the New Zealand Certificate of Engineering and that I was substantially inferior to those with a degree.

On reflection I agree with Bandura's (1999b) claim that one's cultural background context directly influences one's self-efficacy within social arrangements. However, I had been given an unusual opportunity. While the Post Office had a promotion structure based on qualifications which would have entailed years of study at night school, as an academic I had the opportunity to improve both my qualifications and my salary grades through study as I worked. Through years of such study and persistence the gradual increase in my self-confidence and self-efficacy has positively affected my academic performance. As I have stair-cased through educational levels in engineering I have shed much of my negativity and self-doubt regarding my capabilities, and I have increased my confidence. Bandura (1986a) offers evidence suggesting that such a change in efficacy influences our levels of achievement, our choice of tasks, effort, persistence and performance; in my case it accelerated my momentum in terms of gaining confidence and achieving academically.

Bandura (1986b) observed that the efficacious are more likely to engage in tasks, expand effort, persist to overcome difficulties, and perform at higher levels. My growing self-efficacy was evidenced in my willingness to accept the challenge of writing the new Engineering Studies curriculum. The research of Schunk (1999) also supports the hypothesis that social factors influence learners' achievement, beliefs and outcomes, and when social information is internalised, learners tend to employ it self-regulatively.

This connection between beliefs and action in practice has been interesting to probe. Both Bandura (1989b) and Vygotsky (1962) have explored the influence of social environment on social cognition, and their theories have been reviewed during this research to examine these influences in my personal history.

After my early social experiences in tertiary education, my responses now have two strands:

1. To treat people as they deserve to be treated. Rachels and Rachels (2007) state:

> Rational beings … are responsible for what they freely choose to do, and those who choose to behave decently towards others deserve to be treated well in return, while those who treat others badly deserve to be treated badly in return. (p. 194)

2. My Christian principles (which are more charitable than option one) have the expectation that I live up to very high moral principles which, although not always achievable, affect my behaviour towards other people.

Not long after I had begun employment at the Waikato Technical Institute, Telecom NZ Ltd (previously known as the New Zealand Post Office) made many staff redundant. Although I had left the company, the redundancies of my previous co-workers had a profound effect on me. Consequently I worked to gain extra qualifications to keep my position secure. I attended classes and completed a Technician's Certificate, an Advanced Technician's Certificate, and the first two years of New Zealand Certificate in Engineering, which improved my mathematics, my knowledge of electrical and electronic engineering, and my appreciation of the profession in general. I spent three months at the Central Institute of Technology in Wellington to gain a Tutor Training Certificate, and I was beginning to understand the difference between education and training.

Adams, Openshaw and Hamer (2005) describe educated people as those who:

> possess, among other things, such qualities as; breadth and depth of knowledge that informs thought and guides practice, an ability to formulate life plans and the means of achieving this,

> moral knowledge about how to live a morally good life, emotional understanding and control, aesthetic appreciation, a critical attitude, maximum freedom to arrive at one's own ideas and maximum autonomy so as not to rely on authorities for one's ideas. (p. 139)

I left Hamilton in 1980 and was attracted to the prospect of living in Auckland. I had learned the value of hard work and study, and I successfully applied for a teaching position at the Auckland Technical Institute. I was employed to teach the Technician's Certificate in the area of telecommunications, and while doing this I studied for the New Zealand Certificate in Engineering, which I completed in 1988. During the 1980's I was teaching at the top ends of both the Technician's and New Zealand Certificate programmes and using all my telecommunications knowledge. As my mathematics education improved I was able to teach the specialised areas with competence and I continued to study to ensure that I kept my position. The long-term-effect of this was a progressive movement towards teaching at the top end of the engineering degree programmes by the late 1990's.

Up until this point in my teaching career I was not involved in curriculum content development, as I had always taught curricula as prescribed in detail by the New Zealand Qualifications Authority.

5.5 Mid-life career and the University of Waikato

The 1990's was a busy time for me and a decade in which I was learning and teaching modern microelectronics. During this time I had several opportunities to design and implement curriculum specifically tailored to industry. I was involved in consultancies with Fisher and Paykel, Pacific Steel, NZ Telecom, Sky City and Clear Communications, and then contracted by AUT to the Royal New Zealand Navy as a civilian instructor. Although this did not involve engineering ethics, I was learning to design and implement curriculum and, subsequently, to review and improve the curriculum.

In the late 90's I began to get restless and needed a new challenge. With degrees in the offering and rumours about my institution becoming a university I was intent on further strengthening my position. Firstly, I trained as a Cisco instructor and founded what is now the AUT Regional Cisco Networking Academy. (The Cisco company was named after the San Francisco Bridge). I currently lead this AUT teaching group (now comprising seven engineering staff) which focuses on a series of papers in network engineering for the engineering degrees, part-time classes for the industry, and which also functions as a service department to the AUT Department of Computer Science, whose students also require this series of papers. Secondly, in February 1999 I began post-graduate studies in technology education at the University of Waikato, my objective being to work towards a Masters degree.

I began moving for the first time into qualitative education and was introduced to the post-positivist thinking mode along with values in education and critical enquiry. During the programme we looked at education from a feminist viewpoint, and I evaluated my own performance within this paradigm. As previously mentioned, an important change in attitude was my resolution to remove sexist terminology from my teaching – I was even careful to never again refer to male and female plugs and sockets! The term *mankind* was replaced with *society* and *man-made* was replaced with *artificially constructed*. My attitude towards teaching was moving from one of thoughtlessness to one of care.

I also engaged with constructivism, and was exposed to the view that "all knowledge and therefore meaningful reality is contingent upon human practices, being constructed out of interactions between humans and their world" (Crotty, 1998, p. 42). Through further study I came to understand constructivist implications for teaching, which influenced my own teaching. It was here that I began to understand that my style and methods had already changed me as an academic. I had moved from the teaching of facts on certificate courses to teaching degree courses, where I made use of case-studies and industrial experiences (my own or those I had researched) as learning activities for engineering degree students to strengthen their knowledge and understanding. I was reinforced in this respect by Schunk (2004), who helpfully noted that “learning takes place in contexts and that learners form or construct much of what they learn and understand as a function of their experiences in situations” (p. 480).

There were additional benefits from the post-graduate programme. I learned and practised teamwork with colleagues from the Auckland Teachers’ Training College and I began to take more interest in education as a discipline in its own right. I was particularly interested in the examination of *descriptive ethics* (an examination of people’s moral beliefs), of ethical choices, and of the values that are held in a particular society, and also in *normative ethics* (how one ought to act morally) (Kagan, 1998; Bullock & Trombley, 2000). I reviewed literature on the norms by which people make ethical choices. I began to understand the deontological aspect (what we ought to do) and the axiological aspect (what constitutes a good life) of life and gained an appreciation of the holistic nature of education. There was also a growing awareness and appreciation of self-efficacy, including my own. It was a time to make some interesting observations on the social aspect of student learning.

5.6 Interest in engineering ethics

5.6.1 Early arousal

During my progression in engineering I witnessed many changes in engineering education – that which I experienced as a student was very different to that which I now offer as an educator. As a researcher my interest in technology education was renewed in 1999 by the values that were being introduced into the New Zealand school technology education programme (Jones, 1996). During the Masters programme I read the book *Future Shock* by the American academic Toffler (1970), who made some profound predictions about the future of education. Toffler tried to foresee the future beyond the modernist era, and the ethical issues that we would have to contend with in the progression to what is now referred to as a *postmodern* era. At the time Toffler envisioned an education system which prepared people to think for themselves in a modern society (what is now referred to as a knowledge-based economy).

In my first post-graduate paper in 1999 we reviewed various aspects of technology including its history and the changing relationship between technology and society. This was to be an important grounding for the future.

5.6.2 The influence of the Dreyfus Geddes report

The Dreyfus investigation within AUT's Faculty of Science and Engineering (Dreyfus & Geddes, 2001) precipitated my interest in engineering ethics and the University of Waikato programme provided the opportunity to reflect on and evaluate my own thinking with respect to the evolution of values and ethical principles, the relationship between society and technology, and the manner in which engineering subjects were taught in universities. I came to see that this particular area of engineering education appeared to be underdeveloped as at that time only the AUT fourth-year Bachelor of Engineering students received ethics instruction. As I progressed within the Masters programme my research established that almost all of the AUT engineering students sampled had a sense of fair play, and even if they had no comprehension of what ethics entailed, their views on ethical behaviour ranged from a strong sense of honour and etiquette, through to common-sense views within their immediate culture, peers, society and religion. My research data (Reid, 2009/2003) revealed that unless AUT engineering students exit the staircase system at a fourth-year Bachelor of Engineering level, the AUT engineering courses did not adequately prepare the students for living and working in a rapidly changing technological society, one which will involve them making many value judgements, some with complex ethical dimensions. I saw this as a deficiency within the AUT staircase system of engineering education, and an important implication of my research (Reid, 2009/2003).

In 2005 I was formally given the task of teaching the existing ethics curriculum for the Engineering Studies paper in the AUT School of Engineering for the

2006 academic year. After reviewing the paper I decided to make significant changes to it. I wrote the book *The Social Responsibilities of Engineering* (Reid, 2006) and in 2006 I tested it as a handout to 75 students in the Engineering Studies paper. I received good feedback from the students, and adjustments were made to both the content and sequence of the book. Later in 2006 the book was printed by Print*sprint* at AUT, issued with an ISBN number, and published (appendix 2).

5.7 Ethics in undergraduate engineering education

My development as an educator to this point in my life has involved several changes in my beliefs, attitudes, life philosophy, and ways of working as an academic. These changes helped with the Engineering Studies curriculum development and reflect the theories of Agger (1998), who sees a change of direction by scientists and engineers towards *post-positivist* thinking as desirable. Agger believes that the positivist knowledge perspective is being surpassed by the development of a world-wide critical expectation that educational institutions should effectively prepare people for the ethical decision-making they will encounter when developing and applying modern technology in practice.

As a professional engineering educator I continue to have an interest in improving the quality of our engineering university graduates. I have attempted to progressively address this by providing a means for directing the attitudes of undergraduates towards a lifetime of enquiry, so that they can both learn and understand their chosen profession and gain an international perspective on the way they perceive their surroundings.

Although my literature review had revealed a considerable amount of writing, both within New Zealand and internationally, on the need for engineering ethics, no advice was given on how to construct a suitable curriculum. This led me to further examine how and when ethics was taught to engineering students at

AUT and, eventually, to a new curriculum design for all engineering students at undergraduate level.

Before I began the design of ethics education in undergraduate engineering education, I reviewed values, morality, ethics and engineering decision-making, and this review is recorded in chapter 6.

CHAPTER 6
Ethics for Professional Engineering Practice

6.1 Introduction

Having traced my own academic growth, which led to my involvement with ethics in engineering education, I now review my investigation into engineering ethics.

Ethical education should, whenever possible, prepare students for the demands and pressures of the workforce, and in developing an ethics curriculum to address the complex goals of ethics education my primary goal was not the massive accumulation of knowledge, but instead the development of the intellectual processes associated with the problem-solving that modern engineering ethical decision-making requires. If the teaching of ethics in engineering is to be any of benefit to industry, commerce, and of course the students themselves as they cope with the complexities of their technological society, the knowledge imparted to them must be useful, and of a conceptual nature.

Taba (1962) observed that often the confusion surrounding curriculum development stems from insufficient "analysis of what knowledge in any subject or discipline consists of. This lack of analysis in turn causes misunderstandings about the role of knowledge in learning and curriculum" (p. 172).

In light of these remarks, I thought an important aspect of curriculum planning would be an examination of the nature of ethical knowledge and how it should be applied in the teaching of ethics in order to benefit industry and commerce. It follows that before developing an ethics curriculum that will serve IPENZ's original concept of a useful purpose, and before any imparting of knowledge took place, I needed to start the planning by examining the nature of the knowledge itself.

In this chapter I review my investigations of the inter-relationships of society, engineering, technology, values, morality and ethics in education. Throughout this thesis the terms values, morality, ethics and etiquette are used and, understandably when ethics and morality are discussed, a certain amount of confusion can sometimes arise. In a practical sense the words *morality* and *ethics* are often used by people interchangeably. I believe it is desirable that students understand the different meanings so in 6.8 I clarify my interpretations of these terms which arise in the context of engineering ethics education. The terms introduced in this chapter are defined and discussed with the students during the ethics section of the Engineering Studies paper at AUT.

6.2 The engineer and society

6.2.1 The requirement

The engineering graduates in New Zealand are required by the international Accords to:

> 1. Understand and commit to professional ethics and responsibilities and norms of engineering practice.
> 2. Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development. (International Engineering Meetings, 2005, p. 5)

To understand ethical decision-making an engineer needs to consider the effect that engineering decisions in practice may have on society. Therefore the engineer must understand the relationship between engineering and society, which was introduced in section 3.4.

In designing this module I concluded that engineering education should now emphasise the relevance of the relationship between the technological, environmental and cultural aspects of engineering practice. Ideally, the students' "background should also include ethics, philosophy, social sciences, and the ability to interrelate the basic tenets of these disciplines with technology" (Braukman & Pedras, 1990, p. 3). Meizrow (1990) argued that the essence of ethics education is to "help adults construe experience in a way in which they will more clearly understand the reasons for their problems and the options open to them, so that they may assume responsibility for decision-making" (p. 361).

6.2.2 Technology and society

Technologies impact significantly on our lives and cultures. Keirl (2003) believes that although we might be largely unaware of this fact, we could hardly define our existence without reference to them. Keirl stated (emphasis in original):

1. All technologies have contested values. No technology is neutral or universally good.
2. All technologies are created by a manufacturing or enabling process resulting from human intention or design.
3. A technology cannot be in any functional sense without a relational human input, although this may well be less the case in the future.
4. Technologies often undergo a *function creep* – uses other than those originally intended.
5. Technologies converge and gain greater technological power than the sum of the parts.
6. The speed of emergence of technologies is almost faster than the necessary associated ethical considerations and legal framework.
7. Technology is commonly viewed as autonomous or inevitable – *that's the way things are going* or *you can't stop progress.*
8. Identity and power relationships are shaped by the technologies with which we interact. (p. 151)

Graduates must comprehend several issues. According to Chandler (2000), “it is a great mistake to jump from the conclusion that the relationship between technology and society is not simple to the conclusion that the use of a particular technology in a specific context has no consequences at all” (p. 2). Before the students can even begin to comprehend what is expected of them, they need to understand technology itself as a lead into the examination of the relationship between engineering and society, and the consequences that Chandler alludes to.

6.2.3 The elements of an ethical culture in engineering

In terms of these consequences Keirl (2003) suggested that educators promote an ethical culture for engineering education based on three elements that should lead to understanding the relationship. Keirl listed these as knowledge, attitudes and skills:

> 1. *Knowledge;* concerning not only technology itself, but also methods of foreseeing its consequences, ways, methods of teaching and criteria for assessment. The education of engineers should include non-technical subjects including the philosophy of technology, general knowledge of technology, valuation of technology, managing of technology, and typical problems associated with the field of science and technology by considering its relationship with society.
> 2. *Creation of attitudes;* the creation of rational attitudes towards technology and its development, which would be far from extremely triumphant or catastrophic. Such attitudes, albeit not totally free from emotion, need to be rationalised and built upon factual calculation of the various consequences of introducing technology, which would form the basis of legitimisation and acceptance.
> 3. *Developing skill;* not merely the skills of creating and using technology, but also foreseeing its consequences, the assessment of risk connected with the developments of specific technologies, the ability to embrace technology in the processes of social and individual life, and the ability to communicate and negotiate. (p. 148)

These aims are interrelated and overlap. The students need to be given the opportunity to understand and discuss the delicate relationship between society and technology. They need to understand very early in their tertiary education that modern technology is such that we can easily experience dependence on it, and suffer the inevitable exploitation of both technology and our society. Students need to understand that technology has consequences. Pursell (1994) in his non-neutral theorising, states that the "choice of means always carries consequences" (p. 218). These consequences are not necessarily identical to the original means or intent of that technology and require consideration in advance (Abelson, 1970; Lim, 2006; Staudenmaier, 1989; Thring, 1992).

6.2.4 The plan for teaching the relationship between engineering and society

Dougherty (2003) suggests that:

> Education provides the mechanism to study and understand the social change that this relationship brings to society. Intelligent decisions about technological development, proliferation and their impact on society must be made. In many ways, a careful understanding of the relationships between technology, society and education will help members of the technology education profession develop the vision that will shape our future in the public schools and assist us in preparing a generation of students who possess the knowledge and abilities to be considered technologically literate. (p. 33)

I listed the following points of presentation which I saw as a logical progression of explanation and possible discussion for an understanding of the relationship between engineering and society:

1. *What is technology?* The students need to understand that technology is not just computers and cell phones. It involves, over a long period of history, a wide area of improvement to our standard of living including housing/shelter, tools, weapons, clothing, food preservation, communication and transportation.

2. *The relationship between technology and society.* Technology influences society and society influences technology development,

success and failure. What impact has modern technology had on the way we live, work and socialise?

3. *Technology transfer.* Technology does not always transfer easily, and without the proper technical support, it can breakdown.

4. *Is technology neutral?* Can scientists and engineers absolve themselves from the unwanted effects of technology or is it up to the users to take responsibility? Who is responsible for the adverse ecological impact of technology?

5. *The social pressures of technology.* Can we live without technology? Are we dependent on it?

6. *Society's control of technology.* Society has some control over technology, particularly with the resistance to buying, using or consumption of useless or inferior products.

7. *Government control of technology.* Legislation is often passed by governments to keep some control over technology such as traffic regulations, waste management, environmental and resource management.

8. *The equity issue with technology.* While it is estimated that a third of the world lives in poverty, suffering and human degradation, other parts of the world live in areas of luxury and high energy consumption.

9. *The concept of a conscience*. This needs to be defined, and how it is likely to affect students in an engineering career.

10. *The introduction of the concept of ethics.* A complete understanding is required.

11. *Ethics in science and engineering.* A complete understanding is required.

12. *To be society's critic and conscience.* To stand up and speak out against injustice and unproductive or unsustainable activities in engineering.

These major points concerning technology are a good discussion springboard for a class in the introductory stages of an ethics course. The statements given here may be embellished with many examples, and may perhaps receive class input on interpretations of these points. Such discussions on the relationship between the engineer and society include the following ethical factors (Benthal, 1976; Gutek, 2004; Hinchcliff, 1997; Mitcham, 1994a; Perlman & Varma, 2002; Randerson, 2002):

The obligation of public safety: What is an engineer's responsibility to public safety? Just how safe is your safe design?

Risk: Rather than *let the buyer beware*, what is the engineer's responsibility to inform the user of any associated risks?

Conflict of interest: What is a conflict of interest in engineering? What is wrong with a conflict of interest? When should a conflict of interest be declared?

Discrimination: What is an engineer's responsibility regarding the treatment of women, minority and disadvantaged groups in the workforce?

Profitability: How should the engineer's responsibility to society in providing employees with a decent living standard and work conditions be related to profitability?

Accepting gifts: What are the guidelines for accepting gifts from clients?

Whistle blowing: Should engineers be expected to blow the whistle in the interests of public safety? What are the more reasonable alternatives?

6.3 Values

Keirl (2003) noted that "any study of ethics embraces terms such as morality, goodness, right and wrong, obligation, ideals and values, and each warrants analysis of its meaning and role in ethical discourse" (p. 149). When improving my own understanding of ethics during the period of 2005/6, I became immersed in the areas of values and morality, and the values aspect of education. I reviewed the change in general education after the introduction of values, and in the process of establishing the relationship between engineering, ethical and moral theories I came to consider values as an important ingredient to engineering ethics and sustainability education. Hence, I began the ethics review with a study of values.

A value is a subjective principle that holds something to be good or bad, worthwhile or not, desirable or undesirable (Preston, 1996) and the behaviour of individuals, groups of professionals, or nations all reflect the values that they hold. A person's values are developed from a young age, where parents are normally the most dominant influence on a child's upbringing. Parental control is not always exclusive; values are also influenced by guardians, teachers, priests, and peers (Frazer & Kornhauser, 1986). Centralised authority systems such as the church may be a major influence on both family and individual values (Preston, 1996). What people value as good or bad, useful or worthless, will influence how they behave, and expect others to behave (Evolutionary Ethics.com, 1999). A person's values depend very much on the nature and structure of the society in which they reside, and different cultures develop different values for different reasons.

A literature review revealed that in the late 1990's the New Zealand education system experienced a school curriculum reform, which the development of a national technology education curriculum was part of, resulting from growing concerns with the whole school curricula (Jones, 1996). During the 1970's and 1980's calls had been made for a curriculum that was responsive to New Zealand's need for people highly skilled in science and technology, who possessed the linguistic and cultural sensitivity needed to maintain international economic competitiveness (Levette & Lankspear, 1990). Similarly, Black and Harrison (1985) proffered the general idea of technological capability in schools with an "awareness, perception and understanding needed for making balanced and effective value judgements" (p. 54).

As a result, during the 1990's the New Zealand school education system took positive steps to define and establish technology education as an academic discipline and to replace traditional school technical craft subjects. All students are now expected to study technology, following a structured progression of the curriculum from their first year in primary school to year 12 in secondary school. In New Zealand primary and secondary schools today, students taking the technology course are encouraged to develop a broad technological literacy through the exploration and understanding of areas such as materials technology, biotechnology, food technology, and electronic technologies. In all technological areas the interaction between projects and business, industry and local government is encouraged. Not only are the students beginning to understand the relationship between technology and society, but the embedding of values and ethics into the curriculum is an important facet of technology studies in schools (Ministry of Education, 1995).

Reid (2000) has stated that:

> Technology in the New Zealand Curriculum was designed to give the students an understanding of the culture, the values, and the social issues involved with technology. It is intended to bring the concept of technological literacy into the intellectual domain. Such an understanding and intellectual approach to technology is now deemed necessary for all students in order for them to function effectively in our modern technological society. (p. 45)

A 2005 Literature Review on values in the New Zealand school curriculum was completed under contract to the Ministry of Education, New Zealand by the School of Education at the University of Waikato that examined attitudes and beliefs held by New Zealanders about values in the curriculum (Keown, Parker & Tiakiwai, 2005)

The Keown, Parker and Taikiwai (2005) report concludes that the:

> Values that the curriculum adopts will include the values conveyed in the aims, purposes and principles of the curriculum. They will also be evident in the structure of the curriculum and in its content. For example, the values will be evident in the choice of learning areas or subjects for the curriculum, and will also be

> expressed in the learning processes, the skills and competencies, chosen. The values of any specific curriculum can be explicit and fully acknowledged and explained, or they can be implicit, not explained and remain somewhat hidden. (p. 8)

This examination of values revealed that some curricula have quite specific values learning goals. Some national curricula have particular parts of their curriculum that focus on values learning. Some include somewhat broader subjects that focus on values, such as personal, social and moral education. In some curricula, particular learning areas such as civics and citizenship carry a strong values emphasis. Even when there is not a subject specifically addressing values, particular learning areas may be seen as values education carrier subjects.

In New Zealand schools, the Social Studies subject has long been considered an important values subject within the curriculum and more recently such areas as Health and Physical Education and Environmental Education have also been seen as important sites in the curriculum for values learning.

The Keown et al. (2005) review of values in New Zealand School Curricula shows that values in the school curriculum can operate at three main levels:

> 1. High level values related to the choices made about the overall structure and content of the curriculum.
> 2. Curricula can identify values learning goals or outcomes that are expected across the whole curriculum.
> 3. Values are focused on, and/or are implicit in, particular learning areas, subjects, and skill and competency dimensions of a curriculum. (p. 9)

The research of British schools by Taylor (1998) shows that a wide variety of values curriculum experiences are included in national curriculum documents and/or in the curricula of individual schools. She lists these as: spiritual, moral, social and cultural education; personal and social education; religious education; multicultural/anti-racist education; and citizenship, environmental and health education.

Taylor (1998) also suggests that whole school experiences such as pastoral care, school ethos, wider community links, assemblies, and the life of the school as a learning community may also regarded as values curriculum experiences. Taylor observes that such experiences can focus on substantive values such as honesty and respect, and on process values such as reflection and caring.

This concept was taken further in 2007 with the introduction of a set of values into New Zealand school education to give school children a common set of values. This aspiration was part of a common global concern in education (Values to be part of new curriculum, 2007). Most New Zealand schools now have effective and well-established programmes in place.

In the United States the moral development theories of Kohlberg (1984) have changed the study of moral development; his a five-stage progression of moral immaturity to maturity for school children has been adopted. Essentially, Kohlberg's theory recommends taking children from the simple egoistic (or what he refers to as egocentric) stance at an early age, progressively through to a level of maturity that views the world from a contractual, altruistic and principled point of view.

The current global trend to teach values-based decision-making is not exclusive to school education as universities have been introducing ethics and values-based decision-making for some years now in engineering education papers such as Engineering Studies at AUT, where engineering graduates are given a clear understanding of the sustainability of engineering processes and decisions, and how they are expected to conduct themselves ethically in the engineering profession.

In professional occupations, the values of the profession are reflected in their code of ethics and members of the profession are obliged to uphold these values. Also, they are expected to comply with the code of ethics of the company or organisation where they are employed, who, because of the nature of the organisation, may stipulate additional values not expressed by the general guidelines of their professional code.

What is important in this chapter is the development of a learning process with explicit emphasis on values in all levels of education. Taylor (1995) points out that none of us are value-free, and an engineer's assumption of professional status carries with it a responsibility to explore, understand and question the values and attitudes which are the basis of our decisions.

Values are not a new concept in education. In all forms of society, whether human or animal, the most fundamental instinct is the survival of the species, which has always included the preparation and education of the young for adulthood which, in humans, has included a reinforcement of values (Toffler, 1970). However, during the modernist era science and engineering presented curricula that were considered value-free (Gutek, 2004; Toffler, 1970). On reflection, to a large extent my teaching career up to this point appeared to me to reflect the modernist era that Toffler alludes to. I considered that an effective ethics curriculum could not be presented as value-free and as I reviewed this period I became anxious to disassociate its lack of values from my own ethics paper.

6.4 The modernist view of engineering education

In the 1960's, the American influence on science and engineering practice and subsequently education was heavily influenced by the *space race* and the *cold war* (Gutek, 2004; McGinn, 1978). This technological age had broken away from the irrationality and superstition of preceding ages, a process that began during the *Enlightenment.* The period of *modernism* had begun with an absolute faith in science and scientific method, with the ability to discover absolute forms of knowledge where all discoveries must be supported by provable evidence, without subjective, superstitious or unverifiable opinions (Crotty, 1998).

Engineering education in the universities, and the polytechnics with which I was associated have generally followed this philosophy of the *spirit of enlightenment*, where a positivist perspective presents unambiguous and accurate scientific knowledge as the paradigm for all socially useful forms of knowledge, rather than advocating speculation through abstract reasoning (Crotty, 1998; Gutek, 2004; Installe, 1996; Kuhn, 1996).

Installe (1996) noted that from a philosophical viewpoint the university engineering programmes at that time dispensed knowledge oriented towards the skills necessary to solve problems defined in quantitative terms within a deterministic environment. While such a modernist approach has broken our ties to past beliefs that were based around superstition or myths, and was expected to deliver us from ignorance, much of modernist engineering education was taught in isolation, without any reference to the economic, environmental, ethical, political, cultural or global aspects (Gutek, 2004; Nguyen & Pudlowski, 2005; Thring, 1992; Toffler, 1970; Sutton, 2003).

Toffler (1970) reflected on the 1960’s modernist period of education:

> Today it embarrasses many teachers to be reminded that all sorts of values are transmitted to the students, if not by their textbooks then by informal curriculum – seating arrangements, the school bell, age segregation, social class distinctions, the authority of the teacher … . Yet the formal curriculum continues to be presented as though it were value-free. Ideas, events and phenomena are stripped of all value implications, disembodied from moral reality. (p. 377)

At the same time as Toffler was writing, a group of engineers and scientists authored the previously mentioned Santa Clara Declaration in 1970, which was an expression of concern over the failure of engineers and other professionals to exercise significant responsibility for the social consequences of technology (Thring, 1992).

Frazer and Kornhauser (1986) pointed out that in the modernist era it was believed that if everybody understood science and technology, then we would all make the same decisions on any issue following the laws of reasoning, completely unbiased by politics or financial considerations. But politics, financial and human considerations are major influences in modern commercial and industrial decision-making, and quite often scientists and engineers who are equally well informed on a particular scientific or engineering issue can have very different views and opinions on the issue or the influences on it.

Professionals increasingly acknowledge the complex relationships and interactions between society and technology, and while technology can be used to solve social problems, it can also create new ones (Keirl, 2003). As a result of these interactions technology inevitably involves benefits, risks and tradeoffs which may be viewed as a contrast between idealism and realism (Daugherty, 2003; Gutek, 2004; Randerson, 1991).

It is now internationally accepted that engineering education is influenced by other disciplines which are incorporated in engineering curricula, such as management, business, strategy, marketing, philosophy, communication, ethics and sustainability (Sutton, 2003). Sutton argues that engineering education programmes are adapting to a postmodern society, where knowledge becomes functional and where one needs to know how to use the knowledge one learns.

6.5 The postmodern period of thought

Since the inception of the modernist engineering period, critical theorists have argued that science, engineering and technology cannot be value-free and that "objectivity in the social sciences is molten, not frozen" (Agger, 1998, p. 179). According to Agger, postmodernists and critical theorists reject the simplicity of modernism, suggesting that "one cannot legitimately claim to be free of values" (p. 179).

Recent *postmodernist* philosophy offers a way to theorise local situations as fluid and unpredictable. From this perspective it is thought that values can no longer be excluded from engineering education or engineering research. Instead the social conditions of technological development may lead to the opinion that technology is not neutral and technological devices are not innocent (Kiepas, 1997). Atkinson (2002) explained the concept of postmodernism as the:

1. Resistance towards certainty and resolution.
2. Rejection of fixed notions of reality, knowledge, or method.
3. Acceptance of complexity, lack of clarity and multiplicity.
4. Acknowledgement of subjectivity, contradiction and irony.
5. Irreverence for traditions of philosophy or morality.
6. Deliberate intent to unsettle assumptions and presuppositions.
7. Refusal to accept boundaries or hierarchies in ways of thinking.
8. Disruption of binaries that define things as either/or. (p. 73)

Frazer and Kornhauser (1986) point out that while individuals are entitled to their personal opinion and their own set of personal values, members of a profession such as engineering must learn to master and practise an art (their profession) which is indispensable to the progress of society, and the skill and knowledge of the profession must be available to the service of the state or the community. Kiepas (1997) explains that “the global problems of modern civilisation and the perspective of the postmodern future increase the role of ethical factors as regulators of actions in modern technology” (p. 252).

In what has become known as the postmodern period, values are now considered an important part of engineering research, education and practice. It is widely accepted now that engineering is not value-free, and there are global and localised environmental, cultural and social aspects of any engineering decision (Agger, 1998; Gutek, 2004; Herkert, 1997; van der Vorst, 1998). Thus it is the responsibility of engineering education to prepare students to be able to carefully think through the range of implications, issues and priorities that are associated with any engineering project. As Meizrow (1990) pointed out, "rational thought and action are the cardinal goals of adult education" (p. 354).

In terms of the relationship between engineering and society, Buckeridge (1999) suggested that engineering has moved from an occupation that has been constitutionally and functionally introverted to a profession that is increasingly accountable to the wider public. Moriarty (2001) commented that “More and more, socially and environmentally responsible engineering ventures are garnering positive social regards" (p. 32).

Installe (1996) promotes a *systems approach philosophy* to teaching engineering that includes developing communication skills among future engineers and a multi-disciplinary approach to problem-solving which includes the analysis of economic, ecological and social issues. Science and technology have given society enormous control over various aspects of nature as the development of civilisation has extended the range of possibilities of humanity's rule over the world. The concern expressed by many is that this control has unfortunately been developed so far that it now threatens the future existence of the world, including society itself. The immediate issue is that modern technology must be controlled and managed in a manner that the quest for technical excellence should not compromise society or the environment we live in (Benthal, 1976; Mitcham, 1994b; Taylor, 1995; Winner, 1990).

As noted in chapter 4, there is now a world-wide expectation that educational institutions will effectively prepare people for the ethical decision-making that may be encountered when developing and applying modern technology in practice. But ethics is the study of morality, and on what values are these decisions based? Preston (1996) observed that modern shifts in ideology and worldviews have accommodated a breakdown in the centralised authority systems, such as the church, and that we have moved into a "postmodern pluralistic ethical environment" (p. 6) where we now need to recover the importance of ethical understanding for human living, at both the personal and community levels. Hence it is now normal to teach values in schools and this fits with the views of education researchers such as Kohlberg (1984) and Habermas (1996), who both subscribe to the promotion of an ethical stance in modern school education.

I conclude from this review that, while a university of technology raises the knowledge levels of technology, the societal aspects of technology are equally important, because an ethical perception and imagination allows graduates to create and explore possible alternatives beyond the knowledge and constraints of the actual situation. Johnson (1993) connected ethical imagination to value criticism and growth:

> Our ability to criticise a moral view depends on our capacity for imagining alternative viewpoints on, and solutions to, a particular moral problem. In order to adapt and grow, we must be able to see beyond our present vantage point and grow beyond our present selves. (p. 203)

Frazer and Kornhauser (1986) maintain that in tertiary education any science curriculum should include ethics and social responsibility. They suggest that we need to try and understand different values, some of which are common and some which are not. As a result, Frazer and Kornhauser argue that a decision may be seen as a value position, which can influence the particular stance people take on a societal issue. In this manner, values can influence the policy- and decision-making processes of any individual or organisation in any society, which includes of course the decisions of engineers as individuals and a profession. Frazer and Kornhauser warn us that any decision that arises from personal values should therefore "be identified as a value position – not a technological assessment" (p. 40).

Such a value position may not always be evident in decision-making debate. As the report of the New Zealand Royal Commission on Genetic Modification (2002) stated, "values give rise to goals, which in turn determine policies and strategies. Values are often hidden or unnamed, and when this happens there is a danger of becoming lost in a debate about strategies and losing sight of ultimately what we want to achieve" (p. 1). Indeed, most people have experienced values as an embedded hidden agenda in decision-making. Since values can influence goals, policies and strategies in our decision-making, two questions arise:

1. Does our multi-cultural society in New Zealand have any commonality in values?
2. Does the field of engineering have any common values on which to base decision-making?

6.6 Values in New Zealand

In 2009, at least 60% of the students I taught in engineering courses at AUT had been born in other countries. New Zealand's population today is made up of many different cultures and beliefs, covering a rich diversity of peoples from all over the world. Consequently New Zealand society can be seen to be pluralistic, with values drawn from different cultures and different sources, some religious, some traditional and some philosophical (Royal Commission on Genetic Modification, 2002). Some people may have values based on work experiences, others on international values such as the United Nations Declaration of Human Rights, and still others on cultural or religious influences.

Bertrand Russell (2002) posed a number of thought-provoking questions about values and authority within a multi-cultural society:

> As soon as we abandon our own reason, and are content to rely upon authority, there is no end to our trouble. Whose authority? The Old Testament? The New Testament? The Koran? In practice, people choose the book considered sacred by the community in which they are born, and out of that book they choose the parts they like, ignoring the others. (p. 2)

Is it possible then to have a common core set of values amongst such a diversity of cultures and beliefs as we have in New Zealand? The Royal Commission on Genetic Modification (2002) provided argument that commonality does exist. They found in terms of nature and our environment that values from different sources in New Zealand do converge and that New Zealanders do share a common set of values (bracket added):

> Māori [indigenous New Zealanders] for example, drawing on their spiritual and cultural heritage, have a strong sense of the sacredness and interconnectedness of earth and all life forms. Judaeo-Christian groups draw on biblical tradition to reach the same conclusion. Those who come from the ecological world-view have a similar holistic understanding of ecosystems based on the intrinsic value of all life. (p. 25)

So it seems that whether one's background and cultural beliefs are based on an atheistic or theistic principle, the relationship society develops with nature appears to share some common values and reverential care.

All people have values, and Seedhouse (2005) explains that most decisions can be traced back to a value of some description. He explains that, based on our values, we tend to classify other people from a value viewpoint. We can classify others in a host of complimentary or uncomplimentary terms, such as law-abiding or terrorist, kind or unkind, generous or mean. Seedhouse (2005) separates personal values into two groups:

> *Lower preferences/values* – these might be basic preferences such as: I like food, I like sex, I like this mood altering substance, I like the after-effects of exercise, I like this picture, I like this object, I like this sensation and so on.
>
> *Higher preferences/values* – these might be reasoned preferences such as: intellectual pleasures, valuing literature and music, long-term commitment to relationships, deeply reasoned arguments for social projects and so on. (p. 70)

Seedhouse (2005) argues that the development of values is influenced by instinct and environment which is illustrated in figure 6.

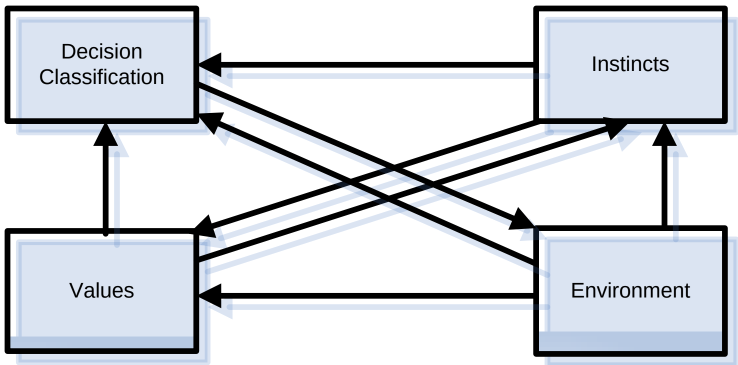

Figure 6. A possible relationship between values, classifications, instincts and the environment.

(Adapted from Seedhouse, 2005, p. 70)

As stated previously, the most fundamental instinct of any society (including non-human life forms) is survival of the species. In some situations this will be the strongest influence on values and decision-making. However, there are times when our environment will be the most significant influence. Seedhouse presented a table in which these aspects and influences of one's values are related. I associate sensitivity to environmental influences with the holistic incorporation of one's surroundings into one's existence which Russell (2002) referred to. Seedhouse's table highlights the additional influence of instinct in values-based decision-making. In terms of one's personal life, the diagram may be interpreted in the following way:

Environment: The environmental influences may include one's upbringing, social pressures and norms, a caring for the planet and its ecology, and so on.

Instinct: Instinct may be based on feelings, knowledge, experience, premonition or feelings of danger, or simply knowing what is right and wrong.

If we are to make values-based decisions in engineering, the diagram takes on greater significance, as there can be many pressures when relating to one's environment or instinct. The concern was how to introduce these influences on values into engineering education.

6.7 Values in engineering

Initially I felt it was important to provide an understanding of the relationship between engineering and society where values may be viewed from both a personal and professional perspective. However, before understanding values-based decision-making in engineering, I thought it important that the students have an understanding of the interrelatedness of morality and ethics.

In industry an employer may have different and additional values to an individual. The cultural, environmental and instinctive influences one has in one's private life may be intensified by more wide-ranging perspectives in a professional position (Davis, 1991; Randerson, 1991; Seedhouse, 2005; Sutton, 2003):

Environmental: The environmental influences may include pressures such as the shareholders, society, government, local government, commercial competition, finances and the quest for dominance.

Instinctive: Instinctive decisions may influence decisions with extraordinary success or failure.

It is here that I began to recognise the importance of a code of ethics for the profession. The IPENZ code alludes to the value of life and the planet we live on, but also clearly defines the values of the profession irrespective of the employer, or an individual engineer's cultural and social values outside the profession. Whatever unethical pressures a professional may be under within an employment or private environment, the code of ethics should provide a guide to the expectations of behaviour of a professional engineer at all times.

6.8 Morality and ethics

6.8.1 Morality

A decision-making process that considers one's personal values is referred to as one involving morality. Morality is what may be considered right or wrong, based on our values (Collins, 1988; Mehlinger, 1986; Pojman, 1998). Morality is "concerned with the goodness or badness of character or disposition, or with the distinction between right and wrong" (Collins, 1988, p. 657). Mehlinger (1986) viewed moral behaviour as the exclusive domain of humanity. His view is that animals act mainly through instinct and it is unusual to hold an animal accountable for a moral judgement in terms of good or evil actions. Similarly, machines are not held accountable for the actions of their operators or programmers. Humans judge other humans in terms of morality based on values. In the legal system humans judge other humans based on the laws of the society. Essentially, the difference between morality and the law is that the law is enforceable by punishment, but morals may only be sanctioned by conscience and reputation (Pojman, 1998).

As a general principle, moral principles provide a guide to moral behaviour and moral judgement based on values (Preston, 1996). As straightforward as this definition of morality might seem, moral principles vary from one culture to another, and such difference between moral interpretations is referred to as *moral relativity* (Seedhouse, 2005). Without a single set of values on which to base values-based decision-making, such decision-making is dependent on human choice and therefore relative to their culture and values.

The concern in the design of the ethics curriculum was the area of professional ethics as laid down by employers and professional bodies. The ethics module points out to students that there may be a significant variety of cultural values in society, and indeed within a classroom, by which human conduct is appraised. I decided that it would be important in an engineering ethics course to acknowledge the existence of relativism and the disparate views on morality, without denying students the opportunity to understand and perhaps even learn a little about other people's realities as their understanding of ethics progressed.

6.8.2 Ethics

Collins' *Concise English Dictionary* defines ethics as "the study of the moral value of human conduct and the rules and principles that ought to govern it" (Collins, 1986, p. 380). According to Birch and Rasmussen (1993) (emphasis in original):

> Ethics may be understood as the systematic study of the moral principles, values and obligations that guide human behaviour. While 'morality' concerns the *evaluation* of such behaviour as right or wrong, good or bad, 'ethics' is the *theoretical analysis* of the major ingredients that shape and validate these moral judgements. (p. 38)

Grenz and Smith (2003) noted that ethics is a division of philosophy "that involves the study of how humans ought to live … if morality involves the actual practice of living out one's beliefs, then ethics is the study of why these practices are moral or immoral" (p. 35).

Thompson (2005) argued that ethical theory is concerned with:

> the general arguments and principles by which people have sought to establish a rational basis for the assessment of moral issues, and also with the consideration of those things that may be regarded as good and right, both in terms of actions and the aims and purposes that motivate action. (p. 151)

Collins (1986) refines their definition, explaining that ethics especially refers to “a code of behaviour that is considered to be correct within a particular group, profession or individual” (p. 380).

From these definitions I judged the ethical examination of morality derive to be divided into three distinct areas.

Group behaviour

Group dynamics are a major influence on one’s behaviour in any part of society. One conforms if one wants to belong. In the extreme, the aspiration to belong can lead to criminal activity, but in a more positive aspect, group influence can be good. Grenz and Smith (2003) give a religious example, where “Christian ethics … is the study of how humans ought to live as informed by the Bible and Christian convictions” (p. 35).

Individual behaviour

The individual has the right to choose what moral (or immoral) teaching to follow. An individual’s standards of conduct and actions will be judged as right or wrong by the society or culture that the individual belongs to (Pojman, 1998).

Professional behaviour

IPENZ (2002) explains that professional ethics is concerned with the ethical evaluation of the relationships and practices that comprise the professional world, where to be considered ethical one must find a balance between self-interest and professional/group responsibility.

One challenge in the professional world is that ethics are often based on relativism, where values vary from one culture to another. When a company or organisation stipulates its expectations of professional behaviour the term *ethics* is used to describe professional behaviour, for example in a code of professional ethics (Hill, 2003). The ethical expectations of a workplace are laid down by the profession or employer (or both), regardless of the particular culture or personal ethical background of its employees. Ethical values consider what is morally right and proper, but ethics is part of a worldview of behaviour which may transcend local, cultural, religious, and ethnic differences.

As a study of morality, ethical theory analyses values-based decision-making. There are many theories, but I consider the essential understanding required is the difference between consequentialism and non-consequentialism in its many guises. A study of virtue ethics is also useful in understanding ethical theory analysis. The different theories are covered in detail in appendix 2 (pp. 45-52).

6.8.3 Ethics and the law

Ethical expectations may often be distinguished from laws. The fact that an action is legally permissible does not mean that it is ethically acceptable (for example, slavery and child labour). Also, there can be times when illegality does not necessarily imply unethical behaviour (for example, political opposition to dictatorship) (Texas A & M University, 2002).

6.8.4 Etiquette

Etiquette is what is considered good mannered and polite (Pojman, 1998). Engineering students need to be made aware of the difference between etiquette and ethics – there are expectations of their behaviour and manner as employees in the workplace just as there are in their private, family and social lives (Mehlinger, 1986).

6.8.5 Dignity

Dignity refers to the fundamental worth of a person, of animals or of nature, and to treat someone with dignity is to treat them with respect and without embarrassment, respecting their right not to be interfered with, or not to be harmed or humiliated unnecessarily. In working relationships people have the fundamental right to be treated with dignity, although in many societies that fundamental right is forfeited when one breaks the law (Reid 2006).

6.8.6 Conscience

Conscience is associated with the feelings of guilt one may have in being associated with something that is considered to be of low morality. Such guilt can result from decision-making outside the frame of society's values (Pojman 1998).

Both the engineering and the medical profession make decisions that impact on people's lives. The term conscience is used in the British Health Regulations relating to personal views of right or wrong, including one's religious or moral beliefs concerning such issues as contraception and abortion (Royal College of Nursing 2001). The engineering codes of ethics are not so clear about conscience issues, but engineers may at times have to consider their conscience, and this can be largely influenced by their core values.

The review of information in this chapter served as a preparation for understanding values-based decision-making, which is covered in the next chapter.

CHAPTER 7
Values-Based Decision-Making

7.1 Introduction

As previously stated in chapter 3, there are environmental, cultural and social aspects of any engineering decision which an engineer has a responsibility to consider. The *wise application* of engineering technologists referred to by van der Vorst (1998) may be termed values-based decision-making. When a decision is to be made by an individual, or by a group or organisation, the decision-making is influenced by numerous factors. Some factors will be clear, as defined by regulation, law or company policy. Other factors that influence the decision may be less clearly defined, and the decision-making process can very often be influenced by the implicit core values that society has acquired, including the expectations of manner and customary rule systems.

For engineers to meet societal needs without endangering the Earth's natural systems and resources they need to understand the relationship between engineering and society, but I deemed it necessary for the students to have an understanding of values, morality, ethics, etiquette, dignity, and conscience before they began the values-based decision-making process. These understandings are intended to serve as informal rules as to how society expects an individual to behave (Evolutionary Ethics.com, 1999).

The most common decisions in one's private life require individuals to make decisions on the basis of taken-as-shared values, conscience and etiquette. At another level there are times when the choices made, whether by an individual or a nation, reflect the core values of those who make the decisions

(Randerson, 1991). However, simply learning a rule does not guarantee that an engineer will be able to use it to solve a problem and they need to understand the IPENZ Code of Ethics, which gives them a guideline to the values of the profession. There is no grand theory that will guide all decision-making, and before solving a problem it is important to understand what type of issue is being dealt with. Rabins, Harris, Pritchard, and Lowery (2005) divide a contentious issue into factual claims, disputed conceptual issues, and ethical issues. All three categories are likely to be encountered in the course of an engineering career.

7.2 Engineering decision-making

7.2.1 Decision-making outcomes with certainty or uncertainty

Before we begin to look at values-based decision-making in engineering, it is important to speculate possible decision-making outcomes in terms of certainty and uncertainty (Forsberg & Kaiser, 2002). Taking this further, one could argue generally that one of the following four types of outcome will result from a decision:

1. Decisions with certainty – there is only one possible outcome.
2. Decisions with risk – where it is necessary to assess all the possible outcomes and assess the probability of each outcome.
3. Decisions with uncertainty – the possibilities of each outcome may be known, but the probability for each is not known.
4. Decisions under ignorance – there is no predictability of an outcome.

On consideration, very few engineering decisions based on a moral solution have only one possible outcome (type 1), although it is very good if we can be certain. Engineers should rarely if ever make decisions in which the outcome is unpredictable (type 4). If the decision is uncertain (type 3) then the probability and risks must be assessed. When making a decision in which risk is involved (type 2), quite often the risk can be minimised through good engineering and the main ethical concern here is to determine an acceptable level of risk. Good engineering decision-making with consideration of safety should always guide the process (IPENZ, 2005).

7.2.2 Decision-making process

Engineering undergraduates learn to apply their technical skills with higher-order intellectual problems where decision-making involves the application of engineering principles through the manufacturing or enabling process in the design of systems and the selection of suitable engineering components. However, engineers are also called upon to apply their skills in a wide variety of legal, institutional, and environmental settings, which may include technology-driven social change. Their wisdom in engineering decision-making should be characterised by a sound knowledge and application of regulations and public safety (IPENZ, 2005). In addition, the following steps in the decision-making process should help identify the best solution to a problem (Smith, 1996):

1. *Recognise the problem*; define the problem in terms of goals, scope and meaning.
2. *Set objectives*; set the objectives for the desired output.
3. *Research*; gather as much information that is possible that is relevant, accurate, complete, and timely.
4. *Identify and evaluate all alternative solutions*; in terms of feasibility, acceptability, risk, benefits, possible negative outcomes, environment, short term consequences, long term consequences, moral principles, honesty, equality, dignity and fairness to others.
5. *Evaluate the options*; identify the positively and negatively affected parties.
6. *Select the best option*; select from engineering, environmental, sustainable and economic perspectives.
7. *Implement the option*.
8. *Evaluate the results*. (p. 42)

To give students the opportunity to practise their knowledge using such a decision-making process a discussion point is required.

Very often when using such a decision-making process, one can reach a point of *dilemma*, where we have to carefully weigh our options.

7.3 An ethical dilemma

A challenging ethical problem such as the *Challenger* disaster is sometimes referred to as an ethical dilemma. Konell (2005) defined a dilemma as a serious problem which has two or more alternative courses of action. Each of the alternatives can to some extent be a painful solution, but ignoring the problem may also have painful consequences. When considering a dilemma the risk needs to be evaluated.

Here is an example of the evaluation of risk that I present to students for them to participate in the discussion of a dilemma.

7.3.1 The robber's dilemma

Two armed robbers are being interviewed separately, and are given these choices (Boberski, 2006):

1. Say nothing and get 1 year for possessing a firearm.
2. Admit armed robbery and get 10 years.
3. Plead not guilty, be found guilty and get 20 years.
4. Blame it on your mate – you go free and your mate gets 20 years.
5. If your mate blames you, he goes free and you get 20 years. (p. 95)

This example illustrates a dilemma with more than two choices, and one in which saying nothing is also a decision with a risk. Each option has the risk of a negative outcome for one of the robbers, and the dilemma becomes a question of which one the robber should risk. The value of this dilemma is that it illustrates that there may not always be one clear solution to a problem.

While this is an entertaining dilemma that my classes enjoy discussing, and perhaps a modern-day equivalent to Stockton's (1882) dilemma *The Lady or the Tiger?*, it needs to be followed with a real-life engineering dilemma.

One of the paradigm case-studies is useful for students at this point. The *Challenger, Ford Pinto* and *Chernobyl* nuclear power station case-studies all give students the opportunity to use their ethical and decision-making knowledge. The case-study I discuss here is the *Challenger* space shuttle dilemma, which shows the students the pressure that an experienced engineer may be placed under.

7.3.2 The *Challenger* dilemma

The *Challenger* disaster was a classic example of a dilemma an engineer found himself in that had many influencing factors and presented two choices: to allow the launch to proceed or not. The background to this dilemma is presented in appendix 2 (pp. 65-76). Figure 7 (next page) shows the influencing factors that the Vice President of Morton Thiokol, Robert Lund, had to consider before allowing the *Challenger* space shuttle to launch on its final and fatal flight (Davis, 1991; Pinkus, Shuman, & Hummon, 1997; Pritchard, 1992).

Students are given the opportunity in class-group discussion to consider the dilemma in terms of consequential and non-consequential theory and to categorise the final decision. Remember, ethics is subjective and, as Seedhouse (2005) noted, “there is no such thing as an ethics expert” (p. 117). What I see as important here is the unknown weightings of the influences on the decision, because we will never know what was going through Robert Lund’s mind at the time. We can only speculate on the pressure he was under, but what emerges as crucial is that a post-1986 engineering code of ethics would have given him weightings in which safety was an overriding factor (Davis, 1991; Texas A & M University, 2002).

Nevertheless, one must consider that if Lund had not allowed the launch, nothing would have happened. What if he had done it again the next day? Is it possible that he had to consider the preservation of his career as a weighting factor? This leads to an examination of career preservation.

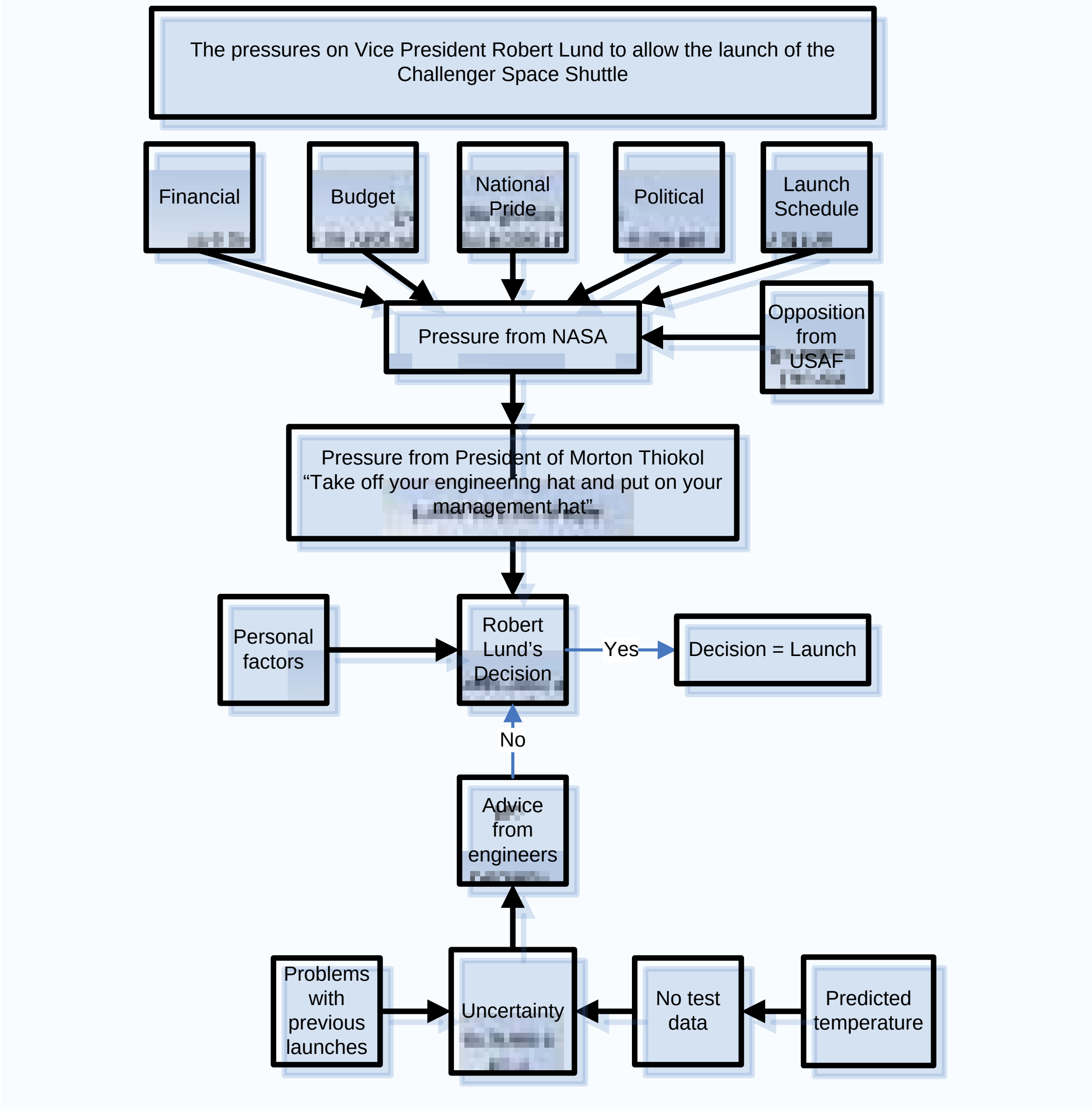

Figure 7. The pressures on Robert Lund's decision.

7.4 Career preservation in decision-making

A consideration in an ethical decision such as Robert Lund's might be whether the decision is one that may enhance or damage the decision-maker's own career. When a conscience issue involves an activity that is in a company employee's view ethically corrupt, a reluctance to comply or obey carries the possible danger of some vindictiveness for refusing to take part.

A classic example of staff reluctance to speak publicly on such an issue involved the Ford Motor Company's *Pinto* passenger vehicle which had a serious design flaw in the fuel tank that resulted in the deaths of many drivers and passengers who were burnt to death as a result of rear-end collisions. The Ford engineers had many opportunities to correct the faulty design of the *Pinto*, but as deaths and injuries continued to occur, Ford conducted a financial analysis on the *Pinto* and argued for the delay in correcting the design flaw based on a cost-benefit analysis of altering the fuel tanks (Lacey, 1987). Lacey recalls that during the resulting prosecution of the Ford Motor Company, one engineer admitted to being expected by the company to participate in building a car that he knew to be unsafe, but he feared he may have been dismissed if he told anyone outside the company.

Hinchcliff (1997) refers to this type of reporting as *whistle blowing*, stating "we would have to admit that ethical resistance to corrupt behaviour can sometimes end in tragic circumstances" (p. 231).

Taking the above considerations into account, the Ford engineer was presented with a difficult choice. Very often such a challenging ethical problem will constitute a dilemma. In such cases where no middle ground is possible, the decision-maker(s) must make a choice at the risk of upsetting or alienating one party. A self-test (see below) may be useful at this point.

7.5 Testing the impact of your decision

7.5.1 A self-test

Once a values-based decision has been made, an ethical decision may be checked using the Kallman and Grillo (1993) self-test:

> Ask yourself the following questions on the ethics and professionalism of your decision:
>
> 1. List the stakeholders who are those with something to lose or win in this case.
> 2. Should someone have done or not done something earlier?
> 3. Who benefits here? Who is harmed here? There could be multiple answers.

4. Apply three important ethical tests to your decision, and evaluate a decision from the perspective of each of these tests.

   (a). Use the *Golden Rule Test* which asks whether you would be willing to accept the consequence of your action if you were the one affected.

   (b). Use the *Rights Test* and ask yourself whether anyone's rights, such as the right to free and informed consent and the right to equal treatment are being violated by this course of action.

   (c). The *Utilitarian Test* asks whether a course of action produces the greatest overall good for the greatest number of people, regardless of what it does to a few individuals.

5. Ask yourself how this situation could be prevented from occurring again. (p. 64)

7.5.2 An alternative test

This test may be used to examine the impact a decision may have and was designed to simplify the ethical decision-making process for the students. In each of these questions examples may be given, which usually facilitates class discussion (National Institute for Engineering Ethics, 2003):

> Test your impending decision from society's point of view by asking yourself the following questions:
>
> 1. *Harm test*: Do the benefits outweigh the harms? Short term? Long term?
> 2. *Reversibility test*: Would I think this choice was good if I traded places?
> 3. *Colleague test*: What would professional colleagues say?
> 4. *Legality test*: Would this choice violate a law or a policy of my employer?
> 5. *Publicity test*: How would this choice look on the front page of the newspaper?
> 6. *Common practice test*: What if everyone behaved this way?
> 7. *Wise relative test*: What would my wise old Aunt or Uncle say? (p. 6)

7.5.3 Decision-making and a conflict of interest

One further test specifically focuses on conflict of interest. A professional employee may find themselves in a situation where a financial interest, a private or personal interest, or a business interest may be sufficient to influence, or appear to influence, their decision-making. In such a situation where the impartiality of one's professional judgements or decision-making in the execution of official employment duties is in question, a conflict of interest exists (Bondesio, 2010). According to Bondesio:

> Conflicts of interest may be actual, or be perceived to exist at some time in the future. Perception of a conflict of interest is important to consider because public confidence in the integrity of any organisation is vital. (p. 1)

Students need to understand that it will be their responsibility to disclose such a conflict of interest in these circumstances. While a conflict of interest is not necessarily unethical or illegal, it would be wrong to avoid its disclosure with the intention of influencing a decision in one's favour; such an action could lead to charges of misconduct or corruption.

There are many circumstances where a conflict of interest can arise professionally and Bondesio (2010) lists the most common areas where such an accusation may arise:

- Tenders and contracts.
- Procurement.
- Allocation of grants, scholarships, awards including honorary awards.
- Gifts, benefits and hospitality.
- Sponsorships.
- Recruitment, selection and appointment.
- Secondary employment. (p. 2)

To help the identification of a conflict of interest, the Integrity Coordinating Group (2004), which was responsible for promoting and strengthening integrity in Western Australian public bodies, provided a checklist that is referred to as the *6 Ps*. While this checklist was intended for public figures, it can be applied to engineering.

1. *Public duty versus private interest*: Do I have personal or private interests that may conflict, or be perceived to conflict with my public duty?
2. *Potentialities*: Could there be benefits for me now, or in the future, that could cast doubt on my objectivity?
3. *Perception*: How will my involvement in the decision/action be perceived by others? Are there risks associated for me/my organisation?
4. *Proportionality*: Does my involvement in the decision appear fair and reasonable in all the circumstances?
5. *Presence of mind*: What are the consequences if I ignore the conflict of interest? What if my involvement was questioned publicly?
6. *Promises*: Have I made any promises or comments in relation to the matter? Do I stand to gain or lose from the proposed action/decision? (p. 1)

My research had now brought me to the point where it was time to assemble the curriculum content, which is outlined in chapter 8.

CHAPTER 8
Curriculum Content

8.1 Introduction

This chapter elaborates on the curriculum content of the engineering ethics curriculum that has developed and evolved over four cycles of action research. The book (appendix 2) was the result of the first cycle which ended in December 2006, and this chapter updates my views, which have been refined, supplemented and enhanced in the intervening four years.

The first difficulty was to decide exactly what to teach engineering students about ethical theory. The objectives of the curriculum content were an expectation of the change required by the students to reach the previously mentioned student outcomes, and would be closely linked to the presentation and assessment techniques of the curriculum design. The criteria for selecting the content would include the question – *What is significant, important, valid, useful, feasible, learnable and feasible, but most importantly, interesting?*

There are countless books available on the subjects of psychology, philosophy and ethics which cover the subject to a high degree of theoretical knowledge, far beyond what I was intending. However, I considered that some theory was necessary, and Lynch (1997) dismisses a *theory-free* method of discussing case-studies without any moral and ethical foundation. Instead, Lynch suggests an approach involving a modest amount of moral and ethical reasoning theory to support the analysis of ethical engineering case-studies, and I decided to adopt this approach and teach just enough theory for a basic understanding. Knowing the students through my involvement with them in other papers, I suspected that too much theory could precipitate disinterest, and I was not willing to push them towards such a reaction. As it was, I was trying to bring about an intervention with a paper that had been relatively unpopular.

I had an idea of the goals and outcome expectations resulting from literature reviews covered in the preceding chapters, but before planning the curriculum content in detail I decided to review the existing 2005 curriculum.

8.2 The first cycle

To begin the task of taking over an existing paper, in 2005 I observed the previous work of Buckeridge and Grinwald (2003), reviewed the course material, and attended the class. They had designed and implemented an ethics module for engineering students in 2001 aimed at the fourth (and final) year of the Bachelor of Engineering. At AUT students were offered it as a 15-point level seven paper, called Engineering Studies (AUT 70.7005) and the ethics section (50%) of that module had always been taught in a three-day block course. Accompanying the course was a book entitled *Ethics and the Professional* (Buckeridge, 2001a). This book was prescribed as a mandatory text for the three-day course at AUT, RMIT University in Melbourne, and Hochschule Wismar University of Technology in Germany (Buckeridge, 2003).

As previously stated, university engineering education is now required to include the relationship between society and engineering, together with an understanding of ethics. At times an engineer may be faced with a contentious issue (dilemma) not covered by regulations or the soundness of design (Keirl, 2003) and formal rules and regulatory systems put in place by a society or profession are not always sufficient to guide people in the complexities of decision-making (Ward, 2003). Very often judgement will be required, and ethical decision-making is a way of bridging the gap between the formal and informal type of decision, as an informal system of decision-making with clear ethical guidelines (Davis, 1991; Keirl, 2003; Winner, 1990).

With these objectives in mind, I reviewed *Ethics and the Professional* (Buckeridge, 2001a). In my opinion it did not fulfil its intended purpose. If I read a book with such a title, I would expect on completion to either understand the relationship between ethics and the professional, or as a professional myself, understand ethics.

I concluded that neither the book nor the curriculum content fulfilled the IPENZ (2002) recommendations that the paper should teach the social responsibilities in engineering and include an explanation of values, morality and ethics, ethical decision-making in engineering, codes of ethics and ethics in research. The ethical case-studies provided in the book consisted of obscure (relative to engineering) scientific and political case-studies that bore no relation to engineering studies. The relationship between technology and society was not discussed. Ethical theory received a superficial treatment, and the book's brief explanations of moral and ethical theory contained definitions that were misleading, inadequate or simply wrong. Finally, it did not cover an ethical engineering decision-making process.

Having an outline for the inclusion of ethics material in the AUT engineering curriculum from the IPENZ graduate profiles, I again looked at the Accord requirements (Figure 5 section 4.4).

Before delivering the curriculum content I had to decide between the two choices I had at this point.

1. Adopt the current curriculum and try to introduce supplementary information to meet my interpretation of the requirements.
2. Design new curriculum content.

Option 1 was probably the easiest path at that time, but it had an important limitation – it was primarily a corrective option as the simplest way to reset a wayward course, and would not generate fresh insights (Garvin, 2000).

In considering the consequences of these choices, I was finally influenced by the unpopularity of the existing course, and seized the opportunity to create a worthwhile solution. I decided that a substantially new module was needed which covered the social responsibilities in engineering, and which would include the relationship with society, values and ethics, ethical decision-making in engineering, codes of ethics, ethics in research, and the use of case-studies specific to ethics in engineering. I felt that the existing content would take considerable time to adapt and the best approach was to start afresh.

Of course, as with most ambitious plans, there was no guarantee for success, but there certainly was the potential for improvement. I envisaged the new curriculum being linked to prior learning and reflection through literature review. The AUT library was a useful starting point for resources; it offers a collection of online electronic resources designed to assist staff and students to access, study and conduct research from desktop computers. During this first cycle I used the online search tools extensively to identify prospective supporting material. From this information, which included catalogues, databases, subject guides, e-journals, e-references, online enquiries, old examination papers and archives, I assembled a large file of reference material. Before beginning the task of writing the curriculum content I reviewed an extensive number of journal and conference papers, and several books. I wrote a brief summary of the papers and books that I thought might be useful and filed them.

The Accord standards (figure 5, section 4.4) for engineering undergraduate degrees require an understanding of ethical engineering responsibility which includes an understanding of the impact engineering can have in a societal, legal and cultural sense. Williams (2003) sees this understanding as a preparation for life in a world where there is an interrelation between technological, scientific, humanistic and social issues; yet the Accords are loose enough to allow national and local innovation.

The first question to research was the relationship between engineering and society. As I stated in chapter 3, people dealing with technology can include scientists, engineers, technicians and semi-skilled workers, and Thring (1992) used the word *engineer* to represent an all-encompassing group including "all applied scientists, architects and technologists (p. 222).

I decided that while it is important to describe the relationship between engineering and society, which includes the harm engineers can cause to society and our environment, the relationship between technology and society would also be an important feature of the curriculum content (Daugherty, 2003; Staudenmaier, 1989; Winner, 1990).

To give an understanding of this relationship I needed to research and understand it myself. This led back to the question *What is technology?*, which I covered in 3.4 in the literature review. As I write in 2010, despite my efforts to convince them otherwise, many of the students' essays tend to express technology in terms of modern artefacts or useful products. One would be led to believe that technology comprised only cell phones and the Internet, without which, they inform me, society would cease to function. However, on reflection, they do consider the social context of these devices within their social groups and cultures.

Technology includes many knowledge bases, and since I expected that students would be aware of these, I did not plan for them to perceive technology in the exclusive role of applied science.

There are issues with economic, social, personal, and environmental needs and constraints which would need to be considered (Gardner, 1995).

I found my review files useful both in understanding ethics when designing the curriculum content in the first two cycles, and when teaching the subject in all four cycles. However, none of the books in the file I assembled contained all of the material I was looking for, which led to my decision to write a text book. The text book in appendix 2 (Reid, 2006) acknowledges all of the authors that I eventually drew on in the process of designing the curriculum content in the first cycle of 2005, and in the planning of cycle 2 in 2006. This chapter acknowledges additional authors I have used in cycles 3 and 4.

The question at this point was just how much theory to cover, and Herkert's (2000b) comments are apt here:

> Recently, philosophers have also begun to challenge the predominance of ethical theory in coming to grips with ethics in an applied setting, arguing that formal discussion of abstract moral theories is not necessary in doing professional ethics, and indeed might be counter-productive by turning off practitioners who doubt its relevance. (p. 305)

I agree with Herkert, but I felt that the prospective ethics lecturer must be careful not to waste students' time with case-studies and rhetoric without offering any understanding of ethical theory. I believe that students need a basic comprehension of ethical theory which can be called on when reviewing the case-studies. So one question that must be answered is what exactly is it that we want the students to understand? In its simplest form, I believe that if you want to be ethical you should have a philosophy in life that you *do no harm*.

Such a philosophy needs to be understood by undergraduates in terms of knowing, doing and thinking ethics. This philosophy can be applied to all facets of one's life, from ethical behaviour, social relationships, and our treatment of the environment. Davis (2002) maintained that students learned basic moral principles when they were young and arrive in class more or less morally mature: "We have little to teach them about ordinary morality, not so ethics" (p. 2). It then becomes the social responsibility of educators in university engineering schools to examine, question and attempt to develop the ethical and sustainability education of engineering students.

One way to design a curriculum is to begin by establishing the desired goals of such a curriculum. A curriculum that offers education rather than skill training requires an understanding on the part of the designer of what this education is intended to achieve. Clark (2005) offers the view that "the aim of education is not some extrinsic goal, like getting a job. Rather, the aims are intrinsic to education. One candidate for the aim of education is the development of good persons" (p.151). Clark explained that this was not just a projection of the expected achievements of graduates in the early years of their careers after graduation as a result of their educational preparation, but also the expectations of their performance in the workforce after three to five years.

Peters (1966) set out two aspects for judging whether a programme is educational or specific skill training:

1. *Normative aspect*: There is an expectation that in the curriculum something worthwhile is being or has been intentionally transmitted in a morally acceptable manner.
2. *Cognitive aspect*: It is not sufficient just to transmit knowledge as a collection of facts, but that an educated person must possess an understanding of the reasoning behind the knowledge gained. (p. 25)

Peters (1966), working with the concept of liberal education, suggests the learning objectives we should aim for. Peters promotes an education where the knowledge acquired should include evidence and pursuit of truth rather than involve training in particular skills, and believes that we must produce educated graduates who have a wide holistic education in which knowledge is not inert and the possession of knowledge changes the way things are viewed.

In terms of engineering ethics education, Harris, Davis, Prichard and Rabins (1996) provided a list of possible outcomes for ethical instruction:

1. Stimulate the ethical imagination of the students.
2. Help students recognise ethical issues.
3. Help students analyse key ethical principles.
4. Help students deal with ambiguity.
5. Encourage students to take ethics seriously.
6. Increase student sensitivity to ethical issues.
7. Increase student knowledge of relevant standards.
8. Improve ethical judgement.
9. Increase ethical willpower. (p. 93)

Haws (2001) suggests that ethical instruction may be divided into six pedagogical aspects: “professional codes, humanist readings, theoretical grounding, ethical heuristics, case-studies, and service learning” (p. 227). Haws cautions the novice teacher that while these may all have value in engineering education, “they are not all of equal value in engineering education” (p. 227).

Haws (2001) stressed that the last aspect (service learning), i.e. helping our students formulate, articulate and defend their ethical resolutions, can only be achieved with theoretical grounding. While I agree with this, I didn't interpret Haws' list as implying a fixed order for his pedagogical steps.

There appeared to be two approaches:

1. Follow Haws' (2001) pedagogical aspects in order and begin with the professional code of ethics, which I view as a *top-down approach*.
2. To adopt a *bottom-up approach* by giving the students an understanding of values, morality, ethics and the relationship between technology and society *before* I covered the IPENZ Code of Ethics, with the expectation of high moral standards, and the safety, health and welfare of the public.

Considering these two choices, I considered the five fundamental ethical values of the IPENZ Code of Ethics (IPENZ, 2005):

> 1. Protection of life and safeguarding people.
> 2. Care for the environment.
> 3. Community well-being.
> 4. Professionalism, integrity and competence.
> 5. Sustaining engineering knowledge. (p. 2)

I then thought that if all this is encompassed within ethics, then the bottom-up approach would be preferable to lead up to these fundamental issues. I decided use the relationship between society and technology as the starting point because, in my opinion, it is this relationship that most affects our culture as we adapt to new technology. I planned to begin the process of student understanding with the inclusion of:

1. The positive and negative effects of a decision, whether they are intentional or an unfortunate and unintentional by-product and consequences (Staudenmaier, 1989).
2. The relationship between design intention and the often unintended subsequent uses (Staudenmaier, 1989).
3. Both sides of the neutrality argument within which scientists and engineers sometimes embroil themselves (Ellul, 1964; White, 1978; Winner, 1990).

4. The success or failure of technologies which can be influenced and decided by society, or the guaranteed success by an open chequebook government defence policy, of which society may often benefit at a later date (Cardwell, 1995).
5. The afterthought required due to the speed of emergence of new technologies, which often exceed controls, ethical considerations and legal frameworks (Keirl, 2003).
6. The social equity issues of technology (Bush, 1983).

Keirl (2003) sees this societal relationship with technology as:

> a functional sense of engineering practice with a relational human input, where the identity and power relationships are shaped by the technologies with which we interact … as the raison d'etre of technology, power and empowerment are subject to attribution, distribution and ownership in equitable or inequitable and often contested ways. (p. 152)

As engineering students, they will be familiar with design procedure but Kierle (2003) suggests that they be encouraged to think of technology in terms of the following steps:

> 1. *Intention*: Before anything else at all, someone or some organisation has an intention. Key questions, particularly ethical ones, can be asked here.
> 2. *Design*: The weighing of competing variables also begs critical questioning and thinking.
> 3. *Manifestation*: When the technology is brought into being – it is made or created.
> 4. *Use*: When it is attributed different values by different stakeholders. (p. 151)

The next step was to decide what moral and ethical theory content would be included, and to use this in the process of good decision-making. Appendix 2 (pp. 46-116) itemises this theoretical content and the outcome of the research on decision-making principles included in the curriculum content. After this I planned to cover codes of ethics and ethics in research.

2006 curriculum content

The curriculum content to be presented in 2006 was divided into ten groups of weekly lectures as follows:

Chapter 1. Introduction to the social responsibilities of engineering.

Chapter 2. Technology and society.

Chapter 3. Technology and society – the relationship.

Chapter 4. Social engineering and society development.

Chapter 5. Moral theory.

Chapter 6. Moral theory in practice.

Chapter 7. Ethics in decision-making.

Chapter 8. Modern engineering decision-making.

Chapter 9. Codes of ethics.

Chapter 10. Ethics in engineering research.

Chapter 11. Student project engineering case-studies.

The subheadings of these chapters may be viewed in appendix 2 (pp. 6-9), and their scope is covered in the remainder of that appendix text. However, what should be noticed in this list is my intention of a progressive journey of understanding, leading towards case-studies with an incremental delivery of theory in which students' understanding was intended to be cumulative, that is, I was following a bottom-up approach.

8.3 The second cycle

I observed student confusion in reaction to the handout in the first presentation of the 2006 content. I noticed the second-language students (usually at least 60%) were using their English conversion dictionaries constantly to understand some of the terminology used. I therefore experienced misgivings about the amount of theoretical material I was presenting, and how I was presenting it. I had too much text on the PowerPoint slides and I could tell from the class attitude that reading it was considered quite boring.

However, my perception in the classroom was that the students appeared to be interested and responsive to the curriculum content.

Reviewing the first class in 2006, I felt the necessity to make changes. In the second cycle these changes included:

1. The removal of words that the students found difficult.
2. The simplification of the material presented.
3. A reduction of information on the screen.

I reviewed the order of presentation of some minor aspects within the main subject divisions of the curriculum content and decided on some minor alterations in presentation order in the planning for 2007, but the original order of chapters would remain the same.

Although the writings and principles of Aristotle's (384 – 322 BC) Virtue Theory were useful in outlining the history of ethics, I felt it needed to be made more relevant by the inclusion of improved examples. I decided that any examples needed to relate to engineering, or the community the students lived in. I also planned to introduce examples of historically significant people in the area of ethics such as Nelson Mandela, Martin Luther King, Gandhi, and Pope John-Paul II because the ethical aspirations of these people seemed well known to most students at that time and could contribute towards giving the students some form of common worldview.

The 2006 student handout was modified and the presentation slides were simplified. In both of these areas unusual words were removed, such as *epistemology* and others were replaced; for example I replaced the word *detrimental* with *harmful*. I also added glosses of potentially confusing words in parentheses. For example: *discerning (showing good taste and judgement)*.

I lessened the amount of ethical theory and made minor changes in the order of presentation to improve the coherence of the programme. The changes were a process of rationalising and I decided to make the theory as simple as possible with a reasonable coverage of consequentialism with an expansion of utilitarianism enveloped within it. In a similar way non-consequentialism was covered with deontology enveloped within it. I continued with a simplified treatment of Virtue Ethics theory, with current and pertinent examples of the theory.

In December 2006 I published *The Social Responsibilities of Engineering* (Reid, 2006, appendix 2) as the main curriculum resource. The contents (see pp. 6-9 of appendix 2) contains the subject list which I adopted as the curriculum content for the ethics component of the paper in 2007.

8.4 The third cycle

The use of plain language in the 2007 curriculum content appeared to make a difference in students' understanding. The reduction in pure ethical theory appeared to give a better balance between ethical theory, decision-making theory and decision-making practice. Relevant examples throughout the module improved class discussion and student interest. For example, the students were interested in the humanitarian work of people like Bob Geldorf (in 2007) and I found that class discussion was easier to induce with the highlighting of such well-known personalities.

As I reviewed the curriculum content in cycle 2, some sections of the curriculum content needed further clarification, and this is detailed in 8.4.3. Because the students come from a wide variety of cultures and many different countries, I thought it would be of interest to review the difference between living in a single-culture society and living in a multi-cultural environment such as Auckland.

After two years of teaching the paper, I had some misgivings about the order of presentation of the material. I had rejected what I had labelled as a top-down approach suggested by Haws (2001) and introduced a bottom-up approach.

However, at this point I questioned the value of teaching the decision-making process before students had covered the five fundamental ethical values of the IPENZ Code of Ethics (IPENZ, 1993). I couldn't see the point in discussing ethical decision-making if they didn't know the values, guidelines and minimum requirements expected by IPENZ.

Although the bottom-up approach appeared to have the same endpoint as Haws (2001), I could now see the value of his ordering of "professional codes, humanist readings, theoretical grounding, ethical heuristics, case-studies, and service learning" (p. 227).

I decided to introduce the five fundamental ethical values of the IPENZ Code of Ethics prior to the ethical decision-making process (see section 8.2). The full explanation and background to codes of ethics were covered in the penultimate lecture, but the introduction of the IPENZ's five canons was useful earlier in the series of lectures. In fact, the only difference in my approach to that of Haws (2001) in 2008 was where and how I introduced the Code of Ethics. I was starting to appreciate the value of reviewing other people's experience.

I progressively tried to give clearer definitions to avoid confusion over the difference between morality and ethics. Of particular importance in this cycle was the inclusion of the expectations of etiquette within the students' social context and, most importantly, the workplace. Discussions were introduced on how they would be expected to conduct themselves in industry, particularly on how they should behave towards and address fellow staff, senior staff, and the virtues of reliability and punctuality. In 2008 the subject was first introduced by getting them to agree that in social situations there are expectations of behaviour. For example, expectations concerning the way they should address their grandmother or aunt at a family gathering would be different to those concerning how they talked to their peers at a social gathering. This thread of discussion naturally led (as intended) to behavioural expectations at work.

The multi-cultural society

In 2008 I reviewed the concept of a single-cultural society where the moral standards are usually set by a single religion and/or set of customs. I compared the notion of a single authority (such as a church, religion or government doctrine) with New Zealand, where there are many cultures with widely varied beliefs and cultural practices. I also pointed out that in New Zealand the original religious beliefs of the early European colonisers still influence the society to this day. I gave the example of religious public holidays that are observed in this country at Christmas, Easter and Queen's Birthday. The European New Year is a public holiday but the Chinese and Jewish New Years are not. (I do not teach theology; I just explained that there are differences in culture and religious beliefs in a multi-cultural society.)

The engineer and society

In my opinion, to understand ethical engineering practice students must first understand the relationship between society and engineering (or technology). Thus, the curriculum began by addressing how engineers work within, and relate to, local and global societies. The content drew on lessons from the past, and noted the impact engineering has had on the worlds in which we live. These issues are updated annually to include current engineering issues. For example, when discussing their role as a critic and conscience of society, the students usually find examples to contribute from their own age group or social surroundings whom they consider to be effective critics and to represent the conscience of society.

The theory of ethics

The theories taught regarding consequentialism and non-consequentialism had not changed up until this cycle, but the explanations were embellished and the examples used had changed each year. For example, in cycle 3 I included the following issue for student discussion:

> Within the theory of consequentialism it can be argued that the Hiroshima atomic bomb produced good to the greatest number of people.

Non-consequentialism is the process of decision-making, which considers not the consequences, but what is right and wrong (Fieser & Dowden, 2004), and these opposite viewpoints were illustrated with the abortion issue:

1. A *consequentialist* approach is to consider the outcome and consequences to all parties concerned if the child is born.
2. A *non-consequentialist* attitude considers what is morally right, for example, considering that the foetus is a human individual, rather than the consequences of the birth.

Existentialism

In the process of preparing students for industry, it is important for them to consider how they fit into society and the workforce, including some of the expectations and limitations they may face. Consequently, to give students a clearer picture I embellished the discussions on existentialism in cycle 3. Existentialism focuses on individual existence and an individual's sense of meaning or overall view of life, placing an importance on subjectivity, individual freedom, and choice (Eiermann, 2002). During these discussions, the freedom of choice through which each human being creates his or her own nature was a primary theme. Because individuals are free to choose their own path, existentialists have argued that they must accept the risk and responsibility of their actions. As attractive as existentialism might sound in theory, the students recognised that they don't always have absolute existentialist freedom to do as they please. There are expectations of compliance with the law, etiquette and ethical behaviour within their culture, and a requirement of professional and ethical behaviour in their place of employment. Furthermore, my personal view is that one's freedom to act should be bound by moral principles. Nelson Mandela once said "to be free is not merely to cast off one's chains, but to live in a way that respects and enhances the freedom of others" (Cardy, 2009, p. A9).

An interesting feature of class discussions and essays regarding existentialism was a feeling of resentment by some female students that their cultures still followed the practice of arranged marriages, which was certainly not existentialist in their view.

I also explained that the existentialist theme of individual existence may be typical of some sections of society, but some consider the ideal existence to be an altruistic one, and the ideal society to be one in which the various groups need the goodwill of each other to prosper. Randerson (1991) is a proponent of this altruistic approach to ethical behaviour, and suggests that while ethical behaviour may guide individual endeavour and responsibility, it needs to recognise that we are all part of a wider community, and we should conduct our affairs in a way that recognises the need to consider the well-being of others who can be adversely affected by our actions, just as we can by theirs.

8.5 The fourth cycle

By the end of 2008 I felt that I was succeeding in relating ethical theory to the world the students lived in. The discussion on existentialism now seemed to have relevance; the theory seemed to interest them, provided I gave them examples that they could relate to. It was the way I presented the material in the lecture theatre that was the important factor here.

While the effect of explaining the multi-cultural society we live in is immeasurable within the classroom, there was quite a lot of interest and input to these discussions.

On reflection, it was important that the material was both interesting and relevant to their prospective employment. I had begun to explore ethical decision-making in terms of current relevance. I felt that I needed to shift the focus from the abstract and obscure to the practical, particularly in relation to commerce and industry, where decisions may sometimes not involve the consideration of others, and instead be based on self-interest.

I was now presenting a moral philosophy that was diverse in terms of moral viewpoints, but I was still unhappy with respect to the difference between morality and ethics. Although the students were unquestioning in my definitions of ethics and morality, there was still confusion amongst my EdD colleagues in the School of Education during discussion of moral theories. The constant argument I was given was that they are the same, and thus interchangeable.

Although the terms *morality* and *ethics* are certainly used interchangeably in everyday language by many people, they are not the same. I was determined to clarify this when planning for 2009.

The Collins *Concise English Dictionary* gives the definition of ethics as "a moral principle or set of moral values held by an individual or group" (Collins, 1986, p. 380). This was not at all helpful. In the first three cycles I had been telling the students that the term ethics tended to be used in the professional sense, rather than morality. While this is true, there was still confusion and I needed to do some more reading. In this cycle I reviewed Birch and Rasmussen (1993) and Grenz and Smith (2003) – their definitions of ethics were presented in chapter 6 (section 6.8.2). The distinctions they draw between ethics and morality formed the focal point of my explanation in 2009 and bear repeating here (emphasis in original):

> Ethics may be understood as the systematic study of the moral principles, values and obligations that guide human behaviour. While 'morality' concerns the *evaluation* of such behaviour as right or wrong, good or bad, 'ethics' is the *theoretical analysis* of the major ingredients that shape and validate these moral judgements. (p. 38)

At last I had a simple solution to the problem: morality is decision-making based on values. Ethics is the study and analysis of this.

Compared to the medical and legal professions, the profession of engineering is relatively new and in engineering decision-making there are fewer precedents to call on, particularly in those decisions involving resource management and development (Perlman & Varma, 2002). Consequently, I have tried each year to improve the presentation of the framework of moral and ethical theory that an engineer can call on when judgement is required. In 2009, I again refined the explanations to clarify the definitions of values, morality, ethics and etiquette.

In 2009 I introduced the self-test provided by Kallman and Grillo (1993) given in chapter 7 (section 7.5.1), which I thought was an improvement on the decision-making process I had been using (see appendix 2, pp 64-66).

To extend the ability of engineering students to resolve the diversities of moral viewpoints in cycle 4, I updated the work on social contract theory with current examples and included *natural law* and *contract law* before the introduction of Virtue Ethics. My desire was to reach the students on a personal level and to reinforce honesty and integrity issues I introduced the robbers' dilemma as a parable through which they could understand the options in the most simplistic of terms. In a quest for simplicity, I included the alternative test for decision-making (see chapter 7, section 7.5.2) from the National Institute for Engineering Ethics (2003). which I thought was more realistic and memorable. In addition, I wanted to help them develop an understanding on a professional level, and since we have a number of students from the armed services, I also planned an introduction to the concept of *just war* (see 8.5.3).

Detailed changes to some material presented during the fourth cycle are now itemised.

Ethical theory

In 2009 I expanded the explanations of non-consequentialism by summarising the definitions of Adair (2002). I felt that it was not enough just to say that non-consequentialism is *doing what is right* so I summarised the works of Adair (2002) with the following short definitions:

Teleological theory: The best action produces the greatest good for the most people with an emphasis on doing what is good rather than right.

Act utilitarianism: A teleological theory where the greatest good is achieved by the act that achieves the greatest amount of happiness for the greatest number of people.

Rule utilitarianism: A teleological theory where the greatest good is achieved for the greatest amount of people, but there has to be a set of rules which can be established by a culture or a professional society.

Deontological theory: Opposed to teleological theories, where we stress doing what is right.

Duty theory: A deontological theory where we stress the argument that ethical behaviour is based on duty.

Rights theory: Considering what a person's rights are.

Social contract theory

In cycle 4, I extended my effort to explain the social contract theory developed by the philosophers Hobbes, Locke and Rousseau which takes as its premise that there is an agreement between an individual and society in which the individual agrees to submit to the authority of the government and its laws in return for the government's protection of their life and property (Cox, 2008; Rawls, 2009). While the classical theories of Aristotle are also of interest, in 2009 I tried to bring a modern relevance into the theory. To endorse the explanation of the students' rights as citizens (in New Zealand), I briefly mentioned these examples in 2009:

1. The pursuit of happiness.
2. Women's rights.
3. Children's rights.
4. Gay rights.

5. Economic rights.

6. Justice and rights.

Natural law

In 2009 I enhanced the explanation of ethics, pointing out that a number of basic principles in ethics have their origins in natural law. Natural law (or the law of nature) holds that some laws are prescribed by nature, rather than by humans, and it has been influential in religious teachings where it has been the focus of some lively debate (Messer, 2006). I don't have religious discussions in class, except to point out that many behavioural principles of natural law in society originate from these teachings and principles. As such, natural law places an emphasis on the ability of humans to discern what is good and what is right. It fits with deontological thought and the background of the philosophy can be traced back to ancient Greek philosophy. Parts of natural law are also evident in religious works such as the Bible and the Koran.

Just war

A subset of natural law is the notion of a *just war* (or justified war). The purpose of the discussion on just war theory was not to indoctrinate, but to offer a more holistic view of the world students lived in, and how some cultures think. The just war theory is introduced to illustrate the moral principles and attitudes adopted by some cultures for the conduct of war. This theory is thought to represent the majority Christian view today, although its roots can be traced back to Plato and Aristotle. The theory is more easily understood by replacing *just* with *justifiable*. Messer (2006) divides the law into two sections:

(a) Justice in going to war

1. It must be waged by a lawful authority.
2. It must be for a just cause (to put right an undoubted wrong).
3. It must be a last resort – all peaceful means of resolving the conflict must have been exhausted.
4. The harm done by war must be proportionate to the good that is aimed for.

> 5. It must be waged with the right intention.
>
> 6. There must be reasonable hope of success – otherwise great harm will be done for no benefit.
>
> 7. The war should contribute to a new state of peace.
>
> (b) Justice in the conduct of war.
>
> 1. Non-combatants must not be directly attacked (the principle of discrimination).
>
> 2. The means used in fighting the war should be proportionate to the goals. (p. 57)

The lively discussion that arose in the class of 2009 involved the merits of the bombings of Dresden and Hiroshima.

Resolving conceptual and relevance issues

In 2009 I was searching for relevant engineering examples in decision-making. The following was added to give an engineering-based example of a conceptual issue.

> In engineering terms, the White Star Line were within the regulations with the number of lifeboats per tonnage on the *Titanic* (Titanic.com, undated), but the concept of tonnage per lifeboat was inappropriate for a liner carrying large numbers of crew and passengers. Had the White Star Line failed to consider the rights of these people? And, was the regulation on tonnage and lifeboats in the case of the *Titanic* relevant to the decision on the numbers of lifeboats?

The thesis now examines my options for teaching organisation and the timing of delivery of this curriculum content.

CHAPTER 9
Teaching Organisation

9.1 Introduction

This chapter outlines the options and the reasoning considered for the teaching organisation of the curriculum presentation that would meet the previously mentioned desired student learning outcomes. The approach to the presentation of material varies between institutions, and depends on their traditions and character. The rationale for the presentation at AUT is considered in this chapter. Most of the review and planning for the presentation format took place in the first cycle, which is given the greatest prominence. There were subsequent frustrating issues for me with the weekly programming in the next three cycles. These challenges and their solution are recorded briefly.

9.2 The first cycle

Having observed the existing module by attending the course and reviewing the curriculum, I had noted that in 2005 it had been conducted as a block course from Thursday to Saturday inclusively. I observed the following problems with this format:

1. Students had to be taken out of other classes which irritated other staff members whose teaching schedules were interrupted.
2. The students were required to be there on a Saturday.
3. Attendance on Saturdays was an irritation to students because many of them have part-time jobs and/or other commitments.

4. Many students complained that the block course's short duration meant they were unable to study the material to the extent they would have liked.
5. Many students complained that the allotted time was insufficient for group work and library searches on the case-studies, which had to be presented on the Saturday afternoon.
6. Although their assignments were to be submitted at a later date, there was no tutorial assistance available after the three-day block period.
7. The final examination took place at the end of the semester, but once again they claimed that they were not given tutorial assistance for adequate examination preparation.

Buckeridge and Grinwald (2003) had conducted the module in a three-day block at AUT, RMIT University in Melbourne, and the Hochschule Wismar University of Technology in Germany, and claimed that this three-day *total immersion education* set an international benchmark in the education of ethics (Buckeridge & Grinwald, 2003). The delivery rationale appears to be based on the convenience of international travel, and when I took over the paper, in order to raise the standards of work output to those expected of a level 7 paper I decided to deliver it as an incremental programme with one lecture a week over a full semester.

Separately from the immersion or incremental options I noted two further differences in the options of timing and delivery (Davis, 1999; Deans, 1999; McGregor et al., 2002; Newberry, 2004; Perlman & Varma, 2002; Staudenmaier, 1989; Whitbeck, 2002; Zandvoort et al., 2000). These may be categorised as:

1. *Stand-alone* (a self-contained paper); this stand-alone format can be either a block course of a few consecutive days or an incremental format of a weekly session of three hours per week over a semester,
2. *Across-the-board* (sometimes referred to as across-the-curriculum); the across-the-curriculum format is spread through many different papers.

Other institutions have considered the same options. For example, the University of Auckland offers a four-year Bachelor of Engineering. The final year of this programme comprises electives and projects and in 2005 the social engineering aspects were covered in two of the programme's second-year subjects. The programme covered what was referred to as the *present-day relevance of engineering* by investigating how engineering fits into the wider context of human social and cultural development (Personal conversation, H Stonyer, 13th August 2005). However, I later noted that in 2009 a compulsory paper in the final year has been added entitled *Professional and Sustainability Issues* (University of Auckland, 2009).

Stand-alone format

Proponents of the stand-alone format believe that the paper should comprise a separate course or module of tuition in engineering ethics (Buckeridge & Grinwald, 2003; Dick & Stimpson, 1999). Zandvoort et al. (2000) consider the advantages of the self-contained stand-alone format to be:

1. The students are intensively confronted with ethical issues for a substantial period of time.
2. It is possible to teach a more substantial amount of the relevant skills and in-depth knowledge.
3. The paper attracts better-qualified teachers or visiting lecturers. (p. 209)

Zandvoort et al. (2000) do however perceive a disadvantage of the stand-alone format, noting that "it may foster the notion already held by some students that ethics is a soft subject" (p. 209).

Across-the-board-format

Other educators are proponents of the across-the-board format where ethics is progressively introduced throughout the degree programme, and sometimes deliberately immersed into other subjects (Davis, 1999; Deans, 1999; McGregor et al., 2002; Perlman & Varma, 2002; Staudenmaier, 1989; Whitbeck, 2002;

Zandvoort et al., 2000). Zandvoort et al. describe the advantages of the across-the-curriculum approach:

> In the ideal case, ethical considerations can be brought in at any place in the engineering curriculum where it seems relevant. The across-the-curriculum approach thus acquaints students with ethics from the start of their studies, so that they will come to perceive ethical considerations and ethical reflection as an integral part of engineering. (p. 299)

Buckeridge (2001b) criticised the across-the-board curriculum delivery approach as a *drip-feed system*. With the introduction of ethical theory in the first year Buckeridge perceived the inability of students to appreciate what ethics is about, and thus without a reasonably comprehensive understanding of engineering practice, their ability to contextualise ethical issues in engineering was weak. I sympathised with this viewpoint but, as a novice in the subject, I considered the Zandvoort et al. (2000) advantages and was attracted to the across-the-board philosophy for engineering studies and the interleaving of ethics and sustainability throughout the entire programme. This concept had been adopted by the Institute of Engineers of Australia (IEAUS) in its approach to competency certification of chartered professional engineers at the time (Johnston et al., 2000), and was used in a number of Australian universities.

During the initial investigations on the curriculum delivery format I had favoured an across-the-board format, but quickly found that to introduce an ethics curriculum across-the-board would necessitate the co-operation of other lecturers. I found that at AUT many of my colleagues had little interest in ethics and I encountered their scepticism. As I proceeded I quickly discovered that changing to an across-the-board style might have been counterproductive to my goals of curriculum design. My feelings about this were reinforced by Claxton and Carr (1991), who wrote that any changes enacted without the commitment of teachers may fail to convey the spirit anticipated, and instead, the curriculum may be implemented in a rigid, mechanical way. I read a great deal into this profound statement, undoubtedly, based on Claxton and Carr's research and experience. As a consequence I formed the opinion that one dedicated lecturer was a compelling justification for the stand-alone format and that there was comparatively little to be gained by asking disinterested people to move outside their comfort zone. However, our School of Engineering had previously used the stand-alone format and I felt that I could not justify such a significant change in presentation format. This preference at AUT for the stand-alone paper was based on the convenience of administration at the time in the School of Engineering. I accepted this decision; it seemed to offer an expedient path to proceed because I would be designing the curriculum myself without the restraints of collective input.

Timing of the module

Another concern was related to the timing of the module. If I was going to conduct a stand-alone module, when was the most appropriate time? Hinchcliff (1997) suggested that students “should have developed a basic understanding of the techniques, processes, priorities and activities of their profession before taking the [engineering ethics] course” (p. 237). However, the paper was already scheduled for the final year of both AUT engineering degree papers so it was not a decision for me to make. The quandary at this point was how to deliver it.

Total immersion or full-semester format?

The stand-alone delivery format can be either taught as a block, or spread out over the semester and it was here that I had a choice. Buckeridge and Grinwald (2003) conceded that in their experience most engineering studies papers are run over a full semester of about 14 weeks, and they weigh the advantages of the full-semester format against their full-immersion format. They see full-semester formats in these terms:

1. They fit well in the existing timetable system.
2. They conform to the general structure of other papers (and as such are familiar to students).
3. They permit gradual learning (or drip feeding) of students over an extended period.

4. They permit cross-referencing to other papers running concurrently. (p. 2)

Buckeridge and Grinwald commented that a quick analysis of these advantages may lead the prospective ethics teacher to conclude that the full-semester format is the best way to conduct the paper. If that was their conclusion, I wondered why they did not adopt this plan. Although Buckeridge and Grinwald maintained that the first of the above two advantages is primarily administrative, permitting a homogenous semester of uniform class/workshop duration in which human and physical resource is maximised, they conceded nevertheless that a structured programme of learning over an extended period of time has both advantages and disadvantages (Buckeridge & Grinwald, 2003) (emphasis in original):

1. It provides the opportunity for the delivery of a more sedate (or less threatening) progression of ideas, many of which may be unfamiliar to the students.
2. Regular feedback is possible.
3. Students can afford to miss a class without severe consequences.
4. The learning environment is likely to be more impersonal, especially in large lecture theatres.
5. This assessment and outcomes of this type of structure will naturally drift towards a *marks-oriented* pedagogic paradigm.
6. The relevance of the material can be demonstrated in other papers by cross-referencing between papers. (p. 3)

As I reflect in 2010, all of their points have some validity, but, notwithstanding these observations, Buckeridge and Grinwald (2003) concluded that their full-immersion format was the better choice because their three-day block module had the following advantages:

1. It is a full-subject immersion environment.
2. All topics studied pertain to the same general topic.
3. It lends itself to interactive teaching where group projects are programmed.

4. It is not marks oriented.
5. It is of short duration.
6. It has an intense learning environment.
7. It demands a high level of group interaction.
8. It has a restriction on the number of students enrolled in the paper (the upper limit is 50 students). (p. 4)

I disagreed with this at the time, as the format was shown to be unpopular with both staff and students (personal conversations with other AUT staff members, 2005). I did not realise at the time that the number of students would exceed 50 in the first cycle and their suggested upper limit transpired to be valid, and one to give me concern in the future.

Considering all the reviews and advice I had obtained, my instinct, based on my own teaching experience, was to deliver the module over a full semester in 2006. This was the format which I was used to following in my teaching, and a format which gave me time to prepare and deliver in short intense bursts of enthusiasm, with the opportunity for formative feedback as the paper proceeded. This was in my view the primary advantage – I would have the time to deal with the enquires and anxieties of the students over a weekly cycle.

9.3 The second cycle

In the first year of 2006 the Engineering Studies paper was divided into the two sections of ethics and sustainability and each was allocated an hour and a half each week. At this time I had been teaching one and a half hours per week on a Wednesday, and the sustainability lecturer (a part-time lecturer from industry) taught the other hour and a half on Fridays. One observation was that the students required coaching in managing large Word documents, and guidance on referencing and the optional use of the Endnote programme. Consequently, part of the weekly time allocation in the classroom had been for tutorial sessions to answer questions about group and assignment work, which usually exceeded the allocated class time.

On reflection, In terms of regular feedback, some of my colleagues held the view that these were senior students who should not require feedback. I found that they did need it in the Engineering Studies paper, if only in the form of clarification at the end of class regarding their assignment. The feedback I found critical was the coaching they required to produce a referenced research report to a high standard. Offering assistance in these tutorial sessions after the class time had ended, and at any time they called in to my office appeared to help, as many had no idea how to conduct a literature review or how to reference a report properly. The full semester gave me the opportunity to allow the students to develop their assignments and projects over a longer period of time, and take advantage of extra time for weekly tutorial assistance sessions. On reflection, the weekly format had suited my teaching style and customary student support. Furthermore, I was beginning to appreciate the views of Zandvoort et al. (2000) that a self-contained stand-alone module offered opportunities for more intensive learning and in-depth knowledge.

In 2007 the sustainability lecturer, for personal reasons, wanted to teach on alternative weeks, so I taught the ethics module every second week for three hours and covered two chapters in each session.

9.4 The third cycle

Observing the paper organisation for 2007, the problems with this fortnightly format were:

1. Three hours is a long time to keep students interested in ethics.
2. I was not seeing them each week to answer questions about their assignments and case-studies and I felt distanced from the paper with this irregular class contact.

I felt that the 2007 effort had been disjointed. There was no teamwork due to the remoteness of the part-time sustainability lecturer. Consequently, I conducted extra voluntary sessions during the paper that focused on report-writing and referencing skills.

I felt at this stage that the organisation was very disappointing. By default, I was responsible for all administration in 2007 including publishing, delivering assignments and exams to the sustainability lecturer and collecting them, all data entry, examination boards and hand back. I reflected on my frustration at the time and felt that the organisation was counterproductive.

I hoped for an improvement in 2008.

In 2008 the timing of the paper was again driven by the part-time sustainability lecturer who was only available for the first half of the semester because of other commitments. Despite my protests, I had no choice but to accept this situation and I did not begin teaching the class until week six. Several significant timing and assessment issues arose, which I itemise in the next cycle of reflection in 9.5.2.

In 2008 AUT had adopted a university-wide policy to provide the students with access to all of the information through the AUT online system using the software Blackboard. This system provided students with the paper descriptors, assessment schedule, assignments, various notes such as APA 5th edition referencing rules, and the PowerPoint presentations which were placed there after each lecture. I was now able to put the opinions that resulted from group discussions onto PowerPoint slides and then onto Blackboard. At the end of the day's presentation, I copied the slides to Blackboard. The students subsequently had online access to the material for the remainder of the paper.

9.5 The fourth cycle

In 2008 the number of students had increased to over 150 and I experienced difficulty preparing them for an exam, assignment and case-study in the second six weeks allocated to me for teaching. Furthermore, the student appraisal for the 2008 paper had a student dissatisfaction level of 25%. I too was dissatisfied, because the organisation was as follows:

1. The Head of School decided to reappoint the sustainability lecturer again for half the semester.

2. I was expected to carry all the administrative work for both modules. This included extra tasks due to her unavailability for picking up assignments and delivering completed marking.

3. I had no choice in the timing of the teaching.

4. In the second six weeks the students were now faced with an ethics assignment, preparation for their two case-study presentations and reports, and preparation for the final exam. Their workload seemed too pressurised.

5. My teaching was again late in the programme and it was difficult to get all the assignments back to the students before the final exam. This rendered the assessment useless in terms of formative feedback.

I do not consider the provision of information by Blackboard to be a teaching tool. Its introduction was simply the result of the university's desire to reduce the printing of handouts, and the cost of printing the material I provided was born by the students. I found the disadvantage of the combined PowerPoint/Blackboard format to be that some students did not bother coming to class in the belief that they could do the whole paper from home. Ironically, the group of students who attended the voluntary revision class in week 13 consisted mainly of those who attended all of the classes.

Although I was in charge of this paper, the problem of programme timing to suit the guest lecturer was out of my control; the decisions were being made by the Head of the School.

I came to believe that the ethics assignment needed to be done in the first half of the semester, and that the students needed a more balanced workload.

Furthermore, I thought a longer period was desirable to coach the students in document management and referencing. In 2008 I had been better prepared for the report-writing aspect of classes and spent time on this from the first lecture, introducing referencing and the Endnote program during week 6 of the paper; however, this was too late for the sustainability assignment.

The feedback I received revealed a twofold dissatisfaction:

1. The students' dissatisfaction with the organisation of the paper was reflected in their appraisals.

2. The sustainability lecturer expressed her disappointment at the lack of document management skills shown by the students in their assignment for her and requested that we do something about it. (On reflection, I couldn't have done anything about this because I had not seen them before they handed in her assignment.)

Early in 2009, the Engineering Studies paper appeared on a list of unsatisfactory papers issued by the Faculty office. This classification occurs after the students' ratings of the paper are assessed. I was requested by the School Registrar to explain what I was going to do to improve the paper. At the same time, the sustainability lecturer requested permission to present her half of the paper in 2009 using short blocks, which did not, in my view, lead to a coherent programme.

I asked if a new lecturer could be found and one was subsequently appointed from industry through a process that I was involved in.

Together we organised a three-hour class on Friday mornings in which we took half of the time each (with a short break at the changeover point during which we would be there together answering questions).

With the burgeoning class size (now 150 plus), the tuition on literature review and referencing became more formalised throughout the curriculum structure and I enjoyed the co-operation of the other lecturer as we conducted these lessons together. We synchronised tuition on report-writing skills so that both of us covered a planned area on the same day. We posted instructions for APA 5th Edition and Endnote on Blackboard for the students' reference.

This method or timing in 2009 seemed much more satisfactory, and had further advantages:

1. I was now in communication with the sustainability lecturer on a weekly basis.
2. At times we were talking to the class and answering questions together.
3. We shared the instruction in referencing, Word and Endnote.
4. We coordinated the teaching of report writing and referencing.

In 2009 the student dissatisfaction for the paper dropped to about 2% (only three students out of 157 were unhappy with the paper). The action we took in the fourth cycle seemed to overcome the timing issues of the third cycle, and had a positive effect on all three assessment tasks. The changes we made to the assessment in the fourth cycle are detailed in chapter 11.

The next chapter reviews my teaching approach.

CHAPTER 10
Teaching Approach

10.1 Teaching approach

At this point in the research, the question became w*hat educational experiences can be provided that are likely to attain the student outcomes?*

The approach chosen should be feasible in terms of staff expertise and facilities available, but it should optimise the development of student skills to understand and rationalise, stimulating them towards a greater understanding of the material, and a greater understanding of their existence within their own lives and experiences and those of any group or culture they belong to.

Such a teaching approach should also broaden their experience, and foster openness to new professional and social experiences.

An engineering educator from North Carolina State University (Felder, 2004) reviewed some frustrations aspects of teaching and commented:

> I have come to realise that nobody ever learned anything non-trivial by having someone else tell it to them. For students to learn in a meaningful manner, they must be actively engaged in the learning process… . Instead of spending all my time writing detailed derivations and problem solutions on the board for the students to copy, I get them – sometimes working individually, sometimes in small groups – to confront problems themselves during class… . Whether they get the right answer or not is not important; what matters is that they are actively involved in the search for it. (p. 40)

Felder's (2004) reports that his experimentation in teaching methods has several types of student reaction:

1. The student grades are now higher.

2. Few students now come to his office for solutions. They tend to work it out for themselves, often involving team debate.
3. Some students (a small proportion) still prefer the teacher telling them everything they needed to know for the exam.

Regarding the third comment, Felder (2004) comments, “I welcome these students to their future life. When they go out into the world to be engineers, there will be no teachers, no lectures and no example problems with worked-out solutions” (p. 41).

This chapter reflects on the development of the teaching approach for the ethics section of the Engineering Studies paper which was essentially of a qualitative and subjective nature. This approach included strategies that were modified in each cycle and this development is documented in the order it evolved over the four cycles of action research.

Reflecting on my teaching career up to 2005, I would categorise myself as a positivist teacher, making extensive use of *reflective teaching* where I used my personal and professional knowledge and experience for reflective case-studies. I assumed that my use of case-studies as a means to reflective practice would not change; what did evolve were the interpretations placed on such reflections, as when teaching ethics, there is seldom only one valid or true interpretation as there might be in a mathematical problem (Crotty, 1998). I adopted a view of human knowledge that was very different from logical positivism with the adoption of a new (for me personally) teaching approach where knowledge is not limited to statements capable of empirical verification.

In this chapter I review the requirements and expectations of a prospective ethics teacher, and I trace the changes in my own teaching as I adapted to a more subjective approach to teaching qualitative information.

10.2 The prospective ethics teacher

To implement an ethics curriculum, we must first have ethics teachers. An early issue for any university wishing to offer engineering ethics education is the selection of a staff member with the expertise to design and teach the paper.

While enthusiasm is an essential prerequisite for such a person, the literature reviewed in this chapter shows that ethics is a discipline with a knowledge base, and as such it would seem reasonable that those expected to teach ethics should have a level of competence in this knowledge domain.

Haws (2001) warned of the dangers of inexperience, and observed that a teacher of ethics needs to know about ethics. The question of who should teach ethics has received parochial answers. For example, Weil (2000) expounded the virtues of ethics taught by engineers with engineering expertise, whilst Hinchcliff (1997) insisted that ethics should be taught by a philosopher.

Either way, the prospective ethics teacher will need to have done considerable reading on ethics and engineering. Hinchcliff (1997) admitted that in order to teach the subject of ethics to engineers, an expert in ethics who is not an engineer will have to do considerable reading about the issues relating to the subject, but argued that a high level of engineering expertise is not necessary. Hinchcliff does however assert that "case-studies will have to be sought and discussed with experienced professionals. This is not difficult for anyone who reads in depth" (p. 236). In my experience, in-depth reading is crucial, whatever the prospective ethics teacher's background.

The recommendations of Hinchcliff and Haws support the view that those who teach ethics to engineering students need an understanding of ethics, and of engineering and the challenges engineers face in the discharge of their work. Hinchcliff (1997) imagined the ideal ethics teacher as a person who integrates learned expertise with professional experience, experience in society, and the personal values that inspire trust.

The research of Dreyfus and Geddes (2001) into teaching in the AUT Faculty of Science and Engineering concluded that actual decisions concerning the balance between various strategies in the curriculum and their adaptation to the demands of training engineers at AUT must be made with the help of specialists. Hinchcliff (1997) reinforced his proposal of using a philosopher thus:

> Those unaware of the discipline of ethics argue that the subject could easily be taught, and in fact be better taught by a professional colleague … to teach ethics properly requires as much training in ethics as it does for an accountant to teach accountancy. (p. 235)

In terms of educational requirements of a new ethics teacher, Andrew and Robottom (2001) see this person's appreciation of ethics as needing to be beyond understanding a code. They see it as an "intellectual process for investigating and evaluating ideas about values" (p. 778). In their research into environmental ethics Andrew and Robottom considered the educative possibility for individuals to question rather than accept current practices, to examine current contestable value positions, and to think critically about accepted practices and norms.

As a prospective ethics teacher, I was an engineering lecturer who was prepared to do in-depth reading in order to design an ethics curriculum. I took the advice of Haws (2001), who reflects:

> Given that I have a responsibility to ground the ethical understanding of my students, I first need to absorb that understanding myself. This takes time and study, requires a divergent mind, and will call for some painful adjustments in the way we train, select, and evaluate our engineering instructors. Learning and then passing along technical skills and knowledge is relatively easy. Becoming morally grounded takes much more time. To enable a sense of moral grounding in someone else requires devotion. (p. 228)

Indeed, my willingness to learn was just a beginning. I was to find that success in terms of course results and student appraisals was going to rely heavily on the quality of the curriculum content, teaching philosophy, curriculum delivery and assessment, and these took several cycles to refine.

10.3 The first cycle

Having reviewed the 2005 student appraisals, I decided that I needed to make the teaching interesting so that the students would look forward to the next lecture. In my experience, engineering students are inspired by what they are most interested in. However, the primary objective for 2006 was to send the students into industry with an understanding of ethics, and the ability to carry on learning and understanding this important aspect of engineering. Currently IPENZ stresses the importance of engineering undergraduates learning to work harmoniously and effectively in groups and ethical case-studies already being used in the module in 2005 provided a good opportunity for such group work.

The strategy of group work with case-studies to supplement the lecture-based theory sessions appeared to be effective in the small class I had attended. The immediate challenge was the implementation of a new curriculum and I had to find a teaching approach to present the subject theory in a way that was stimulating and relevant to engineering (Dick & Stimpson, 1999). Coming from a background of engineering education where I was experienced in teaching quantitative and factual engineering material, I quickly realised during the curriculum observation and review of the first cycle (see chapter 8) that a different teaching approach and strategy for the implementation would be required.

I was used to teaching a curriculum that was clearly defined in terms of what the students were to understand, most of which could be justified with empirical evidence. However, Habermas (1996) cautions teachers against such a teaching approach in subjective areas of education such as ethics. Taking this idea on board I concluded that I would need a teaching approach which does not communicate knowledge in a hard and positivist form, but rather in a softer and subjective manner. For example, the research into teaching sustainable development by Jickling (1994) found that this type of education is not simply training, which “tends to be closely associated with the acquisition of skills perfected through repetition and practise and not necessarily involved with understanding … . Education is concerned with enabling people to think for themselves” (p. 237). Consequently, I imagined myself taking the facilitator's role in ethical education, fostering critical awareness and developing students' capacity to “examine an interpretation – especially one of their own – and develop alternatives to it" (Cell, 1984, p. 204).

Newberry (2004) warns that “ethical instruction runs the risk of being only superficially effective” (p. 343). There is a difference between intellectual and emotional engagement and Newberry suggests that teachers should strive for the former. Gorovitz (1982) also makes the point that “anyone can conduct a meandering discussion of some ethical dilemma or other or can ruminate aloud about ethical conflicts faced and conquered" (p. 204). Gorovitz warns the novice that in this case "the subject is in danger of being reduced to a glorified bull session of opinion swapping, to etiquette, to good advice or merely a fig leaf for conferring respectability” (p. 204). As Newberry (2004) reported, the results can be disappointing and I surmised that the teaching of ethics should avoid a relatively superficial and peripheral treatment of the subject.

At the other extreme, I did not want an engineering curriculum that was totally *referent-centred knowledge* (knowledge organised around facts). My experience of referent-centred learning involved the taking of information from the teacher and books and storing it in memory, to be faithfully reproduced at the right moment, after which it can be forgotten just as quickly as it was learned. Such a hard-line approach would, in my view, be inadequate for ethical decision-making in situations of uncertainty and I wanted to avoid a compartmentalised teaching approach of separate areas of inert knowledge, from which the students would essentially learn a collection of facts.

My intention was to implement ethical instruction using *problem-centred knowledge* where the knowledge was complemented by the practice. I saw the advantages being that the students would relate the theoretical information to practice and that they would interact with other people. Further reading revealed that such a learning process, which involves extended practical attention, is more likely to be remembered when a problem is encountered later (Davis, 2002; Greenfield, 1987; Installe, 1996; McQueen, 1992; Resnick, 1991; Saljo, 1988).

Problem-solving activities need to be implemented with careful planning to insure intended student outcomes. Industry and commerce require the use of problem-solving skills on a daily basis (Randerson, 1991). Similarly, Greenfield (1987) suggested that students do not acquire thinking skills simply by practice in problem-solving, drills, or by osmosis. Just as young children form an intricate socially constructed web of knowledge based on their pre-school and primary years, the subject of engineering ethics tends to involve a structured organisational concept, but I did not want a teaching approach comprising a system of simply memorising a series of isolated facts, with the students having no idea of the usefulness of these facts. The social construction theory of knowledge argues that these knowledge areas should be linked to each other in a structured manner so that knowledge can be transferred from one situation to another. The condition for the transfer of knowledge requires the knowledge to be conceptual (know how) and procedural (know why), with the social aspects being imbedded into both. Essentially, I needed a theoretical learning structure for the learning of ethics in engineering that encouraged the students to think. Resnick (1991) describes this process of constructivism as one that "forces students of many social phenomena to treat social processes as cognition, leading them to the ways in which people jointly construct knowledge under particular conditions of social purpose and interaction" (p. 2).

This process is one that students would have begun in early childhood and continued through pre-schooling and primary school. Students may have already learned in primary education that the information they are taught is generally interdependent. Everything links, and the sum of knowledge is greater than the individual parts. It is the individual knowledge bases that must be socially linked to contribute to the sum.

Simplistically, the student requires an engagement in understanding to meet the desired outcome of the learning. In this respect, Saljo (1988) suggests that this development helps with the real learning that comes later, in that the information given to students is the catalyst, perhaps only one hundredth of the learning, but the desire to learn more goes on “long after they put the book down” (p. 21). It is desirable that the emphasis in learning is not simply on absorption of information, but also involves having to use thinking skills to construct knowledge (McQueen, 1992).

Stephenson (1992) refers to this as giving students *capability education*:

> Giving students opportunities to be responsible and accountable for their own learning prepares them for effective performance in their personal and working lives, enhances commitment to their studies, promotes a deeper understanding, builds confidence in their ability to learn and helps the development of high-level personal qualities and skills. (p.8)

In the experience of Jickling (1994):

> Where education is needed the most, in examining day-to-day realities, is where it is often not found. Students need to be prepared to study those issues that matter the most to them and be given practice in making judgements about them. (p. 238)

In the first cycle I decided on a referent-centred teaching strategy that linked the suggestions of Jickling (1994), Greenfield, (1987), and McQueen (1992). With an amalgam of their advice I planned to implement the following aims in my teaching of ethics:

1. Encourage students to recognise the existence of disparate views, seek to understand them, and engage in reasoned discussion about them.

2. Recognise, state and justify the ethical assumptions which underlie scientific research and management decisions. The value positions of individuals and groups making decisions should be openly discussed.
3. Encourage the process of thinking.
4. Encourage the use of language, which reflects a range of social values in discussion.
5. Encourage education to enable people to think about values, the nature of competing claims, and to evaluate the relative merits of these claims.

These aims did not change in the next three cycles, but evolved as a normal progression of self-improvement.

To embody this concept in the teaching of ethics, Installe (1996) recommends moving the teaching emphasis from passive lectures towards more active, participative, project-oriented teaching methods. To achieve such an objective, many researchers (Agne, 1986; Herkert, 2000a, 2000b; Pritchard, 1992; Weil, 2000) promote the case-study as a useful teaching method for group decision-making. Similarly, Davis (2002) and Installe (1996) both suggest that supplementing the experience of real-life ethical dilemmas (case-studies) with a programme of theoretical learning is an ideal educational tool to assist with understanding.

In view of this suggestion I planned to continue with the existing case-study format as one of my teaching tools, but my next significant decision was about a starting point that would be suitable for engineering ethics in a full-semester format. I found myself with two options:

1. Start with case-studies deliberately containing identifiable flaws in process, design or decision-making to encourage the process of thinking, followed by the introduction of theory as the reason for it becomes evident.
2. Start with some ethical theory and progress to the critical analysis of case-studies with the opportunity to learn in reflection by experience once they understood the theory.

Starting with case-studies is a problem-based learning system based on the principles of using problems as a starting point for learning (Barrows, 1984).

My experience in engineering education steered me towards the latter, as I was well experienced in critical analysis of case-studies as a means to problem-solving practice. For example, in another of my classes in which I teach transmission-line theory, I introduce an incident when the engineers at Tiwai Point, Invercargill, without notice, switched off the aluminium smelter, causing a serious problem on New Zealand's South Island power transmission grid. An in-class mathematical analysis of the problems this caused with the power generation and transmission plant contributed towards my teaching cycle of theory, exercises, case-study analysis, and a laboratory experiment with practical experience. I decided to begin my approach to ethics similarly with several sessions on theory, by adopting this teaching approach of incremental theory, followed by case-studies and practice in problem-solving.

However, in the aluminium smelter example, the students could prove mathematically what went wrong. The application of case-study critical analysis within the ethics paper was going to be a new experience because in ethics-based case-studies a conclusion or judgement would be subjective rather than objective. A point of intrigue in ethical debates, and in particular virtue ethics, is whether it is an intellectual contest where the most skilled debater wins.

In the planning the advice of Andrew and Robottom (2001) was a useful guide. They advise the would-be ethics teacher not to attempt consensus in classroom consideration of ethical issues, which I might have done with an empirically provable problem:

> When common ground becomes a focus of decision-making where disparate opinions exist, then it is usually found in areas that are of little significance, and difficult issues and contentious areas of interest are thus left unchallenged. All issues are essentially contested (otherwise they would not be considered issues). What is required is a debate that focuses on revealing and examining different viewpoints rather than aiming for general agreement. (p. 779)

Furthermore, I decided that whatever depth of theory I went into, the objective would be understanding, rather than rote learning. Here I reviewed Morgan's (1993) advice on improving students' learning, involving the "surface approach and the deep approach" (p. 72). Morgan describes the *surface approach* (referred to by some educators as a shallow approach) as an intention to treat the curriculum as an external imposition, where the students simply complete the learning tasks required to meet the demands of assessment, which may include memorising information and procedures. Morgan (1993) challenges teachers and curriculum designers to improve student learning with a *deep approach,* which implies an intention to understand rather than memorise.

I decided to adopt Morgan's deep approach of qualitative learning. In the initial planning of the module, with the restriction in time it was obvious that such a deep approach could not include the multiple stages of personal growth of moral development promoted by Kohlberg (1984), but this seemed unimportant because, as Davis (2002) has already pointed out, engineering students already have their own sense of morality. Instead, the imperative was to empower students to think for themselves with a strong ethical decision-making ability (Bullock & Trombley, 2000). Zimmerman and Schunk (2003) explain that such a learning programme is not a process of teaching students to learn facts to be recalled at some later point in their study or career. The purpose of postmodern education is to teach students good habits that will be useful later in life and Zimmerman and Schunk (2003) promote an educational approach that teaches people how to evaluate the information they have before them, and to make decisions that are ethically sound. They suggest the purpose of behaviour and habit-forming education is to "help create thoughtful, independent, generous and energetic citizens" (p. 55).

Gilbert (1993) generalises when he states that "most versions of constructivist learning do have particular end-points of knowledge" (p. 35) – the teaching of ethics can be more undefined and indefinite (inhabiting *grey areas*) (Davis, 2002). Davis suggests that such tuition should comprise as much a course in the history of sociology in engineering as it does a course in engineering ethics and it would be helpful if the teaching of ethics was not purely theoretical. Taylor (1995) advocates that classes should explore the subjective nature of human decision-making and the values and attitudes which impact on our decision-making process, rather than an objective process.

Concerning these values, Mather (1996) reflected on technology curriculum development in schools:

> The concept of knowledge used in this development is one in which knowledge is constructed and validated by people, and as such, it is a product of the social environment within which these people participate. Knowledge itself cannot be abstract or neutral, but rather reflects the complex interaction of values and power structures embedded in the social matrix within which it was constructed. (p. 5)

As I was to move from the objective to the subjective teaching style, this concept of students' knowledge construction situated within their own social meanings and interpretations would, in Mathers' (1996) opinion, depend on many variables. What would be important would be to position knowledge within this social context where students could examine and develop an understanding of why past decisions were made.

To continue the case-study format in 2006 the students were divided into groups to collectively conduct a study of high-profile cases, which gave them the opportunity to work, critique and discuss. Examining these high-profile case-studies provided reinforcement of the theory of ethics and the ethical responsibilities of decision-makers.

The selection of useful case-studies was planned to promote a team relationship in the class, providing groups of students with the opportunity to apply some of the ethical theory they experienced in class. While I used the case-study system as a teaching method for the reinforcement of the decision-making learning theory, from the outset of the curriculum design I also took heed of Gorovitz's (1982) warning (see chapter 10, section 10.3), and I covered the fundamental theory of ethics and ethical decision-making process first. After this theoretical teaching the students' consideration of high-profile case-studies enabled them to critique other people's decisions, and they progressed towards making group decisions in terms of the following issues (National Institute for Engineering Ethics, 2003):

1. Identify ethical, technical and economic issues and problems.
2. Identify affected parties (stakeholders) and their rights and responsibilities.
3. Identify social and political constraints on possible solutions.
4. Determine whether additional information is needed to make a good decision.
5. Suggest alternative courses of action for the principle characters.
6. Imagine possible consequences of those alternative actions.
7. Evaluate those alternatives according to the basic ethical values. (p. 5)

For the new ethics module, the lectures at AUT were delivered in the traditional face-to-face format, in lecture theatres which were much bigger than a classroom. I moved away from the previous approach of using the traditional overhead projector and changed to using PowerPoint presentations, which had become a feasible classroom resource with the installation of computers and projector equipment in all engineering classrooms and lecture theatres.

The approach I adopted was mainly founded on the principles of Morgan's (1993) deep approach to the teaching of theory, supplemented with discussion points. The case-studies were used at the end of the course.

10.4 The second cycle

Prior to 2006 the previous lecturer had classes of about 30 students and Buckeridge and Grinwald (2003) had stated that the format of the three-day block course was only suitable for up to 50 students. I had planned the first cycle based on these numbers; in the first year (2006) I had adopted the PowerPoint approach and had expected to teach in a classroom environment.

However, in 2005 IPENZ insisted that all engineering degree students take an ethics paper. Consequently, my first class in 2006 had 70 students. The class was in a large lecture theatre and the 70 students could not hear me unless I used the microphone. I still used the occasional explanation on the whiteboard, but had to return to the fixed microphone to speak to the class. In the first class of 2006 I gave each student a draft copy of the text book I had written as a supplement to the lectures. In this cycle I reviewed student appraisals and their informal comments. I then published the text book in December 2006.

This PowerPoint system of curriculum delivery and presentation initially required extra preparation time and significant re-engineering to move from the traditional chalk, talk and handout model to an electronic-resource-based model. In the next three cycles my competency in using PowerPoint steadily increased.

Reflecting the teaching approach of cycle 1, the students had been divided into groups of four or five people for the case-studies. The groups presented their findings by way of a written report and a PowerPoint presentation to the class. However, in the practice part of cycle 1 I had to expand the number of topics and a selection of case-studies was given in a handout.

I had learned in the first year that the words on the PowerPoint slides needed to be sparse if the students were to read them easily. Colours of the text, background, and the contrast between them were more carefully chosen in the next three years for comfortable viewing. For example, the students told me that yellow text is difficult to read from the back of the lecture theatre and in 2007 we agreed on black lettering with a white background.

Although PowerPoint delivery was easier, I had some further issues with it. The two main ones were:

1. To hold the students' interest the curriculum content needs to be carefully thought out in terms of length and number of slides.
2. The information needs to be tailor-made for PowerPoint, and variation in the use of the media is desirable to hold student interest.

In the first cycle the handout included discussion points at the end of each session/chapter, to facilitate class discussion each week. On reflection, I was trying to replicate the experiential learning system that I normally use in the laboratories when teaching electronics, using for example the previously mentioned transmission-line standing waveform experiment. Many educational researchers recommend this experiential system of learning. Reflecting on what I was trying to achieve I found Kolb and Fry's (1975, cited in Gibbs, 1988) four-stage experiential learning cycle (figure 8). The cycle comprises:

1. Immediate concrete learning.
2. Reflection and observation.
3. Incorporating these reflections and observations into the theory.
4. Implications and active experimentation.

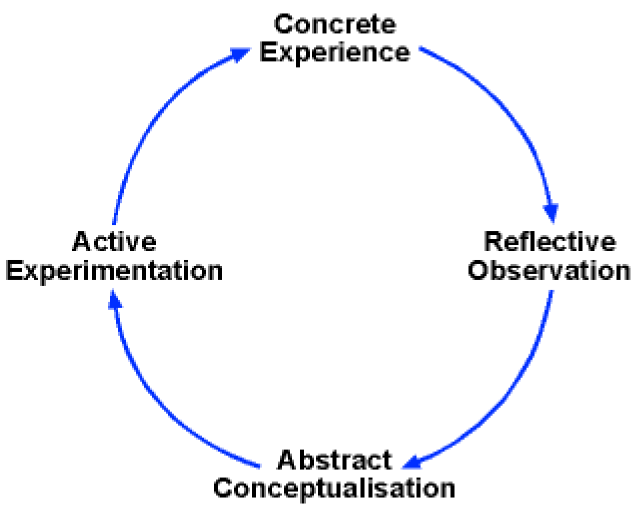

Figure 8. The experiential learning cycle

(Gibbs, 1988, chapter 2, para. 5)

Although Gibbs suggests the learner can enter the cycle at any point, the process follows in the cyclical order. For the teaching structure at the outset I modified the principle and adopted the following cycle of stages:

1. Formal teaching of theory.
2. Classroom discussion on a case-study.
3. Group work in reflective observation.
4. Individual and personal critique.

Originally I had imagined a cycle of learning evolving over the entire module. At this time only the *Challenger* case-study was used in the classroom, late in the module, and it was the subject of a final examination question. I observed that the system worked well, and the students enjoyed the challenge of learning through reflection and discussion. However, as I began teaching in the first year I decided that one cycle throughout the entire paper would not meet the objective of learning through experience. I imagined that a weekly experiential learning cycle would be preferable, and each lecture, which attempted to provide a full coverage of each area in the subject, was followed by discussion points to complete a learning cycle.

The ensuing debate appeared to follow a critical reflection approach. The objective of critical reflection in the first cycle was to introduce a system where the actual learning was followed by the active review to reinforce positive and beneficial aspects of the learning experience. Although I concur with the theory that students construct their own knowledge, I found that they do not construct their knowledge automatically; their knowledge is largely constructed with experience. However, as novices they initially lack the required experience in this field and trial and error is the primary mechanism at work (Revans, 1982).

Rather than impose knowledge from the outside, it was important to recognise that all students have creativity, and the challenge of using their own thinking skills in the process was an important part of the learning process. A good indicator of progress in these sessions was the openness of their challenging questions and observations. In fact, I found that as the lecturer I became something of a skilled listener, having to develop the ability to be involved in several discussions simultaneously during group discussions.

I had taken the previously mentioned advice of Andrew and Robottom (2001) about the futility of trying to reach consensus in this kind of teaching, and I heeded further advice from Eisner (1993), who warned the teacher to be careful with his or her own viewpoint, and argued for the need for objectivity in these discussions:

> Objectivity refers both to ontological objectivity (the nature of being, existence or reality), that state in which one's perception or understanding of the world is isomorphic (an identical or similar form) with the world itself, and procedural objectivity, that method that allows little or no personal judgement or interpretation. (p. 229)

Indeed, there is no blueprint for understanding and applying judgement in such discussions and it seemed important to encourage the students to construct their knowledge in their own way that matches the reality of their own social world. They will come face to face with reality in industry and, as Eisner (1993) points out, "one of the major aims of education is to enable students to use what they have learned in settings other than the ones in which they were taught" (p. 230). I saw the opportunity to reflect as a crucial with respect to Eisner's aim and such critical reflection was encouraged with discussion points to emphasise learning objectives as the lessons proceeded. These points were classified as either issues or events. An ethical issue is an ongoing and as yet unresolved matter, such as a problem encountered in engineering sustainability; while an ethical event is a historical ethical incident that has been resolved and possibly also subjected to an official enquiry, such as the *Challenger* space shuttle disaster.

Fleddermann (2000) speaks of the difficulty in motivating electrical and computer engineering students to study engineering ethics. He believes that case-studies involving technical issues for electrical and computer engineers can be a valuable teaching aid. Consequently, the ethics module uses dilemmas, case-studies and discussion points to facilitate this exploratory type of learning in the classroom. In the first cycle I had approached this experimentally, learning what worked and what did not. I had listed discussion points as questions at the end of each lecture with a view to discussing them during the latter part of the course. However, I found in the first year that it was better to discuss these points as we worked through the material as part of the Kolb and Fry experiential learning cycle.

During 2006 I had altered my traditional teaching methods by introducing a cycle of formal teaching of theory, followed by classroom discussion, group work involving reflective observation, and individual and personal critique. I refined this process in 2007, to accommodate the expanding size of the class. I observed that the case-study report was just manageable with 70 students, so I planned the same system for 2007.

In 2007 the students had the option of buying the text book or retrieving information from the lectures which was available on the School of Engineering copy drive. Handouts were eliminated in the second year. The options for the group case-studies were listed in the text book, and all information was available on the copy drive. It was not compulsory to buy the text book, but many students did and said they found it a useful resource.

To increase the interest in the presentations I progressively introduced photographs, illustrations and short video clips on the slides (these were easily found using You Tube and Google Image Search). I learned from student appraisals that it was important to break the monotony of reading screen information, so wherever possible the slides have a visual on them. Humorous illustrations were also well received but they must, in my view, be appropriate to ethics and engineering.

The discussion points were placed at the end of each chapter of the text book (appendix 2) and are the original lists used during the early lectures in cycles 2006 and 2007. I have revised these continually since that time.

10.5 The third cycle

In 2005, the lecturer had been a geologist and in the first cycle I had dispensed with his case-studies about politics, birds, mice, rocks and plant life. As part of the review and intervention in the first two cycles I had learned that many engineering students only commit themselves fully to a classroom discussion if they consider it interesting, relevant and useful. By now I had found that engineering students required constant motivation. The qualitative aspect of learning that related to the external reality of their social world and their future careers appeared to be a useful motivational technique. I found that many students were reluctant to participate if they were not interested, and the subjects chosen that related to transportation, communications, defence and entertainment seemed to be successful, particularly when covering the relationship between technology and society. I got the distinct impression that the students preferred the reality of their world and interests to abstractions.

During the review of literature on case-studies I noted experienced teachers who thought an ethics teacher should not be forceful in his opinions (Andrew & Robottom, 2001; Habermas, 1996; Lewis, 1986; Mather, 1996). For example, Lewis cautions any would-be ethics teachers about forceful teaching, believing it is essential that ethical matters are not dealt with in an authoritarian way. All of these researchers felt it important to stress that ideally a teacher should present two sides to any argument to encourage the students to make up their own minds in light of evidence. From the outset I felt comfortable with this advice, and I decided that it would be wise to present both sides of an issue and reserve my own opinion.

In the literature review I noted that Newberry (2004) had been very disappointed by the results of his end-of-course student surveys – his students considered his engineering ethics paper as “the least interesting, the least useful and the most trivial” of all those they were taking (p. 347). I identified with this, as there were times when the effort that I had put in during this year brought disappointment. Some students viewed the material as uninteresting and after these two years of experience, I realised that I must be prepared for disappointment as I cannot please everybody. However, at this stage the annual student appraisals indicated that the number of uninterested students in my class in the first two cycles was very small.

At this time I was intrigued by the value of the case-study and further reviewing of literature led me the work of Piaget (1977), who linked the use of dilemma stories back to Kohlberg's early work (Kohlberg is regarded as one of the pioneers of moral development research and moral education in the 1950's and 1960's).

Pritchard (1992) also promoted the case-study (or dilemma) approach as an effective method of teaching ethics in universities, where students can learn from the experience of others. This involved the students being encouraged to question rather than accept current practices, to examine current and contestable value positions, and to think critically about accepted practices and norms.

Quite often, an engineer will learn after something has gone wrong and learning from experience in this way is probably not a new experience for students, because it is a fundamental principle of learning from an early age. I was well aware from my own industrial experience that many lessons are learned in practice and one can learn from the experience of others. McMillan (2000) points out that "there is no substitute for experience, whether it is your own or someone else's" (p. 2). Garvin (2000) found that experiential knowledge construction is most effective when it is "situated and grounded, linked closely with concrete activities and experience … [it is] far more likely to be understood when linked to familiar contexts, setting and environments" (p. 92).

While a university may teach students good practice, one could argue that there is no wholly adequate substitute for the experience that a useful case-study can provide. In the educational process, Andrew and Robottom (2001) see the understanding of ethics as an intellectual process for investigating and evaluating ideas about values, and Winner (1990) reinforces this by suggesting that it should include a willingness to engage others in the difficult work of defining what the crucial choices are that confront a technological society. Meizrow (1991) saw the case-study as socially validated knowledge, and stated:

> Personal experience is to be recognised as organised by forces and structures located outside individual experience. It should be used both as the content for analysis and self-reflection and as a departure point for gaining socially validated knowledge. (p. 197)

To succeed effectively with this style of instruction, Bandura (1991) argues that the content and quality of the dilemmas used as cases need to be very carefully chosen. In Bandura's experience, using a narrow range of dilemmas and ethical conflicts can offer only a glimpse of ethical reasoning and "a person's propensity for principled moral reasoning will vary depending on the information included in the depicted moral conflicts" (p. 5). The dilemmas used by Kohlberg were primarily of a hypothetical nature, and Bandura is critical of Kohlberg's presentation of dilemmas because he believes Kohlberg over-simplifies and strips away many of the complicating factors.

Gilligan (1982) promotes case-studies that use personal dilemmas of the students themselves. However, I would not advise the would-be ethics teacher to try this intriguing approach, as I believe that having a large lecture theatre full of engineering students discussing their personal dilemmas would result in pandemonium!

Instead, from the outset, I unknowingly promoted the theories of Weil (2000) who advocated the use of real historical case-studies in engineering to fulfil students' need to express their own viewpoints clearly (sometimes forcefully). Weil emphasises the importance of students understanding the social relationships around them and gaining appreciation of the perspectives of other parties. Most importantly, they need to be able to imagine the consequences of alternative courses of action and have the ability to negotiate.

In the same vein, Herkert (2000b) reported that the content of his engineering ethics education in the USA consisted of:

> microethical issues focusing on individual professional responsibility and macroethical issues dealing with the development of technology. The pedagogical framework of engineering ethics education has evolved primarily toward utilisation of case-studies and codes of ethics, in some instances supplemented by an introduction to moral theory. Substantial progress has been made in the development of case materials, including high profile cases, everyday cases, quantitative cases and cases highlighting good works. Cases are widely disseminated in textbooks and online. Online resources include interactive case-studies and a rich variety of other ethics-related materials. (p. 303)

There are many sites on the Internet information retrieval system that provide real and fictional case-studies suitable for use in engineering ethics education. Such case-studies are intended to convey ethical dilemmas to students and practising engineers, providing them with an understanding of how to use and apply codes of ethics. Some of the high-profile case-studies, or what Perlman and Varma (2002) refer to as paradigm cases, have become popular in the engineering profession. The classic and widely mentioned paradigm cases are the 1986 *Challenger* space shuttle disaster (now commonly known as the O-ring decision), the rupturing Ford *Pinto* petrol tank, and the accident at the Chernobyl nuclear power station. While these three cases are distinct and individual, according to Perlman and Varma they share a common tragic feature, which involved “the failure of some engineer in possession of positive knowledge to act sufficiently to avoid an outcome that caused harm to others” (p. 44).

Despite my initial enthusiasm for the reflective case-study, not everybody agrees with this approach to teaching ethics in universities and Perlman and Varma (2002) take a rather sceptical view. Their criticism of case-studies is that paradigm cases fail to capture the social complexity of engineering practice.

They believe that the essence of engineering professionalism is the autonomous and independent use of judgement.

One objective in the planning of this module was to actually encourage this professionalism, but from the initial planning of the module I had thought that the review of other people's unethical decisions in hindsight by means of case-study would be a valuable teaching tool for students. I had used this teaching method successfully in telecommunications engineering classes for years, and latterly in this ethics module, and on reflection I felt that the method enthused the class, encouraged group assignment discussion, fuelled their imagination, and fostered the taking of initiative.

In 2008 the discussion points using the Kolb and Fry experiential learning cycle were refined and improved. These were the steps I used, adapted from figure 8(section 10.4):

1. Formal teaching of theory.
2. Classroom discussion on a case-study.
3. Group work in reflective observation.
4. Individual and personal critique.

I began to enhance these points with minor case-studies and current news topics each week to illustrate the purpose of any theory covered. I progressively introduced more case-studies and in 2008 I introduced a minor case-study using the Ford *Pinto* story to explain the pressures an engineer can face. This led (as intended) to worthwhile discussion on whistle blowing and the consideration of more reasonable alternatives.

As the classes continued, I introduced discussion points during every lecture and small case-studies as the module proceeded.

10.6 The fourth cycle

My observations and experience I gained in 2008 were that most of those who attended class and worked through the material each week achieved good results in the assignments and the examination. Many of those who did not come to class achieved low marks and often failed the paper.

The challenge for me was to ensure that the majority of students perceived the paper as worthwhile, and worth attending each week. My strategy had always been that before a class was introduced to the major high-profile case-studies they would need a well-structured and coherent framework to facilitate their understanding of technology, society, ethics and decision-making procedure and how they are related functionally. These knowledge areas needed to be linked in a structured manner so that knowledge could be transferred from theoretical situations to practical ones. I thought it important to structure the link between the theoretical and the practical aspects of the topic and I found that the weekly discussion points and small case-studies helped to reach that goal.

For me it was crucial to support and maintain a class that was engaged and participating by creating and maintaining a stimulating and enjoyable working classroom environment. However, the sustenance of the class had relied heavily on communication that dealt with what the students needed to know and what I wanted them to understand, and how I delivered that effectively to 150 plus students.

On reflection, there were two problems with the 2008 teaching approach:

1. Some students did not come to class, and tried to construct their knowledge of the material at home using Blackboard. In my opinion they often failed for two reasons:

    (a) They did not take part in the Kolb and Fry experiential learning cycle within the class. This denied them the formative self-assessment opportunity (see chapter 11).

(b) They did not study for sufficient hours each week.

2. Some students expected me to give them a handout that they could learn, and reproduce the handout in the examination.

I felt that this latter expectation was an unacceptable trend among AUT students in many aspects of undergraduate engineering education. These two problems were to be addressed in the planning and action for 2009.

I had had no warning that the number students in 2007 would exceed 150. Our growth as a university, together with this paper becoming compulsory, had been reflected in cycle 3 in 2008. In the review of the third cycle I reflected on some difficulties with the system:

1. The length of the semesters had been cut by 2 weeks and I had lost the weeks for student presentations and a special revision class.
2. The educational value of group work appeared to be successful, but it was difficult to judge the performance of an individual within the group.
3. I had tried to increase the number of groups and restrict the number in each group by limiting them to six people, but some students reformed into larger groups.
4. As the groups became larger some students were putting in very little effort, and this annoyed others in the group. My impression was that some students considered there was safety in large numbers!
5. Student presentations to the rest of the class were now taking all afternoon, and students were not staying for other groups' presentations. Hence they were no longer learning from the experience of the other groups.

In the first cycle I had adopted the process of group learning by encouraging class discussion and the use of group case-studies to be explored outside the classroom. In the first cycle when the classes were small, a group project entailed a written submission for assessment. In cycle 3 the large class size meant the group case-studies became unmanageable and I resolved to replace the assignment with classroom work in the fourth cycle. This modified use of group learning in the class promoted discussion and learning. I comment further on this change in the assessment chapter 11.

For group learning to be effective, a certain amount of independence in learning is required. By *independent learning* I do not imply a separation of the teacher and the learner, with the student working in isolation, but refer to a collaborative form of learning within a group. *Collaborative learning* is a term used to cover a variety of educational approaches involving joint intellectual effort, where students work together to find or understand solutions or meanings, or create a product (Morgan, 1993). In the process they are expected to take responsibility for what they learn within the exercise. Brainerd (2003) described the process of active self-discovery as knowledge construction. The term Crotty (1998) uses is *constructionism*; he offers the view that "all knowledge and therefore meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world" (p. 42). He makes a point that I subsequently recognised in the case-studies I used, that "strikingly diverse understandings can be formed of the same phenomenon … . What constructionism drives home unambiguously is that there is no true or valid interpretation" (Crotty. 1998, p. 47). Flavell, Miller and Miller (2002) suggest that in such a form of learning, the students use the processes of "thinking, imagining, creating, generating plans and strategies, reasoning, inferring, problem solving, conceptualising, classifying and relating" (p. 2). In such a process interpretations can differ, particularly from one culture to another.

Further reflection led me to the research findings of Platzer, Blake and Ashford (2000), who reported on using small groups in a post-graduate course for reflection and learning from experience. Their research revealed a positive side to group work, in that some students dramatically increased their critical thinking ability in a way that brought about significant perspective transformations and led to changes in their attitudes and behaviour. These changes were identified by Platzer, Blake and Ashford as “increased professionalism, greater autonomy in decision-making, more self-confidence to challenge the status quo and make their own judgements, and a less rule-bound approach to their practice” (p. 689).

As profound as this enlightenment sounded, after four years I had also noted a side-effect of the case-study process in more simplistic terms. Provided it has some relevance and contributes to the learning process, a case-study provides the opportunity to provide practical examples that reinforce the theory more effectively than abstract thinking. I found a relevant parallel in Garvin (2000), which suggests that managers “should periodically emerge from … the world of abstractions and take a long unflinching look at unprocessed reality” (p. 219).

What was also important in this process of case-study group work was the principle and practice of *co-operative learning*, where students learn to work in co-operative groups. However, Schunk (2004) warns that “when it is not properly structured, the co-operative groups can lead to poorer learning compared to whole class instruction” (p. 323). On reflection, at this stage I felt that the minor case-studies were effective, but, I believed that the major group case-studies were approaching the danger point Schunk alludes to, and changes were planned for 2009.

For cycle 4 (2009) I decided to change the system because the original approach to group case-studies had become unwieldy, and in some instances it was becoming increasingly difficult to assess the individual contribution. In conjunction with the new sustainability lecturer (see chapter 9), I decided to move the case-studies into the lecture theatre and the assessment into the final examination (see chapter 11). This decision was based on practicality rather than educational ideals, and on the shortening of the semester. I would now introduce the major case-studies progressively throughout the final three weeks of the paper.

In moving forward to 2009 I appreciated that there were many factors influencing the motivation to learn, and a review of Schunk (1991) confirmed this. Schunk stressed that the linkage between good instruction and motivation is the most important. Few academics would argue with that; if we give students the motivation to construct their knowledge, competence should follow, and to motivate all of the students to come to class I increased the number of smaller case-studies and discussions throughout the early sessions of the module. I reviewed the principle of problem-based learning (Barrows, 1984), and I found myself progressively moving towards the idea of the integrated approach to learning using the Kolb and Fry experiential learning cycle (figure8, section 10.4). I taught them some theory, and then gave them discussion points and small case-studies to apply that theory. I had refined this process over the four years, resulting in improvements over the four action research cycles, particularly as I adapted to the large-class environment.

In 2009 I had made an effort to encourage the development of positive attitudes by the students to their work. The curriculum content and teaching approach had not been designed to modify the students' value systems in their private lives – it was designed to encourage them to understand that while they have values relating to their culture and background, these may be supplemented by further values expected of them as engineers. This aspect of my teaching seemed to have become more effective over the four cycles of research.

In the previous two cycles I had continued to use discussion points during a lecture, but in 2009 I categorised these into three forms; discussion points, minor case-studies and major case-studies. Minor case-studies and sometimes discussion points were used to supplement the theory throughout the module to promote class discussion and reinforce the information covered in each session. Additionally, in 2009 the major case-studies were done in the classroom. After a presentation of the material the students divided themselves into groups for discussion and input. The major case-studies used in the fourth cycle were the *Cave Creek* tragedy and the *Challenger* and *Titanic* disasters.

While encouraging students to think for themselves, the major difficulty I had was that, while I could move around the large lecture theatre as I talked to the groups, I had to return to the microphone to share a discussion point with the whole class. This precipitated a change in teaching style from the first year (2006), because I could not talk to the whole class as I moved around. I improved this technique in 2009 with a wireless lapel microphone, and by charting discussion points from the groups in the class on PowerPoint so the whole class could see the views of other groups. The collective opinions of the students were entered into the PowerPoint presentation and posted on the student online database for access by all students.

Informal feedback from the students indicated that they used this information as part of their study. A further indication of the effectiveness of this kind of study enhancement was the number e-mail requests I received one week when I forgot to upload the posting.

I examined the case-studies in the examination, which was extended from the earlier two-hours to three (see chapter 11). The next chapter reviews the evolution of these assessment procedures.

CHAPTER 11
Assessment

11.1 Introduction

Assessment design is an integral part of objectives of the curriculum design. It is important to plan the assessment process that includes the consideration of the number and size of the assessments included, the timing or scheduling of assessment, and the critical importance of feedback in supporting student learning.

There also needs to be a balance between diagnostic, formative and summative elements of assessment. Consideration also needs to be given to flexibility of the assessment design to accommodate to maintain inclusive learning, that is anticipate some of the more common potential needs of learners with special educational needs.

The Accord learning outcomes should not be interpreted as a list of topics or objectives the lecturer must do, rather they are statement of change for the students.

Objectives are also listed as topics, concepts, or generalisations; however, this approach does not specify what the students are expected to do with these elements such as apply them to illustrations in his/her life or unify them in a coherent theory explaining scientific deliberation. It may be a useful supplementary reading.

On reflection, the traditions of the Engineering School at AUT tend to perpetuate an assessment system based on formal examinations that have scarcely varied in format or design throughout the 30 years I have worked there. Understandably, engineering papers are more quantitative than an ethics paper and they are more easily assessed through summative examination procedures. At the time of the inception of this ethics module in 2006, my natural and instinctive path to an effective assessment procedure was a continuation of the procedure I was familiar with in my own sub-culture of telecommunications engineering, using assignments, project-work and an examination to assess student learning. While these existing assessment procedures were developed in the past for expediency, the ideals of this assessment format are nevertheless based on several core scientific beliefs, which Eisner (1993) identifies as:

1. The belief that nature was orderly.
2. Faith that rational procedures, epitomised by science could be used to discover those natural regularities.
3. Theoretical ideas about the regularities of nature could be constructed and the truth about those ideas could be determined.
4. An admiration for the virtues of quantification. (p. 220)

In my experience the predictive value of the rigid assessment process that Eisner (1993) describes had proven to be satisfactory in other engineering subjects I had taught in the past. But for this ethics module I imagined a shift in focus away from these previously held core beliefs. The immediate concern in this module was an assessment practice that would provide the sort of challenges that students encounter in the normal course of working and living, and I had to consider in the assessment planning what was relevant to assessment. Rather than tie everything in the curriculum content down in a rigid way, so that there could be no misunderstanding by the students as to the assessment requirements, from the outset in this module the intention was to shift the assessment focus away from a test of memory using the quantitative aspect of remembering facts, systems and procedures and towards the qualitative aspect of conceptual understanding and explanation. From the outset of this curriculum design project I suspected that assessment tasks that test exactly what has been taught might be too simplistic for this module and I believed that the assessment focus should be on student outcomes to communicate what I perceived they needed to understand.

Consequently, with this paper I planned to shift away from my usual empirical assessment methods, a shift which would require an assessment scheme involving work that would be subjective, rather than being constrained to a teacher's implicit interpretation and assessment of the curriculum content. In many respects the assessment of empirical facts and procedures could be viewed as easier because I know specifically what I'm looking for as an examiner. I imagined from the outset that such a shift to the subjective was going require just as great an understanding of the course material as more empirical approaches do.

One has to be careful, however. The assessment must be reasonable, and reasonableness requires judgement (Eisner, 1993). Of course, standards and pass rates may be checked in hindsight by analysing the examination mark mean and standard deviation, leading to subsequent adjustments in levels of difficulty.

While putting my ideas into practice I was to find that the requirements an assessment scheme that provides alternative ways of responding can create labour-intensive demands on staff, and reluctance by staff members to mark essay-type answers may limit the outcomes. Essentially, the inhibiting factor of effective assessment may be a combination of the practicability of assessment administration and the reluctance of teachers to mark the subjective. For example, the multi-choice test (and its true/false predecessor) are very easy to administer and computerised multi-choice varieties of assessment are very popular with AUT engineering staff. However, in my view such an assessment merely requires a student to select a solution rather than construct or reason one. In my industry experience life was not like that, and single solutions or a common set of responses are not the norm of either intellectual or daily life. Eisner (1993) agrees and I formed the opinion that such a system of assessment would inhibit the teaching approach and objectives in this module.

The experience and advice of Eisner led me to imagine an assessment approach more able to determine the quality of understanding and reasoning, and the processes of thinking in situations where there may be a diversity of solutions, opinions and reasoning in response to a common experience.

In my view, the students would need practice in these situations so that they could assess their progress. Consequently, at the outset of this research I planned a formative self-assessment procedure which incorporated a twofold assessment plan:

1. *Formative assessment*: Questions to consider and discuss during each lecture, and a formative assessment part-way through the paper by means of assignment.
2. *Summative assessment*: Case-studies for presentation at the end of the paper, and a final examination.

Although my assessment ideals and focus have not diminished in importance over four years of teaching the module, there have been procedural changes driven by the growth in class size and the inclusion of new material as the module evolved. I was to conclude that these changes in assessment process appeared to improve the quality of written assessments, but the assessment would entail much more marking than my previous experiences. This chapter documents this evolution in assessment by assignment, case-study and examination.

11.2 The first cycle

In 2005 the assessment requirement was two assignments (ethics and sustainability), two case-studies (again, ethics and sustainability) and an examination which segmented the assessment into ethics and sustainability. All of the forms of testing were summative, with no attempt at a formative feedback procedure during the paper.

One objective of this paper (which is also an objective of the entire degree programme) is the expectation that students will graduate with the ability to communicate effectively on complex engineering activities with the engineering community and with society at large. This fits with the expectation that graduates will be able to demonstrate understanding of the societal, health, safety, legal and cultural issues relevant to engineering good practice (IPENZ, 2002). I envisaged that the Engineering Studies paper would contribute to the development of their ability to comprehend information and write effective reports, make effective presentations, and give and receive clear instructions – all leading to their specialisation project reports in their final year of study.

To assess the learning in the module, I had to consider whether to continue with the assessment procedure as it was. To effectively assess the student comprehension and achievement I reviewed the options of continuing the existing process or providing something new.

In planning the 2006 module, there was no data suggesting that something was wrong with the present assessment system methods and it appeared to be sound and functional. On reflection, the 2005 case-study system was a valuable part of the learning and assessment process and worked well in the previously small classes.

I reviewed assessment techniques and there were changes I needed to make to improve student understanding and learning. For effective feedback, Anderson's (2003) theories on mastery learning suggest a series of formative tests to provide assistance with learning. Anderson provided the following guidelines for mastery learning in which testing is an important supporting feature in identifying learning difficulties:

1. Specifications of the objectives and content of instruction (precondition).
2. Translation of the specifications into evaluation procedures (precondition).

3. Setting of standards of mastery and excellence apart from inter-student competition (i.e., absolute mastery standards) (precondition).
4. Breaking the course or subject into smaller units of learning (operating procedure).
5. Design and administration of brief diagnostic-progress test (i.e., formative evaluation) (operating procedure).
6. Use of alternative instructional materials or processes intended to help students correct their learning difficulties as indicated by their performance on the diagnostic-progress tests (operating procedure). (pp. 378-379)

This feedback system is a positive feature of the Cisco series of papers we offer at AUT, in which the students may take chapter tests online, and feedback is supplied as to where they went wrong.

I saw no reason to change the 2005 assessment process as it was functional and expedient, and at this time I had more urgent concerns with the curriculum content, teaching style and course timing. Considering the short time I had to redesign the curriculum content, I decided to continue with the 2005 process of assignment, case-study and examination as a three-tier assessment system to indicate whether the course objectives have been attained. The attractiveness of the pluralism in assessment methods was the possible provision of an indicator for struggling students, giving me the opportunity to provide formative feedback with a remedial assistance to those who needed it. In effect, I was planning a combination of formative and summative assessment rather than one distinct approach.

Following Schunk's (2004) learning theories, the objective was to prepare a set of objectives and a final summative exam. The level of mastery would be compartmentalised into learning units that would be mapped against the course objectives. The difficulty was in providing a formative evaluation by way of corrective feedback. My intention was that the ethics assignment would provide some level of feedback in addition to summative completion of that unit of learning.

However, the content of the 2005 ethics assignment was about business management rather than engineering. Reflecting on the 2005 ethics assignment without knowing what had been taught, I found it quite obscure. My reflection was that if I had difficulty understanding it, how would students with English as their second language fare? In my opinion educational standards are not raised by increasing the toughness of assessment, but by refining the quality of the teaching, and clarifying the objectives of the ensuing assessment. To meet this objective the curriculum assessment would need to concentrate on engineering ethics.

As a result of these concerns the remedy for improvement seemed clear, and I planned a twofold shift in focus. Firstly I continued with the group case-studies, but ensured that the focus was on engineering-related practical activities rather than the 2005 non-engineering content. Secondly the assessment philosophy would involve a movement towards the subjective understanding and comprehension concept, rather than the empirical determination of what is factual. I expected that such an assessment procedure would make it possible for more than one acceptable answer or problem solution in assessment.

The assessment may have been made more manageable with the change from the three-day block course to a semester course. (Since I hadn't experienced assessing the three-day block format, as I planned ahead I could only speculate that it might be a more effective solution for me personally). My plan for the 2006 assessment comprised:

1. An ethics assignment consisting of an essay on technology and society, and a group of questions relating to engineering ethics (see appendix 1). This was to be described in plain English that an engineering student (particularly an overseas student) would understand. This assessment was intended to be summative in terms of the early part of the curriculum, but could be of formative assistance to the students, provided I made the effort to mark and return them promptly.
2. A group case-study as a summative assessment which would involve teamwork.

3. A final two-hour summative assessment examination combining both ethics and sustainability. The ethics section of the examination would be half of the 60 marks.

The marks for grading purposes were as follows:

Ethics assignment	10
Sustainability assignment	10
Ethics case-study	10
Sustainability case-study	10
Two-hour examination	60
Total	100 marks

In the first cycle I retained the two-hour examination format, but I changed the content to relate specifically to the new 2006 curriculum content. At this time the *Challenger* case-study was done in the classroom and a question about this was asked in the final examination.

11.3 The second cycle

In 2006 the main problem I faced with the assignment was the students' diversity with respect to language ability, group discussion skills and writing/research skills. I observed that many of the students required assistance and guidance with their research and report writing to reach what I considered the required engineering graduate standard. I had to contend with a huge variation in ability, which ranged from local students who were in their fourth year to students from overseas who had only been in New Zealand for six months. This latter category of students came into the BEngTech or BE with recognised prior learning credits, and so required 18 months to two years to complete the degree. Although their International English Language Testing System (IELTS) score in English ability must be at least 6.5 to gain entry to AUT degrees, many had great difficulty in this area of research and report writing. For many of the overseas students the assignment portion of the assessment appeared to be a difficult experience, and outside their comfort zone at the time they began the Engineering Studies paper.

In 2006, the inability of some students' to meet the standard I expected of them in literature-review and report-writing skills necessitated impromptu training sessions for new students. However, the case-study reports were always well presented which made me wonder if the student with the greatest writing skills actually wrote the report, while less capable (language-wise) students were not being evaluated in the assessment. While I believed that group work was an important part of the paper and certainly encouraged engaged learning, individual performance was difficult to assess. Who was actually responsible for the production of both the written report and the class presentations?

The evaluation of the projects was based on the group reports handed in, and the oral presentation. Unfortunately, I had no idea what group interaction and exploration had taken place and assessment was by default a collective grade. While I had achieved the assessment objective of managerial and collaborative activity within the groups, I had little choice but to assess the group achievement as a whole, rather than the individual achievement within the groups. In terms of a performance-based method of assessment, it was merely a group evaluation. At this point of the research I noted it as an issue to ponder, but it would become a growing concern.

Reflecting on the final examination assessment, a further concern was the tendency of rote learning shown by some students for assessment preparation. To counteract this, I adopted a deep learning approach to teaching (see chapter 10, section 10.3). In terms of written assessment preparation, my ideas for counteracting this study tendency of some students were reinforced by reading the works of Ramsden (1988). Ramsden defined two learning approaches relevant to assessment: "A deep learning approach involves the intention to understand … . In a surface approach, the intention is to fullfill the task requirement, which leads to memorisation of only what is thought to be required by the teacher" (p. 163). The major focus in student preparation for the 2006 assessment had been this deep learning approach to promote an understanding rather than rote or *surface learning* for the examination.

Essentially, there was no change planned for the 2007 assessment. As in cycle 1, the students were assessed on the assignment and then divided into groups of four or five to collectively conduct a case-study. A selection of case-studies was given in the handout and the groups presented their findings by way of a written report and a PowerPoint presentation to the class.

In 2007 I changed the examination questions, which is a normal procedure each year. I also rewrote the ethics essay assignment to make it clearer what was required and offered an additional revision class for examination preparation which most students attended.

11.4 The third cycle

In 2007 I had continued the process of group case-studies because I perceived this as viable means of promoting the core engineering skills of co-operation, project management and communication. These skills are prescribed by the Accords guidelines (see chapter 4, figure5, section 4.4). The case-study options were extended (see appendix 2, pp. 98-106). Allowing the students to choose their case-study subject ensured in my view that the curriculum was not teacher-dominated. The students were also able, with approval, to choose a case-study outside the list I provided and the whole process allowed the students to take some responsibility for their own learning. Such group work in case-studies had been effective in 2007 as students were able to benefit from the class presentations of all of the group findings, but because of the increased numbers, the presentations were taking much more time.

I used the Google search engine to check for plagiarism, which took a considerable amount of my time. There is little doubt that the Internet is useful research tool, but it can be abused by students who cut and paste information with the intention of representing others' work as their own, with no reference or acknowledgement. I found that there had been a large amount of plagiarism by a small number of students.

At the end of 2007 I had more concerns about the value of assessing the group case-studies. My original intention was a method of assessment that contributed to what Jones, Hawe and Mather (1994) referred to as a *multiple indicator perspective*, comprising a balance between written, oral and work-produced-report assessment I was now beginning to have concerns about the dynamics involved in group decision-making about ethical dilemmas when trying to assess the individual learning achievement.

The altruistic tendency of students can be expressed in group discussions as part of their growth and learning. Vygotsky (1962) offered the social-cultural theory, which holds that socially mediated activity can be an influence on the thought process, where the thought process can be influenced by the social environment a student is in. Learning is context-dependent – what is learned and what is valued being dependent on the situation and context, and these are a major influence on students' perception of ethics (Driver, 1992; Schunk, 2004; Taylor, 1995).

Bandura (1989b) has explored the influence of social environment and while people sometimes have views on what they ought to do, he believes they can be swayed by compelling circumstances or emotional factors in the group environment to behave otherwise. Perhaps this contributes to the value of group learning within the ethics class.

The learning that takes place in group discussion may include the recognition of, and seeking to understand the existence of, disparate views, and may involve reasoned discussion about them. While this is one of the objectives of group work, as an ethics teacher I was beginning to suspect that a group report with a collective view may not necessarily represent all the views of the group.

This evolved into an intriguing question: Do the people in group work recognise, state, justify and evaluate the ethical assumptions which underlie their decisions, or do some mimic, chameleon-like, the thinking, opinions and cultural context of the most influential team member?.

Consequently, while it was evident to me that group discussion of ethical dilemmas in class reinforces the process of learning, when the students are using a group discussion to resolve ethical issues the outcome of a decision may not gauge or reflect the true range of social values of the group. Furthermore, a formal group report may only represent the views of the most influential individual or the majority culture of the group. This is not in my experience what happens in engineering practice and my concerns at the time were the difficulty in assessing individual comprehension of the case-study. I could not definitively answer my question at this stage, but I was to revisit it in a succeeding cycle of action research.

The availability of academic information on the Internet is a great help to present-day academics and students alike. The temptation to represent another person’s work as one’s own work is not resisted by all of my students, but such plagiarism can be detected by a software package called Turnitin. In 2008 I decided to use the Turnitin programme to check for plagiarism. The students would be required to submit their assignments to Turnitin to reduce the amount of time I had spent in 2007 searching the Internet to identify student plagiarism. The Turnitin analysis shows the amount of text in each report that has been taken from another source and its similarity to other submissions.

In 2008 I kept the same format for assessment as in 2007, but I found that the assignment questions on ethics were of little value – students were simply quoting the text book and I did not consider this very useful. Consequently, in 2008 I omitted the ethics questions in the assignment because what I really wanted to assess was students’ ability to review literature and write a report to show their understanding of the relationship between society and technology. I wanted them to concentrate on a well-referenced essay, and copying a list of definitions was not enhancing the exercise.

11.5 The fourth cycle

AUT's growth as a university was reflected in cycle 3 (2008), where the number of students had grown to over 150. While this is not a large class by university standards, it was a size that was new to me, and I had to adjust the way I taught. In terms of assessment, as I mentioned earlier, it was difficult to judge the performance of individuals within each group. As the groups had become larger, some students were reported by other students as putting in very little effort, to the annoyance of others in the group.

I also noted that the membership of the groups was the same for both project assignments in the paper. My observation was that these groups tended to evolve natural leadership within the group, which may not necessarily give all of the students in the group the competence to initiate, conduct and manage a project on their own initiative. I could not judge whether all the students were experiencing any progression in these skills.

As previously stated, the use of small case-studies and discussion points to complete the learning cycle each week provided a critical reflection approach and introduced a system where the actual learning was followed by active review to reinforce positive and beneficial aspects of the learning experience. This appeared to benefit students as a partial means of formative self-assessment, where they could assess their learning and ask for help.

However, although the final summative assessment by way of examination was successful, I had misgivings about the case-study presentations and reports. I was also aware of anger expressed by some students at the lack of participation of some group members. In several cases, a group member was expelled from the group and received no marks for the assessment. As I said earlier, I was having misgivings about the value of this form of assessment because:

1. The group case-study method of assessment became unwieldy.
2. It was very difficult to assess an individual.

3. It provided no formative feedback, as the reports were marked at about the same time as the final examination.
4. The time taken to present to the rest of the class was such that students were not staying for, and benefiting from, other class presentations.

However, the students enjoyed the challenge of learning in class through case-studies, and, as part of the learning cycle the in-class small case-studies were an educational enhancement.

2008 was also a learning experience for me as I began using Turnitin and analysing its similarity reports. My intention had been to detect plagiarism, but I drew several conclusions from the Turnitin data:

1. A few students had a very high percentage of copying and the reports did not always show where the submitted assignment was copied from. While the report shows the similarity between two or more students, the report only shows the similarity, and cannot indicate who copied from whom. For example, a 75-100% similarity without referencing is usually regarded as plagiarism, but it may be that someone else has copied that assignment.
2. A few students had a 0% similarity score, where information does not appear to be taken from other sources. This may mean that they had not researched and referenced their argument which is required as part of the assessment, and marks would be deducted for this. However, sometimes their references were not detectable by Turnitin and the work could indeed be well referenced.
3. Many students were in the 10-15% region, which usually means that they have researched their work. Provided they had properly referenced the source, they received good marks. This is what they were expected to do.
4. An examiner needs to be cautious using these reports. A high similarity percentage can sometimes be misconstrued. For example, a similarity of any percentage may simply indicate that several students have quoted the same source, for example the course text.

5. We must understand that they are similarity reports, rather than plagiarism reports. For example, if two students hand in an identical assignment, the second submission analysed is identified as similar, so who copied who?

As a consequence, I advise new users to be cautious in their interpretation of Turnitin reports. As good as Turnitin appears to be, I have experienced some outcomes which, if not understood, could lead one to the wrong conclusion.

As an example, while listening to talkback radio one evening (circa 2008), it was reported that a Turnitin submission of Dr Martin Luther King's doctoral thesis revealed a 65% similarity figure. To the novice that might be interpreted as 65% copied and this was my initial inexperienced reaction at the time. Without seeing the Turnitin report, my experiences of 2008/9 would lead me to believe that a certain percentage of similarity was due to properly referenced material, but the rest may have resulted from the subsequent referencing of King's work by others. It would need a close examination of the similarity report to understand the data. Again I stress the need for caution when interpreting Turnitin reports, particularly when they are presented in official university disciplinary proceedings as evidence of plagiarism.

In the planning of the 2009 paper the options seemed to be either to dispense with the assessment of case-studies or bring this learning method into the classroom and assess the learning and understanding through examination. I wanted to continue the case-study work as part of the learning cycle, and I hoped that bringing the assessment of the major case-studies into the final examination would maintain the value of these case-studies and give students the motivation to participate in group work and an incentive to come to class.

I now intended to use them as a form of formative self-assessment. The chosen case-study assessment plan for 2009 was:

1. To have the major case-studies common to the whole class as part of the learning cycle to promote group discussion within the class. In this way, I

could provide some formative feedback as they applied their knowledge to the case-studies.

2. As a summative assessment, each individual's conceptual understanding of ethics and their understanding of these case-studies was determined by the final examination.

To achieve this, in 2009 the examination and case-study procedures were changed. The minor case studies were used throughout the paper as discussion points facilitating a formative feedback. The major case-studies were now also presented in the classroom where, after a class discussion of the material, the students would divide themselves into groups for discussion and input. The collective opinions of the students were again this year entered into the PowerPoint presentation and posted on the student online database for access by all students. I examined them on the major case-studies in the final examination which was extended from the earlier two-hour examination to three hours. The students knew in advance that they would have to comment on one of three familiar case-studies as part of the final examination, which they were expected to research prior to the examination. The marking schedule was now:

Ethics assignment	15
Sustainability assignment	15
Three-hour examination	70
Total	100 marks

In the examinations over the previous three cycles it had been noted that the students' responses to ethical questions were as much influenced by their social situations in terms of value issues, social etiquette and cultural laws as much as by the theory they had learned in the ethics module. I thought that this was excellent – the students were thinking and interpreting information for themselves.

The 2009 procedure of individual assessment of group studies in the examination enabled me to gauge the understanding of the individual student in the case-study. Whichever viewpoint a student takes, they are expected to explain and justify their opinion using ethical theory where possible, and the resulting assessment of individuals now appears to be more accurate than the collective views of a group case-study report in the earlier years. The new examination system was particularly successful for those who attended the classes and took part in the discussions on the case-studies.

I have appraised the value of discussion points, and the minor and major case-studies used in this paper in chapter 10. However, for final assessment by examination three major case-studies were used in class in 2009. The important aspects for the assessment of these three case-studies were as follows:

1. *Cave Creek disaster* – used to show the importance of good planning, the necessity to use qualified, competent and ethical staff, the importance of acquiring the legal permits necessary, and the importance of a competent and ethical project manager. The case-study is chosen to show the students their responsibilities in a professional world where colloquial expressions and attitudes such as *she'll be right* are professionally unacceptable.

2. *Challenger disaster* – used to reveal the complexity of an apparently simple decision, where the students are asked to consider all the pressures the engineer faced and consider the weighting of each factor influencing the final decision.

3. *Titanic disaster* – used to discuss a series of disastrous decisions which included engineering design, operational procedure and unethical decision-making.

In the final examination the students were expected to choose one of these case-studies for assessment, and were expected to:

1. Apply their knowledge of ethical theory to the decision-making process.

2. Explain what precautions have taken place since to prevent such disasters in the future.

3. Relate the decisions to the IPENZ Code of Ethics.

As part of the assessment preparation, these three case-studies were again reviewed during the penultimate session in which codes of ethics were more fully covered than in the initial introduction earlier in the paper. The students were asked to review the three cases in light of the IPENZ Code of Ethics, and the influence such a code should have in these circumstances. The new case-study process gave me the opportunity for more group discussion in the codes of ethics session, which gave that session focus, purpose and direction.

An unplanned benefit of conducting the case-studies in the lecture theatre was that *all students* had been given the opportunity to learn in hindsight through the experience of others, because the three major case-studies were now common to the whole class.

I felt that by 2009 I had achieved the assessment balance I was searching for and I reflect this in my conclusions in the next chapter.

CHAPTER 12
Conclusions, Discussion and Looking Ahead

12.1 Introduction

In Chapter 1 (section 1.3) the expected graduate attributes of the Washington and Sydney Accords (International Engineering Alliance, 2005) required at that time in 2005 for the degree programmes were described in a summarized form:

6. Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings
7. Communicate effectively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
8. Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
9. Understand and commit to professional ethics and responsibilities and norms of engineering practice.
10. Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.

Essentially, to meet the programme objectives of expected student outcomes, a curriculum has been designed to provide the students with the necessary knowledge, coupled with the ability to understand and apply this knowledge in practice. The curriculum development goal was to research the most appropriate and effective design and delivery to enable the students to reach the desired attributes of the programme objectives using Taba's (1962) steps to formulating, organising, and evaluating these educational objectives.

1. Diagnose learner's needs and expectations of larger society.
2. Formulation of learning objectives.
3. Selection of learning content.
4. Organisation of learning content.
5. Selection of learning experiences.
6. Organisation of learning experiences.
7. Determinations of what to evaluate and the means to do it. (p. 44)

This chapter now reviews these steps, and discusses the findings, in conjunction with the curriculum design model in figure 1, with the inclusion of some possible future options. The chapter concludes by identifying areas where the thesis is thought to make a contribution to the field of knowledge in engineering education.

The study began with the need to meet the requirements of the Washington and Sydney Accord engineering graduate profiles when there were no national guidelines detailing content for ethics education. I assumed that, just as there is no one universal moral theory, the incorporation of ethics education into engineering education will vary from one institution to another. To begin the curriculum development, the Felder and Brent (2003) curriculum design model (section 1.4) was adopted. The model associates three important areas of curriculum design: learning objectives, instruction and assessment. The literature was explored and searched for academic views, perceptions and experience in curriculum design related to teaching ethics. It was important to understand and interpret the factors that influenced these views. The research however revealed no documentation of an established curriculum, and I found myself without the convenience of a detailed prescription such as was provided in my early academic years of teaching certificate and diploma courses. However, such a system of regimented curriculum would stifle local initiative and academic freedom in universities. This was a professional transition I had to make.

Consequently, this research, based within the interpretivist paradigm, used qualitative data to identify the various options available for teaching ethics, particularly in relation to engineering. In this process I reviewed and considered many options, and changes were made to the inaugural curriculum design as the module evolved over a four-year period. This ongoing development has been described as *action research*.

This was not the same as traditional action research, or *participatory action research*, which includes researchers working with practitioners to plan collaboratively and evaluate the plan or programme together (Reason, 1994). I took the advice of Avison et al. (1999), who suggest that action research is "action research focusing on change and reflection" (p. 95). In this case, I was taking the reflections and opinions of each year forward to the next year's students. However, as stated in chapter 2 (section 2.4), McNiff (2002) promotes the action research method for use by individual educators to improve their own practice in teaching as a regular cycle of self-reflection and course appraisal. Consequently, the stages of action research cycle – observation, review, plan and activate – involved my own observation and reflection and were coupled with a combination of formative and summative student appraisal.

The use of the term action research needs to be qualified because my decisions seemed often to be pragmatic, albeit supplemented by the ideas of others, rather than involving the critical consideration of a range of alternatives. This reflects the gradual and evolutionary nature of the actual change process which I believe, is typical for many engineering educators. During this research process of using the Felder and Brent (2003) curriculum design model, there were five questions I sought to answer in the process of overcoming the design and practical difficulties I faced:

1. Curriculum content
2. The ethics teacher
3. Teaching method
4. Curriculum delivery
5. Curriculum assessment

These questions are now reviewed.

12.2 Curriculum content relevant to engineering

In designing the curriculum, I felt that the curriculum design should introduce enough moral and ethical theory for engineering students to understand the subject before discussing the ethical concepts of good engineering design and practice.

The primary academic obligation with respect to the Washington and Sydney Accords in an undergraduate engineering degree is to facilitate informed thinking, to develop an intellectual independence, and to foster the ability to reason and think logically about issues that will confront students during their engineering career. This thesis has highlighted the point that technical rationality is inevitably entwined and complicated by social values and the Engineering Studies curriculum design is intended to facilitate the development of moral and ethical integrity and sensitivity to the needs of others, with students encouraged to explore possible alternatives beyond the knowledge and constraints of the actual situation and their level of competence.

However, this curriculum serves only as the beginning of a life-long learning process and a concern during these cycles of action research was twofold: that AUT undergraduate engineering students leave the university with an understanding and ability to make value-laden and ethical judgements in the world of industry and commerce, and that the ethics curriculum would be accepted and embraced by the students, rather than be viewed as a soft subject or a waste of time.

I would not say that the curriculum is rigidly or exclusively postmodern – postmodern being a term with multiple and subjective meanings depending on whether it's used in relation to architecture, art, literature or the social sciences. I use the term in relation to education, and although I expect some information to be memorised, my view is that the postmodernist aspect of learning is the process of shifting the balance between *what to learn* and *how to learn* towards the latter, representing a philosophically theoretical movement towards *axiology* (or value) in education. In this module it was the intention to:

1. Shift the learning process from the quantitative towards the qualitative.
2. Move from the modernist approach to engineering education towards a fluid and flexible means of examining issues socially, technically and related to good engineering practice.
3. Provide an approach that does not impose a rigid set of values on the students.

After four cycles of review and adjustment, the approval rating of this module has improved significantly (evidenced through good written appraisals, both formative and summative, which are standard AUT policy and procedure for quality assurance).

Looking ahead, I see the curriculum process as continuing to need adjustments as the factors evolve. I intend to incorporate the changes to the curriculum content documented in this thesis in a revision of the text book (appendix 2) in 2010/11. The revision will form part of a co-authored book on both ethics and sustainability.

12.3 The requirements for an effective ethics teacher

12.3.1 My reflection of experience as an ethics teacher

At the time of being given the responsibility for this module in engineering ethics, the AUT School of Engineering was already committed to a stand-alone paper and I was asked to teach it. Hence, I began this task as an engineering lecturer interested in teaching ethics. A significant amount of study and research was required to develop my competence to teach this paper – I had to acquire new knowledge, including an understanding of the fundamentals of moral and ethical theory.

Hence, one observation from my experience is that an ethics teacher requires development time, time to manage their curriculum and teaching strategies, time to implement changes, and time to reflect on their success (or shortcomings) through student outcomes. It was useful during this process to reflect on my own history and experiences that were relevant in order to contextualise my attitudes towards engineering ethics.

Naturally teachers have their own distinctive ways which predispose them to think and teach in particular styles. While teachers are entitled to this academic freedom in the classroom (American Association of University Professors, 1990), the research established that there are experienced academics who advise that it could be construed by some as unethical for a teacher to impose their personal moral or cultural values onto the students (Andrew & Robottom, 2001; Habermas, 1996; Lewis, 1986; Mather, 1996). There are of course schools and universities in many countries with a direct association to specific religions or cultures, but AUT does not have such an affiliation and, although I have my own personal values and religion, my teaching is as neutral as I can make it in that respect. Even so, in some respects to be neutral on a moral issue can be construed as having another opinion. The obvious dilemma here is that even a neutral educator who takes no side in an issue may represent a stand of retaining the status quo, which may involve steering the issue in some direction. Indoctrination is a risk in the process of teaching and it is important to avoid this. During classroom discussions and case-studies it is important to foster academic freedom and allow students to express opinions, construct their knowledge and reach their own conclusions.

However, we as educators should be cautious with such an open and neutral approach. There are ethical implications in any efforts to assist students in critical reflection and interpretations of meaning where the outcome could be a collective social or industrial action. Although the ideal of academic freedom is to promote the free expression of ideas, university educators should be careful in the education of ethics to be ethical themselves. While teachers are free to express their own opinion as citizens in the community, "their special position in the community as a teacher imposes special obligations, and they should remember that the public may judge their profession and their institution by their utterances" (American Association of University Professors, 1990, para. 7). This of course does not mean that as tertiary educators, university staff should be value-free. In fact, "no curriculum is value-free … a teacher's values will directly influence what is selected for study" (Andrew & Robottom, 2000, p. 776).

Furthermore, as university lecturers we have a significant power relationship with our students and, in the most simplistic of terms, we have the power to pass or fail. An ethics lecturer has the power to influence students and, in my opinion, the only culture I should promote is that of professional engineers and responsible citizens. In this respect I can contribute to providing students with an undergraduate education that has a strong emphasis on future-relevant behaviour skills in industry, and also with the ability and incentive to understand conflicts in their own value systems. As a side effect, it is possible that this module may give some students the opportunity to privately reflect on their own personal lives as well as their intended vocation and how they must fit into that society in a professional manner. In terms of deontological ethics, and utilitarianism, the key questions they might privately consider are: *What should I do*? *How should I behave*? *What sort of person should I be*? As potential professionals they need to understand that while ethical engineering behaviour can establish trust and respect from the society they serve, conversely unethical behaviour can lead to organisational dysfunction, public outrage and personal moral dilemmas.

12.3.2 The future

1. On reflection, my present view of an engineering ethics teacher is essentially someone who has the enthusiasm to teach ethics with the willingness to research and learn about ethics that pertains to engineering-specific issues with a credible level of understanding for the students. The options in my view to choosing an ethics teacher are: Employ a part-time lecturer from outside the School of Engineering who has knowledge of both engineering and ethics.
2. Find an engineering lecturer from within the School of Engineering who has either the knowledge of moral and ethical theory, or the willingness to learn and develop the knowledge and skills to teach it.

I make the following observations on these options from my own experience with guest lecturers:

1. A guest lecturer from industry would have the support of IPENZ who encourage us to have guest lecturers with expertise from industry.
2. A guest lecturer would alleviate the requirement for research by full-time staff, or the employment of such a specialist within the School of Engineering full-time staff (although this may lead away from a research-led curriculum).
3. In the event of a guest lecturer appointment we would rely upon this person to develop and produce their own curriculum content, delivery format and assessment. In the past, we have had to pay a substantial

amount for this type of curriculum development. Finding an engineering lecturer or philosopher from within the School is a cheaper option.

4. Some of the visiting guest lecturers I have experienced from industry have in the past preferred to teach the paper as a block course, rather than commit themselves to a few hours each week over a full semester. In my experience as a Programme Leader, relying on an outsider to deliver each week when such a person has a career of their own can introduce unreliability.
5. It is difficult to maintain quality control over a guest lecturer’s work.

From the work performed in this research I conclude that what should be looked for in a prospective engineering ethics teacher is the ability to:

1. Adapt to a teaching style where practical experiences are brought into the learning environment.
2. Shift the assessment focus of examination preparation from the quantitative aspect of remembering facts, systems and procedures, to a qualitative concept of conceptual understanding and explanation.
3. Take the facilitator's role in ethical education, as one of fostering in graduates critical awareness, with the perspectives, responsibility and freedom to critically reflect and challenge assumptions and premises, and the development of the students' capacity to examine an interpretation and develop alternatives to it.
4. Teach the subject without the indoctrination of one’s own opinion or values, and without imposing rigidity in procedures.

12.4 Curriculum teaching method

Students’ interest in any subject is not always guaranteed, and my responsibility for creating an environment conducive to the development of ethical skills was in my opinion dependent on my skills as a teacher. I found that the students usually already had a sense of ethics and morality before commencement of the module, and some were quite versed in the use of reasoning, logic and language to justify their ethical decision-making. Quite often their reasoning was based on morality, and the curriculum I evolved appeared to help them understand the power of reasoning and how it could influence their behaviour and decision-making.

As the teacher, I found that probing my own ethical background helped me to understand the evolution of my own ethical viewpoints and background. My teaching philosophy was not to produce a surface approach to learning brought about by the impact of assessment which simply demands the necessity to reproduce information, but to encourage a deeper understanding that would lead to the desired quality of learning outcome. In a university learning environment students are expected to take responsibility for their own learning and show greater independence; there is less spoon-feeding of information and less formal didactic teaching.

To be realistic, the primary motivation for an engineering student to engage in the AUT subject of Engineering Studies could sometimes simply be that it is compulsory and necessary to complete the undergraduate qualification. In such cases as these, the learning may be done for a particular vocational purpose, and may be disposed of after the goal is achieved. This led me to think carefully in the first cycle and to plan a structured approach to the curriculum delivery, using a combination of deep learning and collaborative activity to demonstrate and facilitate an understanding of the importance and relevance of ethical engineering in society.

I found that the use of large case-studies helped students practise ethical decision-making by evaluating other engineers' problems in hindsight and I found them useful to encourage students to think for themselves in the process. As I tell them, I don't want engineers who can learn a model answer and write it down in an examination. I want to know if they can think for themselves and give a rational justification for their stance and opinion based on the ethical principles they have either learned or reinforced during this module.

I found that when students showed an interest in the subject, their motivation to internalise the concepts seemed improved, and their assessment results were better. I regard the co-operative group work as important to facilitate student recognition of the importance of understanding their own individual perspectives, but it evidently motivates just as well in a lecture theatre as it does in a group outside the class times.

Looking ahead, I assume that any curriculum cannot be expected to unravel and solve all of the problems associated with engineering, and as professional educators we cannot be expected to provide emancipatory education across the entire spectrum of social or cultural distortions and injustices. We can of course be emancipatory, but we can't provide encyclopaedic education. However, this curriculum process of ethics education must continue to foster in AUT graduates the perspectives, responsibility and freedom to critically reflect and challenge assumptions and premises. AUT students certainly learn from in-class experience in societal, ethical and environmental issues and it is to be hoped that they begin to recognise ethical issues, be better equipped to reason carefully, and be more aware of ethical principles and practice with a propensity to confront ethical issues. The achievement of resilience (how well these abilities will be retained in their careers) is difficult to gauge, but I will continue to advocate the use of innovation in problem-solving and the promotion of a self-awareness of values and ethics. Furthermore, the field of engineering ethics is likely to advance along with new ideas, innovativeness and procedures in ethics education. I too must keep abreast of such developments and it will be important in future to keep reviewing my teaching methods with a view to improvement.

It will also be important in the future to replace minor case-studies with newer and more topical ones that are relevant to current issues and problems in engineering, and I see that the updating of case-studies and discussion points may be a feature of curriculum evolvement. As good as the *Challenger*, *Cave Creek* and *Titanic* case-studies were in 2009, in order to maintain currency and relevance there will be a time to identify and use fresh material.

12.5 Curriculum delivery

12.5.1 The delivery options

As discussed previously, I conclude that there are several options for the implementation of ethics into an undergraduate engineering programme. These include:

1. A stand-alone discipline in its own right.
2. An across-the-board theme by immersing portions of the content into several papers where several current staff will be involved in teaching the curriculum.
3. An across-the-board theme by immersing portions of the content into several papers where several current staff will be involved in teaching the curriculum, followed by a final-year stand-alone module.
4. A stand-alone introductory paper, with the consequent immersion of the remainder across-the-board into the higher level papers.

The directive received in 2005 was for a continuance of the stand-alone course and this was based on the environment at the time in the AUT School of Engineering. During the research I found deep-rooted structural issues associated with promoting the across-the-board approach because I encountered the scepticism of many staff not interested in teaching ethics. I believe that if we adopted an across-the-board approach, such scepticism could produce resistance, resulting in an ineffective curriculum where without some regulatory function we would have no control over the adequacy of content and delivery. In the promotion of such a change Jones and Carr (1993) explain that, in their experience, lecturers' responses to such changes is a critical dimension in the implementation of any new curriculum. In their view, other lecturers can have their own subjective views and often lecturers who have already been in a climate of pressure may not see change as a solution but view it as a further problem. I formed the opinion that one specialised staff member would probably be more effective than an across-the-board format. Hence, the preference at the time in 2006 was for a continuance of the stand-alone format of the paper.

Within this format, learning is intended to be habitual, with a recurring weekly cycle of lesson, discussion, and feedback. I initially adopted a curriculum delivery process of incremental theory by slowly building up the students' knowledge to equip them with the knowledge and skills to consider the case-studies that would follow. I intended this approach to teaching as a method of scaffolding, where the teacher builds up a knowledge structure each week with the support that a scaffold would provide to hold the structure in place. The intention of this principle was that once the knowledge structures are covered, the teacher may take the scaffold away and students should stand on their own as they face the challenge of applying their knowledge to case-studies, assignments, and the assessment of their learning. In the early part of the module the support structure included some practice, as each week the theory was supplemented with discussion points, which are listed at the end of each chapter (see appendix 2).

Over the four cycles I continued to follow this combined format of minor discussion points while building the knowledge base towards the large case-study discussions at the end of the paper. At the time of the initial curriculum design this approach appeared to work well, but as time progressed I found myself leaning towards a just-in-time approach and I have increasingly introduced ethical questions and theories when the need arises. I found that at each lecture I could use a current news story with which the students were already familiar to promote the discussion points relating to ethical theory. For example, some of the front-page stories I have used in 2010 were:

1. The Melbourne Storm rugby league team exceeding the salary cap.
2. Toyota not being truthful about their products.
3. Telecom NZ network failures.
4. The BP oil-spill off the coast of the USA.

The timing of the ethics module must not interfere with other staff members' work. Using the full semester with an allocated weekly class time removes the interference with other lecturers that was encountered in the previous three-day course format at AUT. It also gave me time to raise the students' knowledge from low-strength to full-strength as a gradual process. Rather than a total immersion three-day learning cycle in which information can be just as quickly forgotten, my preference for incremental theory gives the students time to listen, digest, probe, question and discuss. Such a cycle is in my opinion more conducive to motivation and learning, and in my view it more likely to lead to the transferring of information into their long-term memory. Having said that, I do not discount the possibility that a well-taught three-day block course would be remembered by students and may be preferable for some of them. I have not had the opportunity to try such a format.

12.5.2 The future

The stand-alone concept of ethics instruction has critics. Herkert (2000b), for example, argued that the stand-alone style of ethics education conducted at the Texas A and M University was due to the high staffing cost of an across-the-board alternative in an already tightly packed engineering curriculum, and stated that “unless supplemented by further instruction in engineering ethics in mainstream engineering courses, this method can leave students with the impression that ethics is a sidebar rather than an integral part of their engineering studies” (p. 307). When little effort is put into this paper by a student, this might be arguable. To overcome such criticism the paper is offered in the final year, when they might perhaps understand the value of it.

I cannot discount the possibility of a future staff preference for an across-the-board approach which consists of ethics instruction woven into the entire engineering programme, with many teachers taking part. In this event, provision could be made for a visiting expert who is experienced in teaching engineering ethics to help all staff see how they might participate. With a distribution of the ethics learning across the papers the advantages could be argued as:

a. The teaching of ethics can be introduced at times when it naturally compliments the technical instruction.

b. The ethics instruction can be woven into existing papers. With such a format the students may be able to recognise the relevance and importance of ethical thinking at the appropriate time.

c. It does not require a reorganisation of teaching timetables.

d. The students would be given the opportunity to consider ethical issues on a regular basis.

However, I see some issues with across-the-board solutions that would require forward planning:

a. There are very few common papers at AUT after the first year in the BE (three majors) and the BEngTech (five majors).
b. The practicalities of introducing an across-the-board teaching programme would include the need for an ethics team to plan and implement the teaching schedule. Such a team would have to be committed to the ethics programme.
c. The teaching team would need to agree on the assessment schedule in advance, which would have to be spread through many papers.
d. Some of the ethics team may need training and support.
e. The ethics team will require continuous co-ordination by an effective team leader who has the resources (in particular, time) to monitor the schedule. Such a team leader would need the support of senior management with recognition of that status during the implementation.

Perhaps the ultimate solution is the best of both delivery methods, by offering a required module in ethics, coupled with an overall engineering programme that recognises the importance of ethics throughout.

12.6 Assessment

12.6.1 The evolution of assessment at AUT

The assessment as outlined in chapter 11 began as a manageable procedure for small classes, but changes were driven by the necessary efficiency of handling larger classes. As a result, the examination format for assessment did not change from the initial design, but the examination of the case-studies evolved to be included in an extended final examination.

The motivation to learn in a degree programme may understandably be linked to the motivation to pass, and the traditional system of formal examination facilitates this, but the motivation to learn, remember and pass is not necessarily the motivation to comprehend. The aim was to introduce ethics education with a movement away from the traditional *learn and regurgitate* procedure to a new concept of collaboration and interaction. The objective in engineering ethics education was to increase the student understanding of the interrelatedness and interdependence of society and the physical world. As a teacher I consider an assessment which reflects the students' needs when they graduate as being important, rather than one involving the transmission of a pre-established canon of knowledge.

The challenge as an engineering ethics educator was the adoption of an appropriate approach to assessment, because the subject can be examined in diverse ways. The design of the AUT Engineering Studies learning process allows students' opinions to be embedded into the learning environment. The final examination that evolved at AUT sought a student's opinion based on their learning in order to gauge the levels of understanding and the ability to reason and think for themselves.

My observation is that the more recent case-study assessment procedure I adopted gave the process of analysis an enhanced degree of seriousness and focus. More importantly, as explicit items for final examination, the case-studies now ensure that the process of analyses has shifted the focus of examination preparation from the quantitative aspect of remembering facts, to the qualitative concept of conceptual understanding to such an effect that it is given much more respect by some students than the previous group report concept. The strategy for increasing the motivation to understand has involved an increase in the examination of analyses. An unanticipated and welcome side effect of this system of assessment was the incentive for the majority of students to come to class.

Every year since 2006 the students have been required to submit an ethics assignment relating to the relationship between technology and society. The format for this question has not changed in the four years and is attached in appendix 1, although I later dispensed with the definitions.

The decisions I made with the assessment procedures were made as required, based on my experience, and were often made pragmatically to achieve an assessment procedure that was aligned with the module objectives.

As I progressed and adapted, I achieved in my view a balanced assessment procedure suitable for this size of class. There was formative assessment and feedback through the essay and formative feedback by the in-class case-studies. Finally, I was summatively assessing *everybody* by examining the major case-studies in the final examination.

12.6.2 The future

I envisage the next step in improving the learning, feedback and assessment of the paper will be the creation of online self-tests where the students may check their mastery of the programme.

While the current examination format has placed me in a better position to assess individual learning, I have no information as to whether the key features of learning within the module endure once the programme examination is complete. The gauging of past graduate retention of information would relate to potential resilience of the course learning. Future research could comprise a follow-up period to review the residual effects of retention and understanding of ethical issues in engineering in their succeeding industrial situations.

There may be new developments and ideas for technical education and part of the rethinking process in the future may involve re-engineering the way we deliver and assess our programmes. In the future a possible development in learning strategy and assessment is the movement towards problem-based learning (PBL). I am familiar with the model developed by Aalborg University in Denmark (deGraaff & Kolmos, 2006) and the adoption (or partial adoption) of this or other models of education in the future would require another cycle of action research to reconsider the delivery format, timing and assessment of the Engineering Studies paper.

12.7 Contribution of this study and thesis

12.7.1 Contribution to Engineering

The contribution of this project to the engineering industry is to add to the development of an understanding of the implications of ethics within engineering decision-making. The Engineering Studies paper has students examine some of those decisions. In this respect, the successful students give evidence of their changing attitudes. What the course is doing, in terms of both ethics and sustainability, is facilitating an improvement in the quality of engineering decisions concerning the straight-forward practical issues by having students think differently about what they are actually doing. During their programme, particularly in the final-year project, students prove that they are well capable of engineering a device or process, but the questions they are now encouraged to consider, which often involve ethics and sustainability, are:

1. Why are you doing this?
2. How is it going to be used?
3. What are the resources that you are using to make it?
4. Are you using precious resources that might not be available for the next generation?
5. Is it harming the environment, or is it neutral?
6. Will it harm the environment in the future?
7. What is the contribution to society of this product?

As I complete this thesis in 2010 we have seen a really good example with the Apple iPhone model that was launched into the world market in 2010 with a fault in the antenna. Engineers must be prepared to press the point at the marketing level if there is going to be a problem like this. Similarly in 2010, a BP oil well in the Gulf of Mexico required a safety valve in it, but the company's finance department avoided adding another million dollars to the cost of the well and took the risk of not fitting one. AUT graduates now leave the university understanding that engineers shouldn't take short-cuts where there are risks that threaten a catastrophic disaster. In the BP example, the eventual disaster was so great that the extra million dollars required for safety would transpire in hindsight to be an economical precaution in terms of the environmental impact.

The paper is intended to give AUT graduates a level of foresight. As engineers they need to assess the risks in the implantation of faulty products and understand that there can be consequences. In promoting such products or processes it is desirable that the students should leave AUT understanding that it's not ethical or sustainable to practise engineering like this. The students graduating from the Engineering Studies paper appear to embrace this change in attitude, and give every appearance of understanding the implications of their engineering decision-making. I hope that this paper takes them beyond product service, through to both the ethical and sustainable implications of their decisions; this is an objective designed such that they should understand that there is more to engineering than just the design, manufacturing and maintenance of engineering equipment. The Engineering Studies paper results give me every indication that it has encouraged them to consider values-based and ethical decisions, both in their own personal lives and in their prospective professional lives as engineers.

This research gave me the opportunity to reflect on the attitudes of my generation and my parents' generation. These were generations who helped create some of the unethical and unsustainable problems that society now faces; generations that have almost trashed the planet. It is future engineers, including current AUT graduates, who have to address these problems in order to shift our way of life towards an ethical and sustainable future for the generation that follows. The intention is that students leave AUT equipped to consider how the planet will be for the children of future generations who inherit it. As the paper progressed, students were encouraged to see the many long-term implications of decisions or actions that were taken many years ago that are now inhibiting our ability to have quality in some aspect of life. After AUT students graduate one of their important responsibilities as engineers is to address and turn around some of these problems caused by decisions made by my generation and those before it. They certainly have given me a clear indication that by the end of the paper they are beginning to understand the state of the world that they're in (if they hadn't already), which some may have previously accepted without question. This paper has challenged students to think about ethical issues, and how they as individuals will handle these situations before they are confronted with similar situations in a work environment.

I have attempted to provide the AUT School of Engineering with a curriculum that provides the means for changing the attitudes of undergraduates towards a lifetime of enquiry into the learning and understanding of their chosen profession and offers an international outlook on the way we perceive our surroundings.

12.7.2 Benefits to the AUT School of Education

My involvement in this research through the EdD programme is the first for an AUT engineering staff member and may in the future benefit the engineering community. The AUT School of Engineering has advised the School of Engineering staff that the AUT Doctor of Education programme is now recognised as a suitable professional development goal for engineering staff provided it is related directly to engineering education. This is an important recognition for the staff of the School of Engineering who have not always valued or questioned their teaching methods.

12.7.3 Benefits to the researcher

As a personal reflection of my own position, I have been teaching aspects of engineering for over 30 years, and during this period my place of employment has transformed from a polytechnic into a university. My teaching in this area is now research-based, as expected in a university.

Within the EdD programme I have been able to investigate the concept of postmodern education. This facet of the thesis presented me with the opportunity for reflection on my experience in my 1950’s primary education, which involved rote learning. I have also reflected on my secondary years at a technical high school where I experienced an education system that involved the preparation of the young for industrial careers. Toffler (1970) described the American school system at the time he was writing as one which simulated the industry that the children were being prepared for, with its long rows of desks simulating an industrial plant, a school bell simulating the factory whistle, and the organisation of knowledge into permanent disciplines. Toffler observed that such a mass-education machine, with its rigid systems of seating, marking, assessment and a know-all authoritarian teacher was suitable for industry in the nineteenth century, but the format had continued well into the twentieth century. This six-year research project has given me the opportunity to review and understand the historical meanings and contexts relating to some of my childhood education, and realise how my approach as a lecturer in a university is so different.

In my growth as an engineering ethics educator I have embraced the challenge of McQueen (1992) for educators to move from a learn-and-regurgitate rote-learning mentality of curriculum structure and delivery to a mentality of “skills for thinking, skills for communication, skills for creating new knowledge, skills for inventiveness and innovation” (p. 155). While rote learning still has a significant place in education, to me it is crucial in engineering ethics education for students to understand the process.

With AUT having university status there is a growing expectation that staff should be critical of their own standards and possess a self-critical ethos, particularly in curriculum design. I use the term growing expectation because within this transition to university status, I can no longer rely on externally provided syllabi together with an external examination. I have developed my personal attitudes by becoming more critical of my teaching and confronting, where appropriate, the standards, content and teaching methods of each paper that I am responsible for to ensure that the curriculum meets university standards and the evolving needs of the engineering profession. In the process, my growth as an engineering educator has included adopting a wider perspective on our commitment in service to the community, with a growing belief in the necessary provision of a more holistic educational engineering programme. I believe that such postmodern academic attitudes are important as we compete with other universities in a commercial and market-driven environment.

This project has involved several changes in my beliefs, attitudes, philosophy in life, and ways of working as an academic, and a shift towards *post-positivist* thinking. During the journey in this research I have explored my own changing perceptions of ethics, and learned a great deal about both ethics and education. In my view, we academics can hardly expect the communities to take us seriously as a critic and conscience of society if we do not practise professional ethics ourselves. While we live in a market-driven environment, our approach needs to balance the profit motive with an ethical and responsible approach to serving the community.

Consequently, in this research process I have not been afraid to take an in-depth look at my background, culture, upbringing and the previously ingrained childhood prejudices that I have rejected or modified over the years as I grew in maturity and stature as a professional and ethical educator. The personal benefit of this growth has already led me to being asked by IPENZ in 2008 to write a one-day IPENZ ethics seminar, and being engaged by IPENZ in 2009/10 to conduct seminars in Auckland, Wellington, Christchurch, New Plymouth and Queenstown.

12.7.4 Contribution to engineering education

The rationale for educational research is not merely to understand education, but to investigate ways of changing and improving education. Ostensibly, one could argue that I had the benefit of the module I inherited as a point of origin, but as Eisner (1993) stated, “if the programme’s quality is poor to begin with, the quality of the teaching does not matter much: if it’s not worth teaching, it’s not worth teaching well” (p. 225). My thoughts at the time concurred. The module I inherited in mid-2005 had not been popular and the objective of this research was to redesign the curriculum in a way that would interest and engage engineering students.

The new module is now very different to the one I inherited and this research may contribute to engineering education with the provision of suggestions for the implementation of a structured module of ethical studies in university engineering programmes. It is a curriculum design for ethics which could provide a framework for decision-making while promoting the development of integrity and sensitivity in engineering, particularly towards the needs of our society, individuals and the environment we live in.

The sharing of this curriculum development experience is intended to contribute to academic enquiry and knowledge within the engineering community, and although the research is interpretive and therefore liable to be judged subjective, it will hopefully be judged by the engineering community in terms of its potential to make a contribution to the body of knowledge in the field of engineering ethics education. The curriculum that evolved covers the breadth and complexity of the subject area, but it is not presented to the engineering community as the only blueprint to success. Nor do I promote it as being superior to any other university paper on engineering ethics; it is however an improvement on the 2005 AUT curriculum it replaced.

This research has identified a trend towards changing the balance between delivering empirical and the social aspects of engineering education that began during the modernist era in the 1960's. The modernist period was a time of weak or non-existent values in engineering education. Now, instead of simply demanding ever more technical information in their programmes, institutions in the tertiary sector are attempting to equip students with values that match society's expectations of engineers. The thesis is intended to contribute to engineering knowledge by investigating the changes in engineering educational attitudes which have become a global concern in the last decade (and have spread to the schools in New Zealand).

The literature review during the course of this research established the importance of an engineer's sensitivity to and appreciation of wider societal implications and issues of engineering. The results of this research show that there is general agreement with respect to the importance of engineering ethics in an engineering curriculum. The research indicates that the responsibility for ensuring engineers have an understanding of ethics is a direct responsibility of universities and programmes should be designed with the purpose of bridging the gap between technology and society, along with an understanding of the ethical implications of engineering in society.

Engineering education has traditionally used a variety of curriculum designs but the teaching of most subjects in a university remains dependent on the philosophical ideals and the successful curriculum development of the individual educator. This was certainly the case with the Engineering Studies paper at

AUT and the literature I have reviewed and assessed during this project has provided a range of perspectives on the subject of ethics in engineering. The research revealed some equivocations and/or paradoxes which have fuelled my own arguments. My critique of these theoretical positions, particularly where I have placed the claims of one writer against another, is inevitably subjective. I saw part of my role in this research project to question and test the reliability of some of these claims. These collected opinions led to my research questions regarding the implications for teaching ethics, together with the necessary learning structures and assessment models. The practicality of testing these theories, structures and models at AUT was always tempered by practicality and the economic necessity of teaching classes in lecture theatres.

Historically, theories and laws, which can be tested and proven experimentally, have supported and dominated the learning of science and engineering, but the teaching of ethics involves activities, ideas, cultures, relationships and meanings rather than objects. Such theories, which involve starting points for a discussion, would usually, in a more empirical discipline, be rejected as unverifiable, and our staff and students can naturally become sceptical of such *grey areas* as ethics.

Engineering has many grey areas, where compliance is not necessarily compulsory, and profitability can tempt companies, scientists and engineers into unethical practice. This is of concern because the literature review indicates a consensus that the modern engineer lives and works in a rapidly changing technological society that sees them involved in making complex judgements, many of which have an ethical (or value-laden) dimension.

This thesis has identified the need to promote an intellectual learning environment, where the students are given every opportunity to consider these issues, and they should leave university understanding that ethics is not a luxury item. Within ethics education the guidelines we help students construct must be useful and pertinent in clearly identifying the pressures that can be involved in engineering practice, and the contribution to their profession that is expected of them. The transition from formal education (learning) to the world of work (doing) should not be seen as giving students the correct skills at the point of departure from formal education, but as the beginning of a life-long learning process. In fact, the transition in learning is a life-long process in itself. Because they are not learning engineering ethics in an across-the-board format, this paper is the one place at the end of the students' studies where they can be reached effectively.

It will be important in future years to keep up with engineering ethics developments and any new theories related to ethics. As a contribution to professional knowledge and practice in the field of engineering ethics education, I hope this study may engage a wider group of people in the education community in this enterprise. I see the need for ethics teachers to pool their expertise, and I hope that this research, with its curriculum design and critique, will stimulate further possibilities for substantive and informative insights for the profession of engineering, as well as contribute to future developments in the pedagogy of engineering instruction.

An important contribution of this thesis to engineering education is the provision of guiding assistance as a possible beginning for those academics that choose to follow this path of curriculum development. There is no reason why an academic should work in isolation and one of the attributes of the academic community is that knowledge is shared collectively, rather than limited to a privileged few. Hopefully this work may become a useful resource to others.

12.7.5 The future

AUT graduates are about to enter an engineering industry that services a *now generation* in a *consumer society* (and two ethical questions are implicit in these phrases). Within this culture of consumption many graduates will enter a workforce that not only caters for consumers' needs, but very often creates the needs. Furthermore, workers in this country have had to adapt to a new working environment, living in and supporting a business and industrial environment that is open and requires servicing seven days a week. From an employer's point of view, businesses, industry and commerce expect a high work ethic from staff and are getting more intolerant of missed deadlines – if professional staff agree to deadlines, they are expected to meet them, and anything else is totally unacceptable. People in the workforce are expected to take responsibility for their portfolios and their actions. What really matters now is – can you deliver to users' expectations? This is why the ethics module student outcome expectations include work ethic and work etiquette, in which punctuality and reliability are featured as an important function of work ethics.

To meet IPENZ's expectations and prepare its students for today's engineering world, a university cannot simply act as a passive facilitator of technological higher learning. We must also be gentle provocateurs, i.e. graduates can be gently encouraged to face up to any contradiction between what they believe and what they do in society. We can help prepare the students to develop the level of empowerment, both educationally and socially, necessary for these demands and pressures of ethical decision-making which are especially relevant to daily life in their own social world in addition to their preparation for the workforce.

To meet the level of ethical decision-making that employers and society need from engineers and ensure that value-laden implications and societal consequences are understood, we need to adopt a wider perspective regarding the future. I see the gradual inclusion of values and ethics in all AUT papers as the next step, creating an increasing awareness of the good/bad consequences of actions which is part of all curriculum development across all learning disciplines.

Barriers to such an implementation of formal values-based engineering education can exist within the working cultures of engineering staff in new universities such as AUT. However, many of us who have transitioned from the polytechnic environment no longer see engineering in narrow terms of *constructing or maintaining* something, which was our own life and work experience. We have now adapted to a broader learning environment which includes the intellectual rigours of advanced research and debate.

One of the most heartening results of this research is that more colleagues are now involved in discussing engineering ethics amongst their colleagues and ways of including ethics into their engineering papers.

Some colleagues are now informally introducing ethical discussions in engineering classes outside the specialist engineering studies paper to emphasise the relevance of the relationship between the ethical and environmental aspects of engineering practice which have caused environmental and human disasters in the past. An ethical sub-culture is gradually developing in the AUT School of Engineering. By sub-culture I mean the natural groups of curriculum interest that form in a school, particularly in research interest groups, and occasionally in the staffroom.

I hope that the sharing of my research will eventually lead to the formation of an intra-university sub-culture in the future, which will share experiences and cause changes in the emerging teaching and assessment practices in the field.

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Appendix 1: Exams and Assignments

Engineering Studies - 707005

Assignment 2009 (Ethics Section)

Due on Friday 1st May up to midnight

The following assignment is intended as an ongoing work throughout the first six weeks of the course. All work must be fully referenced using Endnote programme, with APA 5th edition format (or numbering format).

Note: 1. Wikipedea is not considered an authentic academic reference. You must not quote from Wikipedea. (However, it is useful for understanding something or finding other references).

2. If you copy an essay or passage from somewhere without reference, or copy someone else's work, and we find out, the marks for that section will be zero.

The grades given for the assignment will take into account; the quality of response, which will include the application of intellectual rigour, and the demonstrated ability to see more than one perspective to the issue addressed.

- Clear description and discussion of the technology - 5 marks.
- A discussion on the effect of the technology on society - 5 marks.
- The justification for any statements, which must include appropriate academic referencing - 3 marks.
- The presentation. Grammar, spelling and use of modern word processor - 2 marks.

Question

Write an essay (minimum 1000 words) on **either**:

(a) The relationship between technology and society,

or (b) The relationship between a particular area of technology and society (such as automation, transportation, communication, food production, entertainment, etc),

or (c) The relationship between technology and a particular area of society, such as women, men, Māori, Pasifika (people from one of the Pacific Islands) etc.

(15 marks)

The Objective of the Essay

Whichever aspect of technology you choose, this essay is intended to document how technology has affected and changed the way society or a particular culture lives, operates, works and socialises.

Your assignment must be submitted to AUT Turnitin which gives a similarity report (a similarity to other works). You may submit trial submissions for your own information before submitting the final assignment.

- The similarity result of a well referenced essay could be up to 15 - 20%.
- A 90-100% result shows you may have copied it from another author, or previous year's students, whose essays are on the Turnitin programme, or that someone has copied your work.

Additional questions in 2006/07

1. Define the following

   Values

   (a) Morality

   (b) Ethics

   (c) The relationship between them (4 marks)

2. Define the following

   (a) Consequentialism

   (b) Utilitarianism

   (c) Existentialism (3 marks)

3. A Vice President of Morton Thiokol, Mr Robert Lund was the engineer required to give final approval before NASA could launch the Challenger space shuttle in its final and fatal flight. As an engineer, he was instructed:

   "take off your engineering hat and put on your management hat".

   Discuss the weighting factors which it is understood he had to consider before making the decision to allow the launch to go ahead, and categorise (in your opinion) his final decision in terms of Aristotle's Virtue Ethics Theory. (8 marks)

Previous examination questions

The written examination questions have changed each year. The following are samples of past examination questions. The principal objective is to gauge their understanding rather than what they have managed to memorise. The following marks are a guide to marking expectations.

1 mark – A concise statement or definition.
2 marks – A good explanation.
5 marks – A full explanation of about a page.
10 marks – A full essay, usually two or more pages.

- When making a decision in your personal life, the decision may sometimes be influenced by your moral principles, or the expectation of etiquette. Explain the difference between these two. (2 marks)
- Define the following

  (a) Values. (b) Morality. (c) Ethics.

  (d) The relationship between them (4 marks)
- Define the following

  (a) Consequentialism.

  (b) Utilitarianism.

  (c) Existentialism. (3 marks)
- Explain the importance of etiquette in the engineering work place. (2 marks)
- Explain what is meant by *treating people with dignity in the engineering work place*. (1 mark)
- Explain the difference between values, morality and ethics. (3 marks)
- Explain the principle of existentialism, and the limitations the theory has as on you an engineer in the work-place. (3 marks)
- When considering Aristotle's virtue ethics, state the difference between an altruistic decision, a utilitarian decision and an egoistic decision. (6 marks)
- Under the Hobbes, Locke and Rousseau Social Contract Theory a citizen has alienable and inalienable rights. Give an example of each. (2 marks)
- When considering an engineering decision, explain the difference between idealism and realism. Give examples. (4 marks)
- When undertaking research in a university, state when it would be necessary to apply for ethics approval from the university ethics approval committee. (1 mark)

- State two important consequentialist factors that are considered by the IPENZ Engineering Code of Ethics to be a moral imperative during the engineering decision-making process. (2 marks)
- Explain the purpose of an engineering code of ethics. (3 marks)
- An example of non-consequentialism is deontology. State how a deontological decision differs from a consequentialist decision and give an example of each in engineering decision-making. (4 marks)
- An engineer who is employed in your company is judged to be unethical because of an apparent conflict of interest. Give an example of what could be judged by your employers a conflict of interest. (1 mark)
- A group of students are sharing a joint engineering research project at AUT. List four important ethical considerations that should be carefully checked before the group's joint research report is submitted for examination. (4 marks)
- An engineering student is conducting engineering research in a university which involves gathering data from other people in the university. Explain four ethical procedures you must follow in the treatment of these people. (4 marks)
- An engineering manufacturer is accused of plagiarism in the marketing of a product. Give an example of what could be considered plagiarism. (1 mark)
- Some scientists and technologists claim that the relationship between technology and society is neutral (or amoral). Some people disagree and view the relationship quite differently. Explain your position in reaction to this statement and explain why. (5 marks)
- The relationship between technology and society is such that many scientists and technologists claim *"society must control technology"*. Explain this statement and give two examples of how society has been affected by each of the following;

  (a) The implementation of effective controls. (b). An absence of any control. (5 marks)
- When considering an engineering decision, the outcome of the decision may be predicted with either:

  (a) Certainty. (b). Uncertainty. (c). Risk. (d). Ignorance.

  Discuss each of these possible outcomes in relation to good engineering decision-making. (4 marks)
- State two types of behaviour towards other colleagues in the work place that would be unethical. (2 marks)
- State two types of behaviour that would considered unethical when using e-mails in the work place. (2 marks)

- State two types of behaviour that would considered unethical when using a mobile telephone in the work place. (2 marks)
- Explain the series of steps you would consider imperative when considering an engineering decision to which there are no rules or guidelines. (5 marks)
- Regarding the Ford Pinto motor car, explain the actions of the Ford Motor Company that were considered unethical. (5 marks)
- Explain the term *whistle blowing*, and discuss reasonable alternatives to such a course of action. (3 marks)
- Explain some of the factors and weightings that may cause people to make different decisions relating to an ethical issue with an example. (5 marks)

2009 case-study examination questions

For this choice of question a full essay was expected which would normally be about two pages or more. The students are expected to relate the issues to their knowledge of the theory of ethics and engineering decision-making.

Section C: Ethics

Answer any **ONE** question from this section.

All questions are worth 10 marks.

1. Challenger space shuttle disaster

A Vice President of Morton Thiokol, Mr Robert Lund was the engineer required to give final approval before NASA could launch the Challenger space shuttle in its final and fatal flight. As an engineer, he was instructed:

"take off your engineering hat and put on your management hat".

Discuss the weighting factors which it is understood he had to consider before making the decision to allow the launch to go ahead, and categorise (in your opinion) his final decision in terms of Aristotle's Virtue Ethics Theory.

What improvements have been made to the IPENZ Code of Ethics to improve engineering decision-making to avoid a disaster like this in the future?

2. Cave Creek disaster

In April 1994, Department of Conservation workers finished constructing a viewing platform, which was built out over a cliff at Cave Creek, in the Paparoa National Park. The platform was built so that visitors could look down a 40-

metre chasm to see the headwaters of Cave Creek come out from an underground cave system.

On 28th April 1995, a group of students and tutors from the outdoor recreation course at Tai Poutini Polytechnic in Greymouth visited the site as part of a field trip to study the limestone formations and caves in the area. As the party walked into the bush, it split into two groups. The larger group of 18, including the Punakaiki field centre officer, reached the viewing platform first.

At 11.25 am, as the 18 people moved onto the platform, it tipped off its base and fell onto the boulders and rocks of the creek-bed below, taking the victims with it. 14 people died (13 students and one Department of Conservation field officer).

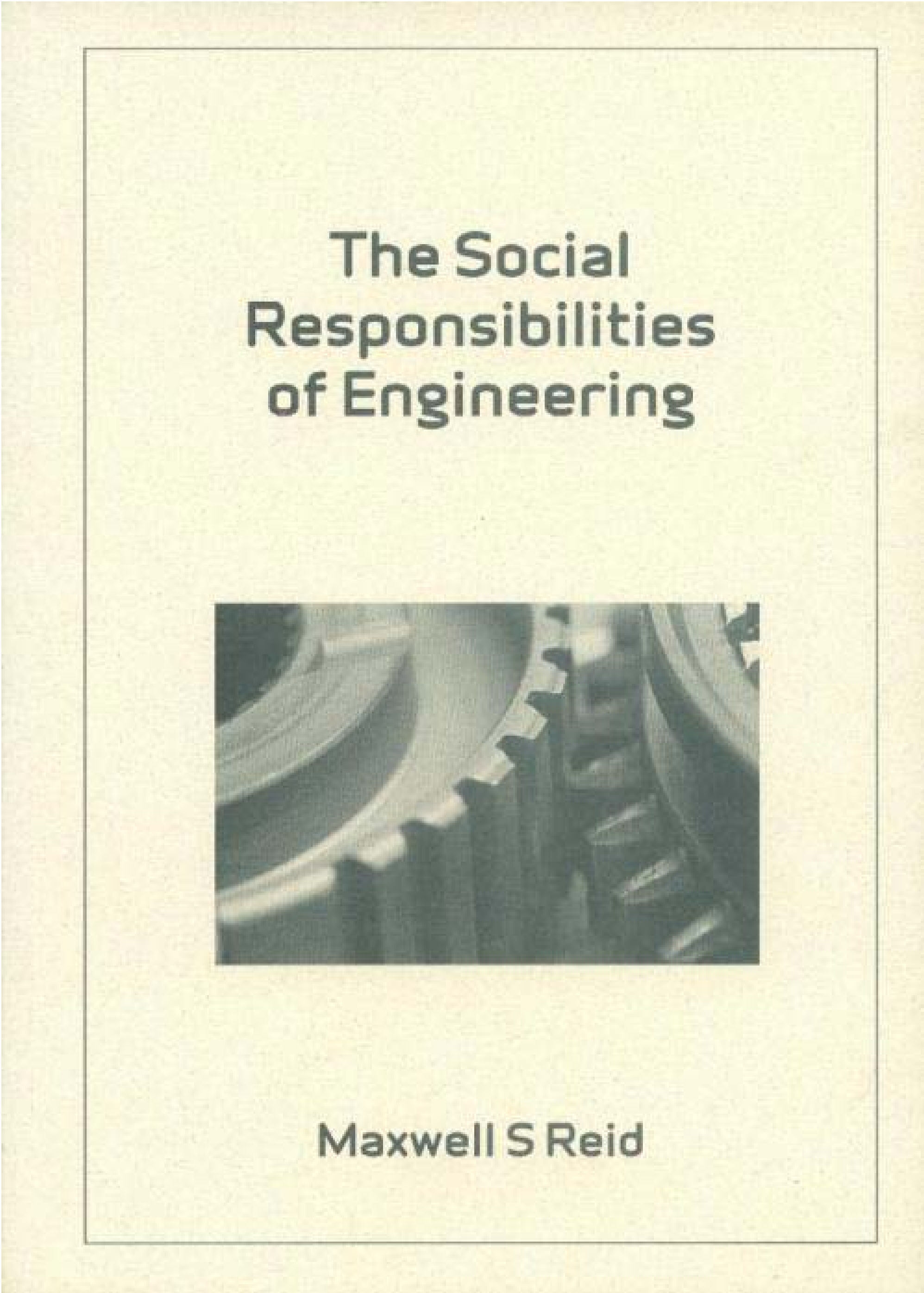
Discuss the issues that contributed to this disaster from an engineering point of view in terms of competency, operational procedures and ethical decisions. Explain any procedures that have been reinforced or put in place to avoid such a disaster in the future.

3. Titanic disaster

In 1912 the largest liner ever built at that time, the new 46000 ton White Star Liner Titanic was on her maiden voyage from Southampton to New York when the ship struck an iceberg at 11.40 pm. As a result of the collision the ship sank approximately two hours later with the loss of 1517 lives of passengers and crew. Of the 1324 passengers and 899 crew members, only 706 people survived the disaster.

Explain the design, operational and ethical factors that led to this disaster and any operational procedures that have been put in place to avoid such a disaster in the future.

Appendix 2: The Text Book



The Social Responsibilities of Engineering

Maxwell S Reid

About the Author

Maxwell S Reid

The author lectures in telecommunications engineering, computer network engineering, and engineering ethics at the Auckland University of Technology, where he studied for his doctorate at the time of writing this book. He has researched and published many journal and conference papers on technology education, the role of a university as a critic and conscience of society, the need for an engineering code of ethics, and the principles of ethical and values-based decision-making in engineering. He has also researched in the area of engineering education, and published papers on effective teaching methodologies for engineering education in the post-modern period.

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Author's note (August 2010):

1. This is a copy of the book.
2. The page numbering and text layout have been modified to fit into this thesis.

The inclusion of the book as an appendix

The intention of this thesis is the development and presentation of a curriculum design. Curriculum design is a specification about the practices of teaching a particular subject, but it is not a package of materials, or a curriculum to be taught. (Stenhouse, 1975). However, the thesis has documented the process of translating the entire curriculum into practice, and the curriculum content was part of the curriculum process. Consequently, the book may be considered useful supplementary reading. It is included as part of the process in reaching the goals of student outcome, and is included as appendix 2 as the initial curriculum content, and the part of the thesis concerning content is restricted to additions and alterations of the content.

The Social Responsibilities of Engineering

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Preface

This book provides a comprehensive coverage of the social responsibilities that a modern engineer can face in the engineering industry. The book is intended to be a useful resource in association with the presentations, lectures and tutorials to Bachelor of Engineering and Bachelor of Engineering Technology students during their studies of engineering ethics.

In conjunction with a series of lectures, this book is intended to give university engineering graduates a good understanding of the ethical expectations of behaviour and decision-making in the engineering industry. The students will have the opportunity to discuss and learn about the concept and responsibilities of engineers in relation to ethics in engineering practice and decision-making. The content involves a study of the issues concerning the development of technology, supplemented by an introduction to moral and ethical theory and the introduction to engineering codes of ethics. The added use of high-profile case studies is intended to develop the students' social responsibility, with an ability to make ethical decisions and possess an appreciation of ethical conduct within the engineering profession.

The content begins with a theoretical grounding of understanding the roles of technology in society. In the field of engineering and technology today, ethics assumes the form of professional standards of conduct, and engineering ethics, as part of the engineering curriculum is considered important to bridge the gap between technology and society. This study of engineering and technological ethics looks beyond the usual health and safety issues to the broader effects of engineering on society. Emphasis is given to broaden engineering ethics to include the ethical implications of public policy issues of relevance to engineering such as risk, product liability, sustainable development, globalisation, and information technology. The ethics discussion should improve the students' perceived ability to correctly identify and handle ethical issues. The case studies used in this programme of study are now an internationally accepted form of teaching ethics to allow the students themselves to shape their views and reactions to value dilemmas in ways considered acceptable to the professional community.

As professional educators, and because of professional or institutional constraints, an educator cannot be expected to provide an emancipatory education across the entire spectrum of social-cultural distortions and injustice. However, this programme of engineering ethical studies will simply begin the process of enhancing the values of engineering graduates, with the process of ethics education fostering in our graduates the perspectives, responsibility and freedom to critically reflect and challenge assumptions and premises. It is to be hoped that they will begin to perceive ethical issues, be better equipped to reason carefully and be more aware of moral principles and practice.

Acknowledgement is due to the Institute of Professional Engineers of New Zealand (IPENZ) for the provision of the 2005 IPENZ Code of Ethics. IPENZ have the right to amend that Code of Ethics at any time.

I would like to acknowledge and express my appreciation to the professional engineering journalist and engineering magazine editor, Mr Eric Russell, of Scarborough, United Kingdom, who edited and made useful suggestions for the contents of this book. On a personal note, I would like to thank my wife, Dr Gillian Reid for her considerable patience and understanding during the preparation of this manuscript, and her encouragement, mentoring and countless hours of listening during the years of research necessary for this book.

Chapter 1
Introduction

Introduction to the social responsibilities of engineering

The current working environment in engineering, and that of the foreseeable future, requires people who are technologically qualified, have an ability to make critical judgements and who can work in challenging environments and working relationships while acting in a socially and environmentally responsible manner. This structured book is intended to include an integrated spectrum of engineering knowledge, by including an awareness of engineering ethics, the social implications of technology, and an understanding of how the practice of their profession impacts on the environment.

The decision-making process of a modern engineer is no longer a simplistic process of construction and reconstruction. Modern engineering has evolved from an occupation that provided employers and clients with competent technical advice, into a wide-ranging profession whose applied technologies have a global impact, which can affect future generations of society. Modern engineers have a moral imperative to consider the long-term impacts of their work, with an increasing need to choose technological solutions that are appropriate to their social context, to avoid unintended consequences of engineering decision-making.

> The modern engineer has a moral obligation to consider the impact of any engineering decision-making

There are environmental, cultural and social aspects of any decision in which an engineer has a moral responsibility to consider the impact and also the wise application when making an engineering decision. Engineering university graduates will be required in future to meet societal needs, without endangering the Earth's natural systems and resources. A review of literature on the subject indicates that many researchers and engineering societies consider the social responsibilities of an engineer, or any person considering becoming an engineer, should include looking at the long-term worldwide problems that engineering can cause. It has become a worldwide trend for educational engineering programmes to include consideration of the societal, environmental and sustainability aspects of engineering. These embrace problem-framing and problem-solving in ways that reduce the risk to the planet and society of predictable environmental, social and economic failure. Similarly, scientists cannot divorce themselves from the social, environmental and sustainability aspects of their work. Abelson, (1970) in an editorial in the journal *Science,* stated (brackets added):

> One important function [of science] is that of watchdog. In exploiting scientific discoveries humanity will squander resources and unwittingly conduct profoundly important experiments on it and on the environment … thus, academic scientists and the scientific societies have responsibilities that they cannot escape. (p. 241)

While Abelson (1970) talked of scientists having such a moral responsibility, Thring (1992) did not differentiate between a scientist and engineer. Thring used the word *engineer* to represent an all-encompassing group including "all applied scientists, architects and technologists who apply the experimental and theoretical knowledge of science to the solution of practical human problems by the development of hardware ranging from a drug to an aeroplane" (p. 222). Thring maintained that even if the pure scientist is disconnected from societal applications of this work, "it is becoming increasingly difficult for any branch of pure science to be separated from its practical consequences for humanity" (p. 222). He pointed out that the work of an engineer affects all aspects of human life, particularly its: "By-products and side effects, such as noise and pollution; effects on the destruction of the environment and wild life; effects on future generations – particularly in using up scarce resources so that they are not available in the next century" (p. 224). Now, over a decade later, these concerns are even more salient.

Society's expectations of modern engineering in practice

Modern science and engineering industries need a new type of professional. The main area of change seen by Vasilica (1994) is the requirement of a very high level of skills, attitudes and personal qualities, and "it is the area of attitudes and values where corporations are making a dramatic shift in their expectation" (p. 396). Values and ethics have increasingly become an area of concern for the field of science and engineering. A high standard of personal integrity is now expected of any such professional in a position with responsibility. As Chisholm (1990), cited in van der Vorst, (1998) stated "high standards of personal integrity not only have intrinsically high moral value, but their possession makes a substantial contribution to successful operations in practice" (p. 172). McGregor, Johnston & Bagia (2002) also asserted:

> Ethical behaviour underpins successful long-term global engineering practice. Ethical sensitivity is central to professional moves towards sustainability. Indeed, ethics is becoming a matter of central importance for engineering practitioners and their organisations. (p. 255)

As the demands on engineers have increased, ethics has become an increasingly important issue to be addressed in undergraduate engineering curricula. A global consensus of importance has emerged that tertiary science and engineering students should develop an understanding of their ethical responsibilities during their tertiary education.

Introduction to ethics

When people are faced with a decision, they may not always agree on a common solution to a problem. Different decisions can be made based on mitigating criteria such as profitability, humanitarian concerns, ecological and environmental concerns, political policy, political correctness, aesthetics, customs and etiquette, religious or moral beliefs, or simple public opinion and pressure.

With such a variety of criteria for solutions and decision-making, the subject of ethics often arises, where the question that is reasonable to ask is:

Who is to say what is right or wrong?

In terms of actions, particularly in engineering, the question becomes:

What is to say that an action we take is right or wrong?

The limitations of our physical and psychological worlds can at times make it imprudent or impractical to pursue certain behaviour, attitudes or methods of reasoning, and the evolvement of ethical systems is a response to the human need to survive in an environment where we are competing with many other organisms for scarce resources. Human experiences accumulate over a period of time, and a reservoir of knowledge is built up which influences the social perception of which behaviours benefit society, and those that do not (Pojman, 1998). As a consequence, society writes laws to control certain behaviours and a typical example of these limitations is the traffic laws in our country, which are designed to minimise our pain, and to maximise social harmony, prosperity and efficiency.

At other times, behaviour within a society is judged by a morality system – decision-making based on values. Ethics is the study of morality, but is also viewed professionally as a code of conduct that has evolved from logic, reason and professional experience. Morality and ethics as a means of influencing behaviour can extend to rule systems, legal codes, customs and etiquette, all of which can prevent the disruption of peace, and add to the productivity and survival of society.

Ethics and engineering

Because of the changes to the structure of society in the last several decades, ethical issues are considered nowadays to be an intrinsic part of an engineering degree. In this current post modernist age, many of the cultural institutions that mediated between the individual and society to give purpose and meaning to life have lost their credibility with some sections of society. Religion for example, is no longer considered a practical guide for action in the lives of many people in our current society, and even the promise of the modernist era of science to usher in a new millennium of peace and prosperity is viewed sceptically by post-modernists (Preston, 1996).

Changes in society over the last several decades have pushed engineering and technology to a position of greater prominence than ever before, and by default, technology and growing economies make it possible to fill the vacuum of many lives as an all-consuming occupation and as a kind of substitute ground for being. As a contrast to its beginnings as a means, technology is increasingly asked to be the ultimate purpose or end, and modern-day philosophers question whether this is a role technology should fill.

In this respect, Singleton (1991) argued, "as society becomes increasingly dependent on technology, it is more and more incumbent on the masters of technology to assume the responsibility for protecting the public from technology gone awry" (p. 145). It follows that to become fully professional employers and employees and fully responsible citizens of our society, an engineering or science graduate should understand a code of professional ethics in that it is one thing to build a structure, chemical or device, but the quest for technical excellence should not compromise society.

This concept of ethical responsibility was expressed by the political philosopher Langton Winner (1990):

> Ethical responsibility … involves more than leading a decent honest, truthful life … and it involves something much more than making wise choices when such choices suddenly, unexpectedly present themselves. Our moral obligations must … include a willingness to engage others in the difficult work of defining what the crucial choices are that confront technological society. (p. 62)

Engineering ethics in education

In the last quarter of the twentieth century there have been many changes to engineering education including a growing recognition of the importance of ethics and social responsibility. These changes have been spurred partly by political controversy over nuclear weapons, environmental concerns and consumer rights. This increasing concern for the value dimension of engineering decision-making is also, at least in part, as a result of the attention that the media has given to cases such as the Challenger space shuttle disaster, the Kansas City Hyatt-Regency Hotel walkways collapse, the Exxon oil spill and in New Zealand, the collapse of the Cave Creek platform.

What has also become increasingly of concern in the latter part of the 20th century is the relationship between human society and nature, a field now referred to as *Environmental Ethics*. Modern-day engineering professionals will inevitably find their consideration of ethical issues in applied technology and engineering practice is inescapably enmeshed with environmental ethics. As a result, there is now a global opinion amongst engineering professionals that ethics is necessary in modern engineering education.

The consequent question of what non-technical subjects should be included in an engineering degree has been the subject of debate in engineering schools in many countries, where the humanities have been considered increasingly important in the last few decades. As a response to this concern, a new discipline, engineering ethics, has emerged. Such is the importance of this new discipline that it may in time take its place alongside such well-established fields as medical ethics, business ethics and legal ethics.

According to Davis (1999) the teaching of engineering ethics should achieve at least four desirable outcomes:

(a) Increased ethical sensitivity.

(b) Increased knowledge of relevant standards of conduct.
(c) Improved ethical judgement.
(d) Improved ethical willpower (that is, a greater ability to act ethically when one wants to).

The role of ethical studies in engineering education

Most engineering degree papers concentrate on the *how* almost to the total exclusion of the intellectual *why*, and while the principal function of any university is to advance knowledge by research, and to maintain and disseminate such knowledge by teaching, there is now the obligation to develop intellectual independence (Hinchcliff, 1997). This intellectual power is the power of understanding, rationalisation and judgment over an increasingly unpredictable future. Ideally, as the students progress through their chosen course of tuition, a university course needs to take them beyond knowledge, to wisdom (Garrison 1997). From this viewpoint it is no longer sufficient to teach engineers about the past, or even the present, we need to have them anticipate the future, and their place within it (Toffler 1970). What kind of structures and organisations will they have to contend with? What sort of ethical and moral issues will they contend with in the process? It is only by generating such questions, trying to define what might be, debating and continually updating this, that we can give students the effective and cognitive skills required to survive in a rapidly changing work-force environment (Toffler, 1970).

> Stephan (1999) pointed out: "engineering work is now more complex than ever, and its ethical, social and cultural effects can no longer be dealt with on a 'seat-of-the-pants' basis that sufficed when engineering systems were simpler" (p. 7).

The changing role of technology education

The role of a university in technology education is to provide an educationally challenging environment for the development of students. The typical vision of most universities embraces professional, vocational, and community education and research to an internationally respected standard, with the provision of quality in the educational programmes. A modern university's aim should include equity, which incorporates effectiveness, efficiency and accountability in education, academic excellence in a culturally diverse academic community, and respect for the principles and rights of indigenous peoples, such as of the Treaty of Waitangi in New Zealand. Because of the ease of modern travel, a university also needs to facilitate, accept and appreciate the differences among the people and multiple cultures that often make up the society in a country.

Historically, it would appear the concept of a university of technology has grown out of the changes that have occurred in the application of technology since as far back as the industrial revolution. Technology is no longer purely skills-based, and so it follows that it is no longer the exclusive domain of the artisan (Blakey, 2002). Much of technology is now knowledge based, in that the technologist must very often build an intellectual base before any artisan skills can be applied. An example is the computerisation of modern construction and assembly, where a technologist simply doesn't have time to learn everything, and intellectualising, where intellectual learning is a critical part of any technological endeavour, is often the greater part of the skills required. In our modern society where the intellectual aspect of technology has become increasingly important, there is a compelling requirement for an intellectual understanding before any technology can be applied in practice.

This fundamental shift to the intellectual aspect of technology is particularly relevant in engineering education, and hence what we teach prospective engineers. In this respect, Bereiter (1992) observed: "Higher-order conceptual knowledge … may be better organised around problems than referents" (p. 342). Similarly, van der Vorst (1998) argued that the changes in modern engineering education should include "a decreased emphasis in factual learning and an increased emphasis on life-long learning and continued professional development" (p. 172).

> The relationship between technology and society is a contentious and fragile issue that needs to be understood by all engineers.

For a university to be a successful educator in the field of engineering, it is not enough for the resulting graduates to be competent in some area of science or technology. While channelling their efforts towards their academic goals, it would be preferable if they also understood the relationship between technology and society, and had an awareness of some of the social issues that accompany such a fragile and sometimes contentious relationship. The graduates need to be thoughtful and caring about the social issues, with a sober consideration of the extraordinary new relationship that is developing between humanity, technology and nature. They should have the opportunity for critical appraisal of the diverse political, social and economic forces driving both support for and opposition to new technology. The knowledge and the technological skills acquired should ideally be responsive to society's needs, and should contribute to the betterment of society.

Any action students take in society and the workforce should be tempered with a social conscience that balances the profit motive with an ethical and responsible approach to serving the community's needs.

Johnson (1993) observes "beyond knowledge of our own and others' cognitive and moral capacities and perspectives, beyond an abiding fellow-feeling, beyond the ability to inhabit imaginatively the world of another, something more is yet required. That … is an ability to imaginatively discern various possibilities for acting within a given situation … and to envision the potential help and harm that are likely to result from a given action" (p. 202). In Meizrow's (1990) view, the essence of ethics education is to "help adults construe experience in a way in which they will more clearly understand the reasons for their problems and the options open to them, so that they may assume responsibility for decision-making" (p. 361).

A university as the critic and conscience of society

A university has a challenging role as a social critic and conscience, and both the students and staff should be bonded in a common enquiry into the values of society, nurturing the free expression of ideas. It is the duty of the staff and students to speak out and act responsibly upon the social implications of their knowledge and as an effective critic, there must be willingness on behalf of the staff and students to draw attention to ideas and practices in society that are illegitimate, harmful, unjust, or just simply unproductive. Wallace, Schirato & Bright (1999) opined “academics – although in some senses detached from the world – should be prepared to comment on what is wrong with the world from the perspective of their discipline – that is, to engage in critique” (p. 21).

New Zealand education policy

The *critic and conscience of society* concept is referred to in tertiary education policy. The role is enshrined in the Education Act 1989.

In New Zealand, for example, the Ministry of Education states that the government should use the Crown’s ownership interest in tertiary education institutions (TEIs) to ensure, among other things, “protection of the academic freedom” (p. 2). It goes on to define academic freedom: “the role of academic staff to act as critic and conscience of society under which they question and test received wisdom, put forward new ideas and challenge orthodox, or state unpopular decisions” (p. 2).

The *Initial Report of the Tertiary Education Advisory Commission* (2001) also makes mention of the role of a university “encouraging staff and learners to serve as informed critics of society and contribute, as active citizens, to the formation of public values and policies” (p. 3).

As a consequence of the new insight students gain as they progress through their university education, it is hoped the students will have the ability to judge and deal with situations where their conscience is alerted. Such responsible actions may also include changes in their social behaviour, or participation in collective social action as a result of the values this university has given them. At times it is expected that they will challenge, rather than passively accept the social, economic, commercial and industrial realities that are defined for them by others. As Meizrow (1990) pointed out “rational thought and action are the cardinal goals of adult education” (p. 354).

Society must be technology’s conscience. There are times when the results of technology can be despairingly beyond the community control. Unfortunately, at times societal input to technology control has been in hindsight. Furthermore, in a commercial or industrial environment, a professional may experience the expectations of accountability to the management, which may outweigh any moral convictions of accountability to society and the consumers.

Consequently, universities endeavour to place graduates in society who will think very carefully in these situations, and hopefully, have a conscience. As responsible members of society, students must understand that society's control and influence of technology is important. They must understand that technological tools are a human tool, and while undoubtedly used by some against the will of others, it can also shape and design the way society lives, not to mention any harm that the indiscriminate use of technology has done to the environment.

The university input to social critique and improvement can contribute to positive social change with a role that properly stimulates reflection, provokes new thinking and leads positively towards the future. However, because universities have such an enormous influence in society, they need to be held accountable for that influence, which calls for an ongoing two-way relationship between universities and society.

Discussion

From the book ***"Future Shock"*** (1970)

The American academic Toffler (1970) offers the view of modern education that “students are seldom encouraged to analyse their own values and those of their teachers and peers. Millions pass through the education system without once having been forced to search out the contradictions in their own value systems” (p. 377).

Example of a critic and conscience of society

In 2005 the people of the Catholic Church mourned the loss of their leader, Pope John Paul II.

This remarkable Pope grew up in pre-war Poland, and as a young man he was forced to study for the church secretly under the harsh Nazi regime that banned church activities. He may have been a conservationist in the latter part of his life in so far as women in the Catholic church were concerned, but his anti-communist freedom cause gave the people of his native Poland and other Warsaw Pact countries great hope and belief in their future, inspiring them to spiritual and eventually, actual freedom with an insistence on non-violence during an oppressive Soviet communist regime and a declining economy. During his lifetime, he became the spiritual godfather of oppressed peoples of the world, and he had an uncanny ability to undermine undemocratic regimes.

Unlike other Popes domiciled in Rome, he travelled the world with more than 100 journeys during which, as a man of peace he was not afraid to make his views known, and was not afraid to lecture or admonish the rich or powerful. Through his work for peace and the amelioration of human suffering, his morality earned him the incredible respect of other world leaders. He had tried to make a difference, and through the beliefs and actions of his life’s work he tried to leave the world with a legacy of peace and tolerance. He may be remembered by future generations as one of the great moralists of the twentieth century.

Questions to consider

1. The stopping of the Vietnam War was directly attributed to public protest. Do you have a democratic right to protest against injustice?
2. As a university student, how do you see your role as a critic and conscience of society?
3. What sort of conscience or critical issues do you believe you as educated people should have an input to?
4. Who are some other famous critic and conscience proponents or moralists of our time?

Chapter 2
Technology and Society

The cultural evolution

Technology is the human solution to fulfilling human needs, and as these needs change, new technologies replace the old ones, which inevitably change the culture behind the technology. As technology changes, so does the culture of society. Cultural evolution is the progression of human lifestyle and customs, as the culture adapts itself to new technologies.

Technology traditionally has given solutions to survival by creating more efficient ways to get food and energy, and it has given us a certain amount of mastery over resources and sources of energy. Technology has enabled us to have fewer people involved in food production, which in turn enables a large part of the population to work on other areas of technology. However, as technology improves our quality of life, the threshold between survival and comfort becomes unclear, as in some more of the affluent economies, or what is now often referred to as the first and second worlds, the human focus on technology has moved from survival to fulfilling luxurious wants.

> The term *Third World* is commonly used nowadays when referring to a country with an underdeveloped economy. The original term was used during the *Cold War* to describe those countries not in the first two; i.e. the *NATO Pact* and *Warsaw Pact* membership countries.

Expectations in modern engineering

Modern engineering has moved beyond the historical concept of the building and maintenance of engines, and engineering as it is understood today is the consideration and application of technology to everyday problems. Engineering involves the design, planning, problem solving, decision-making, communication, and application of technology, for the purpose of fulfilling the needs or desires, either actual or created, in society. Essentially, such a definition considers an engineer to be within the occupation of a technologist, albeit in a specialised area of technology. Van der Vorst, (1998) also defined an engineer as one who deals with “technological systems and using them for the best of society” (p. 172). He defined the goals of engineering with the statement “the ultimate aim of engineering is to modify the natural world to further human purposes through the wise application of technical knowledge, skills and judgement” (p. 172).

Another perspective of a definition of engineering was found in New Zealand, where the Royal Commission on Genetic Modification (RCGM), (2002) found it necessary to clarify a definition of engineering when challenged by conservationists as to the title of that commission. As a result, throughout the report the term *genetic engineering* was liberally used. The Commission’s report conceded that the term *modification* infers a tinkering of an existing life form, plant or artefact, whereas, *engineering* is the design, construction and reconstruction, and hence the term genetic engineering.

A modernist view of engineering

In the 1960's, the American influence on science and engineering practice, and subsequently education, was heavily influenced by the *space race* and the *cold war*. This modern new era of technology broke away from the irrationality and superstition of preceding ages through a period of *enlightenment*, where the period of *modernism* during this era began with an absolute epistemological faith in science and scientific method, with the ability of reason to discover absolute forms of knowledge. Such knowledge was good for its own sake, and one gained knowledge through education, with a *positivist* philosophy within this modernist era (Crotty, 1998).

This age of the 1960's was also referred to by researchers such as Spengler as the *Normative Turn,* which interpreted the role of technology differently to the modern philosophy where ethical factors were becoming the regulators of technology. The *Normative Turn* concentrated mainly on the social conditions of technological development with the view that technology is not neutral and technological devices are not innocent (Kiepas, 1997).

Continued through the 1970s and 1980s, this so-called *spirit of enlightenment*, was the self-proclaimed *age of reason*, where a *positivist perspective* offered unambiguous and accurate scientific knowledge (Crotty, 1998). All scientific thinking and practice operated within theoretical frameworks or as Kuhn (1962) termed them, *paradigms.*.

Engineering education in the universities followed an epistemological philosophy in the theory of knowledge, where positive science was derived from direct experience and observation - the observation in question being scientific observation carried out by way of scientific method rather than speculation through abstract reasoning. Scientists and engineers in the period were required to distinguish between objective, empirically verifiable and subjective or unverifiable knowledge (Crotty, 1998).

> *Modernism - Positivism*
> Human reason can discover how the universe, nature and society function.
>
> All discoveries must be supported by provable evidence. This means using the rational means of empirical discovery and verification.

From a philosophical viewpoint, the current university engineering programmes understandably spend an enormous amount of time dispensing knowledge oriented towards the skills necessary to solve problems defined in quantitative terms within a deterministic environment. It could be considered a largely *positivist*, or objective approach to education where teachers tend to distinguish theory consistent with reality (Crotty, 1998).

Within this ideal world all scientific thinking and practices operated with theoretical frameworks, or paradigms, offering supreme confidence in the conviction at the time that scientific knowledge is both accurate and certain. When such an ideal world is governed by reason there can be no conflict between what is true and correct, and science stood neutrally as the paradigm for all socially useful forms of knowledge.

While a modernist approach in engineering education has broken our ties to past beliefs based around superstition or myths, and delivers us from ignorance, much of today's engineering education, regardless of the subjects, are taught in isolation without any reference to the economic, environmental, political, cultural, technological and global aspects (Nguyen & Pudlowski, 2005). This concern expressed by scientists in this perspective of modernism in science and engineering was traced by Thring (1992) back to the *Santa Clara Declaration* of 1970, in which a group of engineers and physical and social scientists expressed concern with the harmful impact of technology on environments, culture and values. Their particular concern was the failure of engineers and other professionals to exercise significant responsibility for the social consequences of technology.

Frazer and Kornhauser (1986) pointed out that at that time it was believed that if everybody understood science and technology, then we would all make the same decisions on any issue following the laws of reasoning, completely unbiased by politics or financial considerations. But politics, financial and human considerations are an influence in modern commercial and industrial decision-making, and quite often scientists and engineers who are equally well informed on a particular scientific or engineering issue can contrast idealism and realism resulting in very different views and opinions on that issue (Frazer and Kornhauser 1986).

The post-modern period of thought

Consequently, there is now a global body of opinion that engineers cannot divorce themselves from the social, environmental and sustainable aspects of their work, and the responsibilities of an engineer should include looking at the long-term worldwide problems that engineering can cause. In what has become known as the *post-modern* period, values are now considered an important part of engineering research, education and practice. It is widely accepted now that engineering research and practice are not value-free, and there are global and localised environmental, cultural and social aspects of any decision in which an engineer has a moral responsibility to consider when making an engineering decision, and engineering university graduates will be required in future to meet societal needs, without endangering the Earth's natural systems and resources. It is the responsibility of engineering education to carefully think through this

> The political philosopher Winner (1990) wrote:
>
> Ethical responsibility … involves more than leading a decent, honest, truthful life … and it involves something much more than making wise choices when such choices suddenly, unexpectedly present themselves. Our moral obligations must … include a willingness to engage others in the difficult work of defining what the crucial choices are that confront technology today. (p. 62)

range of implications, issues and priorities associated with any engineering research or practice, and declare them open to discussion.

In this postmodern period engineering has moved from an occupation that has been constitutionally and functionally introverted, to a profession that is increasingly accountable, particularly to the wider public. Moriarty (2001) commented "More and more, socially and environmentally responsible engineering ventures are garnering positive social regards" (p. 32).

Installe (1996) promotes a *systems approach philosophy*, with a *constructivist* approach to teaching engineering that includes developing communication skills among future engineers with a multi-disciplinary approach to problem solving which includes the analysis of economic, ecological and social issues. Thanks to science and technology, society has obtained enormous power of control over various aspects of nature, as the development of civilization extends the range of possibilities of mankind's rule over the world. The concern expressed by many learned people is that this control has unfortunately been developed so far that it now threatens the future existence of the world including society itself. The immediate issue seen by many is that modern technology must be controlled and managed in a manner that the constant quest for technical excellence should not compromise society (Thring, 1992).

However, Agger (1998) saw a change of direction by social scientists to post-positivist thinking, where the positivist knowledge equation is being surpassed by a variety of critical developments in epistemology, methodology and the philosophy of science, and there is now world-wide expectation that educational institutions should effectively prepare people for the profound ethical and moral decision-making that will be encountered when developing and applying modern technology in practice, with an understanding of the moral and ethical implications of technological advances in our society.

The intellectual aspect of technology

It is interesting to trace the ancient Greek attitude towards technology. In ancient Greece the higher classes were not involved in technology or trades level work. The activities associated with technology were considered by Adams (1993) the work of slaves and foreigners, while the "citizens involved themselves with the more disembodied mental activities" (p. 12). Even though technology has changed radically through the centuries, this attitude seems to have been passed down to us through western intellectual tradition, to continue this influence on our modern society. As Adams (1993) points out "after all, Oxford and Harvard do not teach engineering, and the engineers our society admires have often achieved wealth and social power by organising others [managing]" (p. 12).

> Technology is no longer the exclusive domain of the artisan

The continued development of technology education has grown out of the changes that have occurred in the application of technology since the industrial revolution. Technology is no longer purely skills based, and it follows that it is no longer the exclusive domain of the artisan.

Much of technology is now knowledge based, in that the technologist must very often build an intellectual base before any artisan skills can be applied.

For example, while the ancient Greeks and many other succeeding generations have tried to build a flying machine or contraption, to successfully build an aircraft in the 21st century there are many restrictive rules and regulations that inhibit such an exercise. There are many variables and factors that must be considered before the building takes place, such that it is really now beyond the skills of a simple skills-based artisan to succeed in such a project. Consequently, in our modern society the intellectual aspect of technology has become a greater part, and the requirement for an intellectual understanding before any technology can be applied is such that most universities have moved away from the original exclusively intellectual concept of a university.

Such is the computerisation of modern construction and assembly that one simply doesn't have time to learn everything, and intellectualising is often the greater part of the skills we acquire. It is said that we have moved from a *skills base,* in ancient times the technical work was done by slaves, to a *knowledge-based society,* where the intellectual learning is a critical part of any technological endeavour.

Hutchings cited in Hinchliff (1997) takes the intellectual aspect further:

> The power we want our graduates to have is power in and over the unpredictable future. The power the college is best equipped to help them gain is intellectual power. It is the power of understanding and judgement. Its contribution to the moral, physical and spiritual natures of its students and to their 'success' in the world are made by way of this power. No other agency in the community has the responsibility of supplying the intellectual power that the community requires. The progress and even the safety of a democratic community depend in part upon the intelligence of the citizens. (p. 338)

Consequently, in our modern society the intellectual aspect of technology has become a greater part of the whole process from design to production.

Toffler's view of technology education

Every society has its own characteristic attitudes and the powerful determinants of not only social behaviour, but also the technology to survive, are clearly reflected as a society prepares its young for adulthood. Toffler (1970) observed that: "in such a society, the most sensible way to prepare the child was to arm him [sic] with the skills of the past – for these were precisely the skills that would be needed in the future" (p. 361). Thus the father handed to the son, and the mother handed to the daughter the necessary practical techniques (technology), along with a clearly defined traditional set of roles, values and morality. In civilisations and peoples of the past, this technology education, role stereotyping inclusive, was deemed necessary for the survival of that society. Toffler (1970) maintained that as the modern schooling system has evolved, the skills disseminated by the schools were those that neither the family nor church could any longer have provided. What is necessary today is to educate for the future.

The development of technology education

Technological knowledge over the last few decades has increased rapidly and the science, engineering and technology professionals of today work in environments where they can no longer be expected to acquire in advance all the technological knowledge required solving day-to-day problems. Knowledge must constantly be acquired in order to understand technology and solve the problems of the time. It is difficult to train somebody for a professional situation where the demands of tasks may be to some extent unpredictable, and where the knowledge and skills needed are not easily defined by some prior instruction or coaching of the concept or process.

As McCormick (1997) pointed out "technological activity is by nature multi-dimensional, requiring understanding from a variety of points of view" (p. 144). In addition, most people working in a technological occupation must retrain in technology at least once in their working lifetime. As this knowledge explosion seems likely to continue, the balance between what to learn and how to learn has in recent years shifted towards the latter. We can no longer condone the traditional views that minorities and disadvantaged persons only need high school education so they can get a job. Given the impossibility of knowing everything about anything, the educational requirements for a job and those for higher education are now converging, and the economic and social needs of our country are forcing us to provide for many students the kind of education previously reserved for the elite few. Vincent and Vincent (1985) go further stating: "oral and social skills, it is argued, are the skills most employers need from their employees" (p. 108). These skills underpin high levels of intellectual capacity in many ways, and are indicative of deeper levels of understanding.

The philosophical requirement in engineering practice

Technology education has seen a movement away from a political and sociological class structure, which maintained a dominant class structure in ideology. Although Freire (1998) maintains that education can never be neutral or indifferent in regard to the reproduction of a dominant ideology, this researcher has documented that changes have certainly lessened this trend, with a technology education for all, which aligns with Freire's earlier argument (Freire, 1970) for a system of education that emphasises learning as an act of culture and freedom.

Engineering also needs a philosophy that not only will students gain a deep professional knowledge of their technical subject, but they must learn about the impact and effect of technology on society and culture through the enhancement of the human side of engineering in technology education.

The 1960s began the *modernist* period or the *age of reasoning*, of the *golden age of science* where it was necessary to be "up to date", and Ward (2003) considered this was (and still is in some respects) an era where engineering is a matter of maths, science and function, toward progress and perfection, on the basis that all human institutions and practices could be analysed and improved through scientific principles, reason and objectivity. As previously stated, such a philosophy could be construed as *positivist* where facts and values are separated.

However, this modernistically very tidy hierarchy of academic disciplines using knowledge gained through the power of reasoning is too simplistic. Bagnall (1999) maintains that "knowledge (as a function of facts in the world) and meaning (as human interests in the world)" (p. 56) are inseparable. Consequently, in more recent times some areas of the philosophical community such as particular postmodernists and critical theorists have accused engineers of building nuclear weapons that could destroy our civilization, manufacturing transportation systems that are an offensive eyesore to urban culture, and designing communication technologies that can enhance central or authoritarian controls by both governments and private corporations by creating computers that have the ability to depersonalise human life. Engineers have also justifiably been accused by critics of polluting the natural world with toxic chemicals and greenhouse gases while flooding the human world with ugly structures and useless consumer products (Mumford, 1970). Of course, engineers would argue that they are simply fulfilling society's demands.

Critical theorists argue that technology cannot be value-free and that "objectivity in the social sciences is molten, not frozen" (Agger, 1998), and it follows that an engineering philosophy which enables engineers to understand and defend themselves against these philosophical criticisms should also be important to engineering.

In fact, there is a tradition in engineering that this philosophy is largely overlooked. Philosophy, especially ethics, is necessary to help engineers deal with professional ethical problems, and because of the inherently philosophical character of engineering, philosophy could be viewed as a functional means to greater engineering self-understanding. Such a change in philosophy began in the Twentieth Century when it was discovered that some technological applications were producing unintended harmful consequences.

Although science and technology had brought development, innovations and continuous improvement to our living standards, the over-reliance and misuse of technology has brought many new problems to society. A new philosophy was required in the new era that followed modernism.

Just as engineering is normally divided into different branches, such as civil, mechanical, electrical, chemical, nuclear and computer engineering, so too is educational philosophy (Gutek, 2004). One could argue that this consequent *post age of reasoning* in engineering design process embodies and exhibits precisely the kind of philosophical reasoning processes that *post modernity* analyses, explores, and celebrates. It appears that engineers practice postmodernism in some respects, and although it is rarely acknowledged by an engineer, Mitcham (1998) states "engineers are the unacknowledged philosophers of the post-modern world" (p. 2). However, some sections of society still view engineers as artisans, at the opposite end of the thought spectrum!

A philosophy is required for engineering to help deal with ethical issues and the social context of engineering in practice, and Mitcham (1998) argues for a *post-modern* philosophy that is important to engineering in that engineering is modelling a new philosophy of life.

The philosophical requirement for engineering education

Much of present-day engineering education continues to operate in what appears to be the *modernist* period where the engineering education policy puts an emphasis on knowledge, and great faith is maintained in the ability of reason, to discover absolute forms of knowledge in which a valid hold on reality is achieved (Crotty, 1998). As a university of technology, New Zealand's AUT, for example, puts further emphasis on skills and training in technology education, rather than on a vague humanist ideal of education in general. Most engineering papers this researcher is associated with focus upon the acquisition of knowledge and skills associated with engineering design such as creativity and problem formulation. However, in this postmodernist age value and spirit can no longer be excluded from data and research.

It is also an international trend that engineering education is becoming progressively less and less a standalone subject, and can now be heavily influenced by other disciplines which are incorporated in engineering curricula, such as management, business, strategy, marketing, philosophy, communication, ethics and sustainability (Sutton, 2003). Sutton (2003) argues that in some respects engineering education programmes are moving towards a *post-modern* society, where knowledge becomes functional, where one learns not just to know them, but to use that knowledge. As technology entered the information technology era, this post-modern era has been born where we are now concerned with questions of the organisation of knowledge. In such a post-modern society education is characterised by its utility, where knowledge is also distributed, stored, and arranged differently in post-modern societies than in modern ones. Specifically, the advent of electronic computer technologies has revolutionised the modes of knowledge production, distribution, and consumption in our society. Indeed, some might argue that postmodernism is best described by, and correlated with the emergence of computer technology, which, starting in the 1960s has now come to be viewed by some sections of society as the dominant force in all aspects of modern-day social life.

To avoid confusion, Ward (2003) distinguishes between *postmodernism* and *post modernity* where the first term really refers to art, artistic and cultural developments, whereas post modernity has to do "with social conditions and the 'mood' that these conditions give rise to" (p. 14). But, rather than being seen as just *development*, engineering is now moving towards a philosophy of *sustainable development* in which any forward movement in technology should be accompanied by social and environmental considerations. Therefore any approach to teaching engineering ethics in an engineering programme could be seen as an opportunity for the development of a post-modern course design, which does not claim to be free of values.

While conceding that a *post-modern era* of education is desirable, this author is not keen on the non-structured approach to a teaching methodology promoted by the theory of postmodernism. Although this book presents a constructivist approach to step by step student learning, it could be argued that the design philosophy for this programme of learning concludes within a *postmodernist age*, by taking the *critical theory* approach by putting in place a system to address the social functions of science and the character of science and the nature of theorising in the social aspects of science. The critical theory philosophy in education facilitates an understanding of the important interactions between technology, education and social change, where values and facts are inseparable, and provides the mechanism to study and understand the complex relationships between society and technology (Daugherty, 2003). In this respect van den Brink-Budgeon (2002) promotes *critical thinking* which contributes to an improved educational performance in all subjects studied in a programme. Relating these into a holistic education is essential to the students' understanding and learning process.

Technology can be used to solve social problems or to create new ones and it inevitably involves benefits, risks and tradeoffs (Randerson, 1991). Through critical theory in engineering education, a careful understanding of the relationships between technology and society should lead to intelligent decision-making and assist universities in preparing engineering graduates with the knowledge and abilities to be considered modern technologically literate professionals.

Consequently, because of this dependent link between technology and society, ethics interrelates with, and directly influences the nature of technology, and if one considers that ethical values can determine a course of events, then ethics should be regarded as an essential part of a scientific or technological curriculum.

This has not always been the case in tertiary education. The retired AUT Vice Chancellor, Dr John Hinchliff (1997) studied philosophy at the University of Auckland, and he was to comment in hindsight of the modernist period that during the time of his studies "it was argued that education should teach only definitive answers to tangible problems, using scientific methods. Ethics had a poor image" (p.229).

From a philosophical viewpoint, the current university engineering programmes understandably spend an enormous amount of time dispensing knowledge oriented towards the skills necessary to solve problems defined in quantitative terms within a deterministic environment. It is largely a *positivist*, or objective approach to education where teachers tend to distinguish theory consistent with reality (Crotty, 1998).

Within this ideal world all scientific thinking and practices operated with theoretical frameworks, or paradigms, offering supreme confidence in the conviction at the time that scientific knowledge is both accurate and certain (Bullock & Trombley, 2000). When such an ideal world is governed by reason there can be no conflict between what is true and correct, and science stood neutrally as the paradigm for all socially useful forms of knowledge, and any engineering problem could be solved with yet another differential equation!

The modern challenge is also connected with the new role of responsibility in engineering, namely with a subject, object and instance of responsibility in this area. The new requirements are important for education in engineering. Kiepas (1997) believes that

> The aim of education is the formation of a technological culture which is connected with the transmission of knowledge and the forming of skills and attitudes. The modern challenges mean the new requirements in these three areas; their unity will be expressed in responsible decisions and actions of engineers. The process of education should give foundations for proper and effective practice of the ethics in engineering. (p. 259)

Kiepas (1997) explained how in modern times there has been an increase in moral factors as regulators of the various practices of society. This stems from the fact that thanks to science and technology, society has obtained enormous power of control over various aspects of nature, as the development of civilization extends the range of possibilities of mankind's rule over the world. Unfortunately, this control has been developed so far that it now threatens the future existence of the world including society itself. The issue now is that the rule of mankind over the world must be controlled and managed. This means "controlling the control of man" (p. 259).

Kiepas (1997) sees the relationship between ethics and technology as changing the way technology is perceived, and changing the way responsibility is perceived (p. 261). The ethical education for engineers should lead to the creation of a technological culture for engineers based on three elements, namely knowledge, attitudes and skills.

> 1. The delivery of knowledge concerns not only technology itself, but also methods of foreseeing its consequences, ways, methods and criteria of assessment. Education of engineers should thus comprise such non-technical subjects as philosophy of technology, general knowledge of technology, valuation of technology, managing of technology, or problems from the field of science-technology-society.
> 2. Developing skill, not merely the skills of creating and using technology, but also foreseeing its consequences, valuation of technology, assessment of risk connected with the developments of specific technologies, abilities connected with including technology in the processes of social and individual life, as well as abilities to communicate and negotiate.
> 3. Creation of attitudes, the creation of rational attitudes towards technology and its development, which would be far from extremely triumphant or catastrophic, such as attitudes, albeit it, not totally free from emotion, need to be rationalised and built upon factual calculation of the various consequences of introducing technology, which would form the basis of legitimisation and acceptance. (p. 264)

In this way, engineering education must now look towards insight and wisdom, with graduates who are able to contribute to the world in ways that shape our social relationships and infrastructure, and not solely for the financial benefit or the needs of business and economy.

Questions to consider

1. The modernist period was thought to enable all problem-solving with technology. Can you think of a technology that has now been exchanged for an older remedy?
2. Can you think of a technology or engineering design that failed because society did not accept it?
3. What technologies have been much more successful than originally planned because of the unexpected universal acceptance by society?
4. Can you think of an unforeseen negative consequence of technology?
5. Can you think of an unforeseen positive consequence of technology?

Chapter 3
Technology and Society - The Relationship

To understand the principle of ethics in engineering students must comprehend what is ethically expected of them in engineering practice, which means they need to understand technology itself.

Technology defined

Technology is the systematic study of techniques. It is an age-old human activity built on the traditions, ingenuity, the application of discoveries and the practical skills of society through the observation, knowledge and resourcefulness of people throughout history. It encompasses all of the artefacts and services people devise to meet the human needs of their time.

Throughout history, the human race has sought to survive, improve their lives, solve problems and satisfy their needs and wants, and any improvement to their living conditions can be viewed as technology, which includes:

- Housing shelter
- Tools
- Weapons
- Clothing
- Food preservation
- Communication
- Transportation

Technology is the human quest for solutions and the human process of applying resources to satisfy our wants and needs to survive, and subsequently this process is used by society to solve problems and extend our capabilities (Chandler, 2000). In the common usage of the word *technology* Chandler maintains that the term technology is variously used to "refer to tools, instruments, machines, organisations, media, methods, techniques and systems" (p. 1). If technology includes methods, techniques and systems, in other words the way we use a tool, then the neutrality of the instrument is difficult to argue. In fact, the neutralist Ellul (1964) defined technology by adopting the broad umbrella of *technique* by which he referred to "the totality of methods rationally arrived at and having absolute efficiency … in every field of human activity" (p. 5).

Bush (1983) related technology to activity with this definition: "technology refers to the organised systems of interactions that utilise tools and involve techniques for the performance of tasks and the accomplishment of objectives" (p. 155).

The key words here are activity and technique, and in essence technology includes human activity. It is the activity of technology that has influenced society, and in turn, society influences technology. Society and technology fuel each other and the relationship between them is supported by Bush (1983) who included in her definition of technology "all the norms, values, myths, aspirations, laws, and interactions of the society of which the tool or technique is part" (p. 157).

Further statements to support this relationship between technology and society include:

> Basalla (1988) who observed that the selecting agents to determine whether a technology is accepted by society could be influenced by economic and military requirements and restraints, as well as the social and cultural forces.
>
> Benthall (1976) who argues that "a complete historical analysis of any technology must study a reciprocal action between technical and social factors … social including economic, political, legal and cultural" (p. 145).

It is believed that somewhere in our history, thought to be the 17^{th} Century, the word technology (derived from the Latin word *technologia* and the Greek word *teknologia*) was applied to this activity that improves our lives. The root word is *tekhne,* which is Greek for art and craft.

Historically, technology has always had a unique influence on the individual, society and the environment through the development of specific tools, skills and the solutions to practical problems. The New Zealand Ministry of Education (1995) considers these activities of technology continue to be "a creative, purposeful activity aimed at meeting the needs and opportunities through the development of products, systems or environments" (p. 6). Technology takes many forms, and it has enabled societies throughout the ages to improve their environment, and tragically, sometimes to degrade or endanger it.

Technology produces social change, and has led to a standard of living inconceivable by society a hundred years ago. It is speculated that half the population of the United States is alive today due to technological changes in the 20th century. Nowadays, technology is such an everyday part of people's lives that it has become largely invisible, becoming transparent to the people, because it is so user friendly that people don't realise they are using it. Technology has changed the world and the ways of society. Many inventions, discoveries and developments of technique have influenced society and these influences are now examined.

Influences of modern technology

In order to establish the influence that society and technology have on each other, the influence issues are examined from the following perspectives:

- Security
- Commercial competition and survival
- Dependency
- Social

- Environmental
- Communication
- Political
- The Mass Communications Medium
- Food Technology
- Transportation

Security

In any species, either animal or human, the most fundamental instinct is to survive. Historically, human society has always developed its technological capability to the extreme limits of knowledge in order to survive a threat (either real or perceived).

Technology has been used throughout history to aid both the aggressor and the defender. During a wartime crisis thousands of men and women, either officially funded or of their own patriotic volition, have extended the frontiers of the technology known to them to protect their nations. Such was the influence of society, that the funding for technology in this time of crises is often increased dramatically in the quest for the development of technology for both aggression and security. At times in wartime it becomes difficult to differentiate between these two.

Technology is activity and the development of it is usually accelerated during wartime. As an example of the benefits to society resulting from wartime research, the following technological developments developed under wartime research funding and have found peaceful applications and activity, in which society has in turn, been influenced by their development:

- Atomic energy – developed for nuclear medicine and nuclear power/propulsion.
- Magnetron – developed for the microwave oven.
- Jet propulsion – used in modern passenger transport.
- Rocket propulsion – used for space travel, installation of communication satellites.
- Electronic computer – used for mass communication and information retrieval.
- The Internet – initially designed for the American armed services.

In terms of security, technology and society are inextricably enmeshed within each other to such an extent that Mitcham (1994) stated “if power or the ability to act increases, then so must intelligent control” (p. 260). Sadly, intelligent control does not exclude evil.

Commercial competition and survival

Current modern day improvements in technology should not be perceived primarily as a means to instigate or counter aggression. Often the advances in technology simply satisfy the Human Being’s natural curiosity, and quite often the advance in technology is to facilitate survival in a different concept – retaining that competition edge, regardless of whether the motivation for competitiveness is global, financial, and militaristic or simply power. A good example was the space race. Further examples of competitiveness include

> Staudenmaier (1989) states "the fiscal investment of a company or individual is a powerful factor in a given technology's momentum" (p. 157).
>
> Bush (1983) states "people accept and adopt technology to the extent that they see advantage for themselves and, in competitive situations, disadvantage for others" (p. 164).
>
> Adams (1993) states "these days one needs modern technology in order to be successful in economic competition" (p. 5).

New technology can put people out of work and retraining is usually required.

Modern technology has influenced society in such a way that higher percentages of our workforce are employed now days in technological fields such as product and industrial design, engineering, and a wide variety of other related careers in technology. In most countries, the economy depends on a balance of trade in the global marketplace, and having products and innovations to offer that other countries want. As such, modern technology is a necessary ingredient for commercial success and the competitive drive for commercial success has affected society with mass production. Computer controlled machines can be operated by a workforce with minimal training so manufacturing can take place anywhere in the world, which enables a manufacturer to pick a country with the lowest labour costs. This can be beneficial to that country if the manufacturer is ethically minded and pays a reasonable wage to previously unemployed people and perhaps help improve that country's infrastructure by building new schools and roads. But, if the manufacturer is concerned solely with profit and pays the minimum wages with no other benefits, this can lead to the exploitation of economically underdeveloped people and countries.

Although new technology is critical to the economic future of a developed country, the downside is that technological skills are not always integrative and transferable. For example, Iacocca (1985) wrote "between 1957 and 1975, 674,000 textile workers were laid off in New England. But despite that region's booming high-tech industries, only 18,000 – about 3% - found work in the computer industry" (p. 345). Typically, at the end of each technological era, skilled people were put out of work, which had a dramatic effect on communities. Very often the financial benefits of a new technology are only distributed between the owners of the new technology, and others can suffer in the process.

Dependency

Is society is now dependent on technology?

Technology can control our lives to such an extent that society has become dependent on it. As a result of the advancements in technology, many older technologies for our survival have been lost. Our modern society is such that, just as we find it difficult to shop without an automobile, in the event of a power-cut, some people cannot perform even the most fundamental level of survival. Basalla (1988) spoke of our electricity system "the system that produces and distributes electricity is so large and complex, and we are so dependent on it, that our first concern must be its maintenance as a functioning entity" (p. 205). Society in many developed countries has become so dependent on electricity, that it controls their choices. In fact, very often the choice is no longer theirs to make. The threatened Y2K bug at the turn of this new century led people to the realisation of our almost total dependence on modern technology, and gave society an important opportunity to examine simple alternatives for emergencies.

Ghandi's rejection of European style clothing was intended to rejuvenate the clothing industry in India.

Technology does not always easily transfer. The transfer of technology from developed to underdeveloped countries can cause the recipient to become dependent and passive on a foreign technology, and the introduction of a foreign technology can very often spell the end of a local manufacturing industry. Technology can become equally dependant on society, and as a case in point, Staudenmaier (1989) observed of foreign aid projects "when modern technology is carried to points remote from its source, without adequate supportive services, it will often shrivel and die" (p. 126). The technological intellect must also transfer, and a classic example was the setting up of a Union Carbide factory in Bhopal, India. The area was a rural community, and without proper training and support in modern factory technology, several maintenance and safety issues were ignored by the local staff, leading to a terrible disaster.

Technology seems to form a self-fulfilling loop. Wajcman (1991) writes of the early 20th century: "the disappearance of domestic servants stimulated the mechanisation of homes, which in turn may have hastened the disappearance of servants"(p. 85). The introduction of technological machines into the household, according to Wajcman (1988) enabled the American housewife "to produce single-handedly what her counterpart of 1850 had needed a staff of three or four to produce" (p. 85). The effect of this is that while the housewife or househusband may still have a great deal of work to do in the house, the mechanisation of the home has enabled one person to now reach the standards of living, cleanliness and personal hygiene, previously only attainable by the wealthy.

Social

Such a dependency brings with it the necessary examination of the social aspects of technology. Technological practice takes place within, and is influenced by, social contexts and throughout history there has been an evolution of social change through the sequence of technological events (Cardwell, 1995). These successive stages of technological development are often referred to as *revolutions,* leading to historical eras defined by the innovations in technology. Social advancements are claimed for a long list of technological inventions throughout history and Staudenmaier (1989) comments "recent technological changes have also generated unforeseen societal and technological consequences" (p. 148). For example, the inventions of the wheel, bicycle and the automobile have all changed the way society lives and works. The advantage of the bicycle and automobile is that a person can live further away from a place of employment.

The New Zealand Ministry of Education (1995) states "technological practice affects our environment, our standard of living, and our quality of life … technology plays an increasingly important part in our health care, choices of food, transport, and the very functioning of society" (p. 6). Technology and society have historically fuelled each other, and while technology gives society cause for change, the acceptance by a society or culture can shape new designs, or continue the momentum of existing designs. (Staudenmaier, 1989, p. 158). In effect, if society does not accept a new artefact or innovation into its culture, then it will not succeed. Classic examples are the satellite telephone, the wrist-worn calculator and the Wankel engine. Alternatively, a technology adopted by society can change our lives dramatically.

The environment

One begins to wonder if technology is beginning to slide out of control as a self-perpetrating and self-generating monster. The impacts in some respects are the side effects that affect the environment. For example societies of developed countries like the USA and New Zealand removed their forests for the purpose of timber supplies and productive farmland long ago. Such is the current scale of devastation with the removal of the rain forests in underdeveloped countries that it is believed to be contributing to global warming. However, the release of fixed carbon is considered by many to be the main cause of the *greenhouse effect.* Unfortunately the Americans output 4-5 tonnes of carbon per annum per capita, as against the Chinese output of 0.6 tonnes. (Buckeridge, 2001). It is thought that the Earth's hydrosphere, or the watery part of the surface and atmosphere, can only absorb about 0.5 tonnes of carbon per annum for every human inhabitant. It is now reported that the Chinese output is increasing dramatically and it is a serious concern. It is important for all nations to agree to a serious programme for the reduction in carbon output.

> Ellul declared (1964) "technique has become autonomous; it has fashioned an omnivorous world which obeys its own laws and which has renounced all tradition" (p. 14).

The introduction of technology has sometimes been disastrous on our environment, and the sense that technology may be out of control is also influenced by the way in which technical developments can lead to unforeseen side-effects (Chandler, 2000). Along with the benefits of technology, we have inherited:

- Global warming
- Soil erosion
- Pesticides
- Chemical poisoning
- Nuclear waste
- Air pollution

Communication

Although technology had brought us sophistication in war, transportation, agriculture, buildings and personal possessions, the means of communicating beyond the range of the human eye was not discovered until the 19th century. It was the invention of the Morse code in 1837 that finally enabled complex messages to be sent beyond the range of the human eye.

The need to communicate has always been of primary importance to society. Since time immemorial, society has always promoted the technological development of the need to communicate at a speed beyond that of a messenger on horseback, or beyond the range of the human eye (Adams, 1993).

The Leaning Tower of Pisa was a defensive observation tower, and the bell within it was used as an audible warning system.

Modern telephones, fax machines, and computers are further developments of this long distance signalling technology, which have brought many changes to society. For example Pool (1977), cited in Rakow, (1988) stated that "the telephone has no deleterious effects, but adds to human freedom and choice of action" (p. 208). The invention of these communication machines have dramatically changed the way we live, work, travel and communicate, in such a way that the use of the telephone in the daily life is now deemed necessary for the successful operation of industry and commerce. The habitual and widespread use of telephones has become part of the social structure of society, with the effect:

- People living in remote areas are now less isolated.
- There has been a move to the suburbs, which are now more practical.
- There has been a reduction in single industry neighbourhoods.
- A company's offices may now be remote from an industrial plant.
- The use of skyscrapers became feasible.
- There has been a reduction in social isolation.

The benefits of the modern cell phone and its text messaging system are such that parents nowadays are equipping their children with these devices for safety and security purposes.

Communications has also taken a quantum leap with the arrival of modern computers. This revolution of the information technologies, the so-called *I.T. revolution,* was preceded by the *writing revolution*, and the *print revolution*. E-commerce and the Internet can be seen as perhaps the final phase of an *electronics revolution* that began with telegraphy and telephony (Chandler, 2000). The speed of communication is such that e-mails and texts are now replacing much of the communication by post. It is the use, and the resulting activity centred on these inventions and developments, that has changed society, and shaped our lives and environment. For example, the introduction of modern broadband Internet service is considered to have contributed to economic growth by giving society benefits which may include the following:

- *Healthcare* – people living in rural areas have improved healthcare with the facilities healthcare specialists have via the Internet.
- *Telecommuting* – people are able to work from home or remote areas, cutting the cost of businesses, easing traffic congestion and generally contributing to an improvement of the environment.
- *Commerce* – the ability to buy and sell goods via the Internet has led to lower costs for retailers and consumers, promoting unprecedented levels of consumption.
- *Entertainment* – has given consumers the ability to choose entertainment.
- *Community* – the Internet enables people to contact each other easily and cheaply.
- *Research* – people can take part in world-wide research, and have contact with other academic institutions.
- *Education* – students are able to study and search for information remotely, as the Internet has become a giant information retrieval system.

There can be a negative side to modern advancements in communications, for example, while broadband Internet communication has created tremendous opportunities for consumers to enjoy high-speed communication and entertainment, it has also been a boon to illegal activities such as the pirating of music, videos and software. High-speed Internet has given pirates the ability to readily distribute entertainment software around the globe. It enables the plagiarism of intellectual property, and it has enabled a new wave of crime including various money scams and the transmission of illegal photographs.

Political

Although technological direction can be effected by several of the preceding issues, there are times when, possibly for no reason other than national prestige, the government may encourage the accelerated development of a technology such as the 1960s space race. Just as equally and there are times when, if a natural brake to a technology development is not apparent, a government will or should apply one. The cancellation of the US supersonic transport was responsible for deflecting a half-century quest for higher speeds. For social, economic and political reasons the decision was made to override a purely technical demand. The decision not to have nuclear power plants installed in New Zealand was made for similar reasons.

Many governments have seen the necessity to legislate monopoly laws to protect its society against a ruling industry force and give society a freedom of choice. The break-up of the Standard Oil and the Bell Telephone Companies in the USA, and the attempt to dilute what was viewed by some as a possible Microsoft monopoly are examples of the US Government trying to control the impact that technology has on society.

In fact, the sociocultural pressures of the development of technology often depend on the economic, political, ideological and social interests of a nation, and may have a direct effect on the rate of technology development. McGinn (1978) credited the cold war with effecting the increased funds into research into energy and automative technologies, and the international politics on weapons technology. In this respect, one suspects that the development of aerospace technology during this time could have been justified by the claims of ideological superiority and the fears of losing prestige had directive effects on both of the first two worlds in the so-called space-race. As Basalla (1988) put it: “technology is so intimately identified with the cultural life of a people that it is difficult for an indigenous observer to gain the objectivity necessary for critical appraisal” (p. 169).

The mass communications medium

The printing press, radio, television and then the computer were machines designed to convey information on a *one to many* delivery format. While the inventors of these machines had good intent, and no doubt some monetary reward for the invention, it is the users of these technological tools of the mass media that can deliberately skew the views and beliefs of the world, and the events that take place within it. Unfortunately, the mass media can be deliberately and quite cleverly managed in terms of the following biases:

- Parochial
- Content
- Emotional
- Intellectual
- Sensory
- Social
- Political

. Very often the survival of an undemocratic political regime depends on the political control and manipulation of the mass communications medium

In the modern competitive environment of selling newspapers, selling advertising, attracting contributors to a cause, or simply political survival, the media can be quite deliberately manipulated, and used as a technological tool towards some end or ideal. The media influences society, trying to persuade our choices, influence our values, and manipulate our decision-making.

Food technology

Since ancient times, the importance of preserving food to survive the winter has always been an important technology for survival.

However, in the last century the need to produce more food to feed the world has relied on technology. The United Nations Food and Agriculture Organisation reveals that significantly higher crop yields have resulted in feeding twice as many people than in the 1950’s with the same amount of land area. The food supply initiatives in developing countries have been so effective that the proportion of the population in chronic under nourishment has been cut in half. The World Food Outlook document produced by two World Bank senior economists states that crop yields are continuing to increase faster than the population.

While the use of machinery has increased the food production in some countries, the effect of global warming may produce droughts and a reduction of food production in other countries. What now becomes increasingly important is the need to put resources into finding ways to reduce the harmful emissions that are polluting the planet. The Kyoto Protocol is an example of this attempt at control.

Transportation

Transportation has changed the way society lives and works. The canal networks in some countries enabled goods to be transported into the cities, and particularly coal for heating. Later the countryside was further opened up by the railways, enabling people to travel vast distances to work or holiday. Until quite recently, people had no choice but to live in small communities where they worked, schooled and shopped locally. The invention of the bicycle enabled people to live further away from their place of work or school. In modern times the application and refinement of public transportation, has dramatically changed the way society lives. People can travel great distances for work, education, medical assistance and pleasure. Consequently the village concept of living is now replaced by large shopping malls where access is by public transport or an automobile.

The current popularity in the ownership of an automobile has given society more individuality and flexibility than a public transportation system. For individual transport, the attraction of automobile development was that it was less expensive to keep than a horse which few people could afford, and it created less visible pollution in the streets. The momentum of automobile development began with Karl Benz, and was refined through Henry Ford's application of mass production to give cheap personal transportation to the masses. Like many new technologies, it has given our society and the environment some detrimental side effects. The automobile has changed society, bringing it joy, freedom, convenience, pollution, congestion, suffering and misery.

Similarly, aircraft have made travel easier, and it is now possible to buy goods in the supermarket on a global basis. For example, the dramatic change to shopping brought about by modern airliners has enabled modern supermarkets to sell fruit and vegetables out of season. Through modern transportation and communication the world has become a global village.

Despite the changes that modern technology has brought us, society needs to carefully monitor technology, and place controls on its development and operation. Since the red flag law at the inception of the automobile, government legislation continues to be inevitable to prevent technology causing a catastrophe both to society and to our planet.

> The consequences of technology can be an unintentional and harmful by-product.

Society's control of technology

In any technological investment or innovation a company usually looks for three benefits to justify the introduction: competitive advantage; reducing costs; and improving productivity, but when considering the adoption of a new technology, Bush (1983) earnestly recommends we need to consider "the ecological impact of accepting the technology versus the impact of continuing current techniques" (p. 165). Such is the impact of technology on our environment that, rather than describing it as neutral, the society who tries to live with it now must have waste management, water authorities, pollution acts, traffic planning and controls, resource acts, etc., to try and keep technology under control. There is a delicate relationship between society and technology and society can easily experience dependence on it, and suffer the inevitable exploitation of both technology and our society. Technology can have consequences, and these consequences are not necessarily identical to the original means or intent of that technology.

Technology has influenced and changed society, and from the times when human beings learned to survive in caves and hunt for their food, they have progressed and improved their standard of living and improved their survival rate through the development of technology. Each step forward in the long history of technological development has changed the way we live, usually for the better, but sometimes, perhaps not. Quite often the advance of technology feeds such ideologies as *progress* and *modernisation*, where the enthusiasm for technological progress, while providing a means to an end, may in fact serve the needs of greed and the gathering of wealth. Bush (1983) believes that there is not a fair distribution of the benefits of technology and was quite scathing of the belief held by many people in technologically advanced societies that technology represents the triumph of human intelligence. Bush instead maintains that technology has an equity issue, where its development has everything to do with who benefits and who suffers, whose opportunities increase and whose decrease, who creates and who accommodates.

There are now suggestions that technology has become *autonomous,* meaning that technology changes in accordance with *its needs* rather than the needs, desires, or wants of society. One wonders if technology has developed from a means to an end in itself.

Regardless of how technology is used, it has of itself a number of positive and negative consequences, and is not just a matter of intention. Society must be its conscience, and there are times like Chernobyl, when the results of technology can be despairingly beyond the community control, and any society input is unfortunately in hindsight. Consequently, society must strive to control and influence technology. Technological tools are a human tool, and while undoubtedly it is used by some against the will of others, it can also shape and design the way we live, not to mention any harm that the indiscriminate use of technology has done to our environment.

Fortunately, society is changing its views, and technology is not always deemed to be progress, and any given use of tools, techniques or technology can have both beneficial and detrimental effects at the same time. Increasingly, the human-made world is impacting on our life and well being, and while tools might make it easier to perform certain functions, we now have a health and safety employment act to protect us.

As new technological artefacts and practices become part of our daily life, the effect of technology on our society is such that strict controls are required. Quite often it is necessary for a government to embody some response to existing technology in its laws. For example, the ease with which one may distribute or access objectionable material over the Internet has led to increased policing in that area of communications.

Basalla (1988) commented “the process by which a novel artefact is selected for replication into the life of a people involves various factors, some more influential than others” (p. 169). We have a society in which the technologist builds the devices and processes, and in some respects, society decides its fate. Equally, we can have a political doctrine that may choose what is useful, rather than what is good. Often public opinion has no input to the process, and such is the effect of technology on our society and environment that technologies such as weapons, literature or computers can just as easily be used for repressive, as they can for liberative purposes. Adams (1993) states: “we also have technology to thank for an unprecedented ability to exploit others and destroy ourselves” (p. 1). One could argue that a gun or an atomic bomb is specifically designed for one purpose only, and the technologists that manufacture them cannot absolve themselves from responsibility for the ensuing devastation by claiming a neutral position. One could also argue that a farmer needs a gun, and nuclear weaponry helps keep the peace merely by its possession and presence. This begins the neutrality argument.

The neutrality argument

There are technology theorists who maintain that within the process of societal change brought about by technology, the technology itself is *neutral*. That is, technology is value free and neither good nor bad in itself in that its influence on our lives and environment is of our own choice. This instrumental view of technology is supported by neutralists such as Langdon Winner, (1979), who expounded the philosophy that technologies are neutral in that they are tools that can be used one way or another in which the benefit or harm they bring depends on how they are used.

Is technology neutral?

Can we as scientists and engineers absolve ourselves from the consequences of the systems we design and build?

White (1978) was another proponent of the neutral theory, who supported the neutrality argument with the statement; “a new device merely opens a door; it does not compel one to enter” (p. 28).

These neutrality theorists will argue that irrespective of whether the technologist has designed an artefact with good or evil intent, it is how society chooses to use technology that determines and varies its intent. Just as the old folk saying goes *a good worker doesn’t blame his tools*, it is easy for a technologist to argue that technology is neutral, and in fact, they often present technology as amoral (Ellul, 1964).

Alternatively, one may theorise the *non-neutrality of technology*, in that we cannot merely use technology without being influenced by, or used by it. Jacques Ellul (1990) was a prominent non-neutral theorist who stated that “technical development is neither good, bad nor neutral” He dismisses the old argument that “a knife may be used to cook, cure, kill or maim, but the tool remains neutral” (p. 35). Instead Ellul argues that the resulting positive and negative consequences of it shape our lives and environment. “We become conditioned by our technological systems or environments” (p. 37).

So the questions remain:

1. Is technology neutral? The argument can be hotly debated amongst learned people, and an individual is free to take either side of the issue. It certainly can be looked at both ways, because it is the technology we develop and use that in turn develops influences and determines our view of the world and the way we live in it. At the same time, the forces of our society drive, control, inhibit and shape the destiny of technology.
2. Is technology good or bad? This question is the root of a continuous debate on whether the effects of technology on society are more positive or negative.

The global inequity of technology

Currently it is estimated that one third of the world’s population exists in poverty without the benefit of modern energy supplies, and the suffering and human degradation in these underdeveloped areas of the world leads in some cases to regional instability and conflict. What is required for the prosperity and sustainable development of those societies is affordable energy.

Energy is a substantial ingredient in the trading of most western nations, but unfortunately, the huge consumption of energy contributes to the most difficult environmental problems. Currently it is estimated that the world’s most developed countries constitute less than fifteen percent of the global population, but are responsible for consuming half the world’s current energy resources. While the environmental impact of this energy consumption was commonly experienced at local and regional level, it is unfortunately now a global experience and concern. Furthermore, developing countries such as India and China are currently improving their standard of living, which dramatically increases their energy consumption and adds further to the global environmental impact.

This rising energy consumption and its associated environmental impact leaves the scientific community with one of the most urgent and technologically challenging problems, and further revolutionary advances in technology will be necessary to meet future challenges that will inevitably face society. Science must develop an affordable energy source without further undermining the environmental foundations of a sustainable planet.

The Kyoto Protocol

In this fight against Global Warming, over 180 nations have agreed to a pact, the Kyoto Protocol in an attempt to cut emissions of gases blamed for global warming.

The Resource Management Act (RMA)

In New Zealand, the RMA came into force on 1 October 1991 after four years of intense work. It replaced more than 20 major statutes and 50 other laws related to the environment with some dating from 1889, and was the largest law reform exercise in the country's history. During the development of the RMA the significant environmental problems facing New Zealand were identified.

The stated purpose of the RMA as contained in Section 5 of the Act is to promote the sustainable management of natural and physical resources. For the purposes of the RMA, sustainable management means:

- Managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while:
- Sustaining the potential of natural and physical resources, excluding minerals, to meet the reasonably foreseeable needs of future generations; and
- Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
- Avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Antitechnologists

The cult of *antitechnology* arose in the middle of the 20th century and was partly in response to their realisation or belief that society had the potential to destroy the biosphere. Antitechnologists believe that the unpleasant aspects of our life are not caused by human spirit, but by technology itself.

Questions to consider

1. It is believed that the modern standard of living an average family with modern technology could only be achieved 200 years ago by a wealthy family with a minimum of four servants. What technology has enabled this?
2. How has technology in the past 100 years changed the way we live?
3. Is there an equity issue with the distribution of technology?
4. Antitechnologists believe that society can revert to an idyllic world if we abandon modern technology. Is this realistic? What are the implications of this?
5. Is technology neutral?
6. What are the important factors we need to consider in controlling technology?

Chapter 4
Social Engineering and Society Development

Social engineering

A comparison can be made between the evolution of sound structural engineering, and the engineering principles of human society.

For example, if a building is constructed to conform to prudent engineering principles, it should hopefully stand a greater chance of withstanding an earthquake than one that is not built to conformity.

> Social Engineering – Integral systems, whether mechanical or social, can clearly survive uncommon stresses and strains better than poorly constructed systems.

A building's ability to survive in an earthquake is a function of its conformity to basic engineering principles (Evolutionary Ethics.Com, 1999). Societies can also have such a structure. While a societal structure is usually thought of in terms of economic and political arrangements, there is a deeper structuring of laws traditions and customs that generally form the backbone of a thriving society. When people abide by the rules of their culture, they reinforce and add to its structural integrity. A person's ability to fit into a culture and derive benefit from it can be said to be a function of conformity to laws, customs, manners, morals, etiquette and traditions.

The societal development of rule systems

For a society to live together in peace there needs to be some form of shared decision-making. The website of Evolutionary Ethics.com (1999) claims that much of society's day-to-day life operates at an emotional level, and without some regulatory restraint, an uncontrolled system of decision-making may be highly unstable. In the western societies such regulatory restraint has developed over the centuries and has resulted in the development of formalised rules by way of the establishment of laws. Society attempts to keep operating smoothly by means of a system of imposed regulatory mechanisms known as laws, and also by informal rules, both of which can vary considerably from one culture to another, or from one country to another.

A common thread is that in each society or civilisation, morals, manners, customs and laws have naturally evolved from the positive and negative effects of certain behaviours over a period of time. Evolutionary Ethics.com (1999) explains that as a natural course of experience, people observe the behaviour of others, and the observation of the negative effects of certain behaviour usually sets in motion a counter-force to constrain such behaviours that cause social problems. This has resulted in a conscious process of *civilisation building* over the centuries with the proliferation of rule systems. To ensure harmony, there needs to be a clearly organised form of rules and regulations. Societies are generally regarded as being *civilised*, when they have a set of such rules, usually known as laws, by which all people in that society are expected to abide, in order to co-exist in a peaceful manner. In western society the formal regulatory systems have been developed in the form of democracy, which involves some form of shared decision-making process by that society, and a decision-making body elected by the people (Fieser and Dowden, 1999).

When a decision is to be made, either as an individual person, or as a group or organisation, the decision-making process may be influenced by certain factors. Sometimes the factors will be quite clear, as defined by regulation or law. At other times, the input that influences the decision can be less clearly defined, and the decision-making process can very often be influenced by the implicit core values that society has acquired. These often serve as informal rules as to how that society expects an individual to behave. Such informal and evolving societal control systems usually include moral, manner, and customary rule systems. The most common require individuals to make decisions on the basis of taken-as-shared values, conscience, morality and etiquette. At yet another level there are times when the choices made, whether as an individual, or as a nation reflect the core values of those who make the decisions.

Values defined

A value is something worth striving for, and the word value has several meanings and applications, but in the sense of decision-making, the Concise Oxford Dictionary (Collins, 1988) defines value as: “worth, desirability, utility, qualities on which these depend” (p. 1297).

Values in the decision-making process

Society’s informal rules have evolved from dynamic circumstances over a long period of time, so that the basic decision-making process in a moral issue essentially comes down to making the most reasonable set of choices in a given set of circumstances. Evolutionary Ethics.com (1999) explain that some choices are inevitably judged to be better than others, but certain fundamental values can nevertheless be agreed upon by a particular society, and any choice can be systematically evaluated as to its inherent worth to society. Over the centuries the logical manner in which mature people organise their lives, and the appropriate behaviour, which endures the test of time, eventually becomes part of the foundation of the cultural morality of that society, where the informal decision-making process may be influenced by the values and morality of that society. Hence, as a civilisation grows, it archives its wisdom and the informal control systems become based on wisdom rather than opinion.

Since human experience spans thousands of years, many varieties of these moral models and lifestyles have already been tested for their inherent moral worth. In engineering decision-making, this accumulated wisdom and experience will at times be a factor to be weighed in any decision, and as previously stated, the main influence in a particular decision can sometimes equate to plain common sense.

However, sometimes decisions can be influenced by values, and most people have values of some description. Because values can influence any engineering decision-making process, as a prelude to a review of engineering ethics, the nature of values is examined, and the next section traces the origins and influence of a person's values.

The origins of values

A person's values may be developed from quite a young age, and these values can be influenced by a combination of parents and guardians, teachers, priests, and peers. What people value as good or bad, useful or worthless will determine how they behave and expect others to behave. The way people behave and the decisions they make, whether as individuals, as a group of professionals, or as a nation, can reflect the values that they hold, and behaviour, which is influenced by such values can be judged by society to be right or wrong (Andrew & Robottom, 2001).

Your values
All people have values. A person's values may be developed from quite a young age, and these values can be influenced by a combination of parents and guardians, teachers, priests and peers

Influences on values

Centralised authority systems such as the church, or family have traditionally informed our values (Preston, 1996). Parents are normally the most dominant influence on a child's upbringing, although parental control is not always exclusive. While one's values depend very much on the nature and structure of society, the values a child gains can also be influenced by peer groups, extended family, tribal or village organisations and schools (Frazer & Kornhauser, 1986).

Different cultures, races and countries will inevitably develop different values for different reasons. Preston (1996) observed that modern shifts in ideology and worldviews have accommodated a breakdown in the centralised authority systems such as the church, and we have moved into a "post-modern pluralistic ethical environment" (p. 6) where we now need to recover the importance of ethical understanding for human living, both at a personal and community level. Similarly, Frazer and Kornhauser (1986) associate ethics and values when stating that any science education curriculum should naturally include ethics and social responsibility, where we need to try and understand the different values, some of which are common and some which are not. In the context of this study, simple examples of the values and social responsibility that students usually encounter are those of being on time to class, handing in work on time, the unacceptability of racism and harassment, and the unacceptability of copying and cheating.

The value position

As a result of values, Frazer and Kornhauser (1986) argue that a decision may be seen as a value position, which can influence the particular stance one takes on a societal issue. In this manner, values can influence the policy and decision-making processes of any individual or organisation in any society, and also by implication, the decisions of engineers as individuals and a profession. Frazer and Kornhauser (1986) warn us that any decision that arises from such a personal value should therefore "be identified as a value position - not a technological assessment" (p. 40).

But, such a value position may not always be evident in decision-making debate, and as the report of the New Zealand Royal Commission on Genetic Modification (2002) stated "values give rise to goals, which in turn determine policies and strategies. Values are often hidden or unnamed, and when this happens there is a danger of becoming lost in a debate about strategies and losing site of ultimately what we want to achieve" (p. 1).

Since it appears that values can influence a decision manner, and considering the richness and variety of different cultures in the world, the question arises as to whether there is a common influence on our values. To understand the global variety of values that engineering students are likely to use as the basis of informal decision-making, the next section sets out what values a student may have that could be an influence in decision-making.

New Zealand values - do we have a common set of values?

In New Zealand there have been some major cultural changes over the past few decades. The re-emergence of a sense of identity within the indigenous Maori people has seen the Maori language adopted as an official language, and the development of a unique New Zealand identity and culture. Many New Zealanders share parts of indigenous Maori culture. For example, the Koru [native fern symbol] is displayed on Air New Zealand aircraft, and the haka [war dance] is performed by many sporting teams that represent New Zealand. This shared New Zealand culture is underpinned by the Treaty of Waitangi, which was signed in 1840 by representatives of the British Crown and representatives of iwi [tribal grouping] and hapu [family or clan] (Randerson, 2002).

However, New Zealand's population today increasingly is made up of many different cultures and beliefs, covering a rich diversity of peoples from all over the world. Currently many university students taught in engineering courses in New Zealand originate from another country. Consequently New Zealand society can be seen to be pluralistic with values drawn from different cultures and different sources, some religious, some traditional and some philosophical. Some people may have values based on work experiences, others on international values such as the United Nations Declaration of Human Rights, and still others based on cultural or religious influences. With such a wide variety of influence in our society Bertrand Russell (2002a) posed a number of thought-provoking questions about values and authority within a multi-cultural society:

> As soon as we abandon our own reason, and are content to rely upon authority, there is no end to our trouble. Whose authority? The Old Testament? The New Testament? The Koran? In practice, people choose the book considered sacred by the community in which they are born, and out of that book they choose the parts they like, ignoring the others. (p. 2)

Is it then possible to have a common core set of values amongst such a diversity of cultures and beliefs as we have in New Zealand? The RCGM (2002) provided argument that there is such a commonality. They found in their enquiry into genetic modification that values from different sources in New Zealand do actually converge and that New Zealanders do indeed share a common set of values (bracket added):

> Maori, [indigenous New Zealanders] for example drawing on their spiritual and cultural heritage, have a strong sense of the sacredness and interconnectedness of earth and all life forms. Judaeo-Christian groups draw on biblical tradition to reach the same conclusion. Those who come from the ecological world-view have a similar holistic understanding of ecosystems based on the intrinsic value of all life. (p. 25)

So it seems that whether one's background and cultural beliefs are based on an atheistic or theistic principle, the relationship society develops with nature appears to share common values and require the same reverential care.

Having established that the nature and development of a common core set of values and informal rule systems in a society is possible, from the values society holds, society will judge its people, and such judgement of values, which may result from morality, conscience or etiquette, are explored in the next chapter.

Ethics and social engineering

In engineering, the sum total of all turning, deflecting, and stressing forces on a structural member at a particular point is calculated as the *moment*. In social engineering, the same type of calculation is possible. An *ethical moment* might be calculated as the sum total of all influences and conditions under which a person decides to act on a problem that is inherently risky and stressful.

Since human relationships are complex, many stresses and strains can suddenly converge, putting a person's emotions to a severe test. Social morality inevitably reflects activities as being healthy and worth pursuing, or those which can cause problems if one is not prudent in the management of one's life (Evolutionary Ethics.Com, 1999).

Social equilibrium

Whenever dynamic systems are in motion, there can be a form of equilibrium or balance.

Example

Take music for example. You are listening to a familiar piece of music that you like, and there is a certain rhythm and harmony in the music. Once you ear has established a predictable theme for the music, any wild variations on that theme (like a wrong chord) can create dissonance in your ear.

Social equilibrium is similar, in that there are boundaries in behaviour and actions that cannot be crossed without dissonance.

Social equilibrium can either be of a positive or negative type. Positive social equilibrium is highly tolerant of extremes. It accepts a wide diversity of talent in order to gain maximum social benefit. Negative social equilibrium does not tolerate a wide diversity of ideas, where peace and tranquillity are maximised at the expense of diversity (Evolutionary Ethics.Com, 1999).

Values and value judgement

When making a value judgement, the type of judgement used may be divided into one several categories:

Epistemic or knowledge value – using criteria such as importance, significance, insightfulness or informativeness.

Aesthetic value – using criteria such as beauty, skills, or mastery of execution.

Prudential value – using criteria such as prudentness, effectiveness, stupidity or short-sightedness.

Moral or ethical value – using criteria such as virtue, moral character, kindness, generosity, evilness, viciousness, or simply, the right thing to do.

Example - the Aswan dams

The Aswan High Dam was designed to control the Nile River flooding and stores water for times of drought, and provides hydroelectric power. Although most people agree that the flood control and the electricity the dam provides helps economic growth, the cost of these benefits must also be examined. When the Aswan Dam was built, the country of Nubia was flooded. The Egyptian government made arrangements for the Nubians to be relocated, but their lifestyle was destroyed. In fact many of the nomadic tribes in the area were not warned of the changes that would be happening to the river, which affected their routines in caring for their livestock. Prior to the appearance of Lake Nasser, as the northern part of the reservoir created by the dam is known, the Nubians cultivated plots along the shore. Those areas are now completely underwater. Many people have left the settlements that were created for them and returned to the lake's edge, trying to recreate their lost culture.

Dams, like any other technical advancement, need to be analysed not only on the basis of their perceived economic benefits and their dollar cost, but also on their environmental, and social impacts as well. The next chapter investigates the moral nature of judgement and decision-making.

Questions to consider

1. What level of importance does social engineering have in our society?
2. Does a capitalist society promote positive or negative social equilibrium?
3. Can you think of other examples where positive and negative social equilibriums exist or are promoted?
4. You all have values, what are some of the major influences on those values?

Chapter 5
Moral Theory

The influence of morality, conscience and etiquette in decision-making

There are basically three categories of a moral judgement: morally right, morally wrong or morally neutral. Moral judgements are often made by people in direct situation-related situations with such a strong conviction that the question is whether a judgement is actually morally right or wrong. Within this process of informal decision-making, the influence of the informal control system becomes based on the decision-makers' wisdom, which may be influenced by the combination of values, moral principle, conscience and social responsibility within that society. This chapter explores these areas of decision-making.

Morality and decision-making

Morality is defined by the Concise Oxford Dictionary, (Collins, 1986): "concerned with the goodness or badness of character or disposition, or with the distinction between right and wrong" (p. 657). Morality is a concept to do with how we should live and what we should or should not do. Moral beliefs are an assertion of what ought to be rather than what is (Mehlinger, 1986; Pojman, 1998).

It follows that a person can be judged to have *moral integrity* or *moral standing* in a community. Moral integrity can be better described as a moral wholeness, rather than rigidity, and one can change one's views if something that was thought to be moral is now considered not to be. Many professions allow their members to refrain from activities they consider immoral even though the profession does not. Common examples are abortion and weaponry.

Moral behaviour is generally seen as the exclusive domain of humanity. Mehlinger (1986) for instance asserts that animals act mainly through instinct and it is not reasonable to hold an animal accountable for moral judgement in terms of good or evil actions.

Similarly it is argued that machines are not held accountable for the actions of their operators or programmers. Consequently, questions of moral behaviour and moral education are considered as a uniquely human concern. A *moral agent* is a being whose actions are capable of moral evaluation, which would not include animals, machines or natural disasters such as a flash flood or an avalanche which are considered to be *amoral*.

> Only humanity can exercise moral judgement, express moral outrage, forgive moral offences, and undertake good or evil actions.

> An obligation is a requirement of what must or must not be done, arising through moral, legal, religious or institutional reasons.

Consequently, morality may be viewed as an assessment of the rights and wrongs of human conduct. The disciplines that may involve morality include religion, law, etiquette, economics and politics. They range across the entire spectrum of human activity as a behavioural normative, consisting of prescriptive beliefs. These beliefs cover societal issues that act as a guide to how one should behave towards others. For example, the relationship one should have with one's family, teacher, neighbour, stranger, government, and even to animals. Thus a person can be morally opposed to adultery, stealing, murder, suicide and eating certain food, while morally approving respect for parents, telling the truth, and keeping promises.

Moral behaviour as defined by a religion, while in essence may be essential for the practice of that religion, is not necessarily dependant on, or motivated by religion. As an example law in many countries upholds some of the 10 commandments of the Jewish and Christian religions. Moral principles do vary from one culture to another, but as a general principle, they provide a guide to moral behaviour. For example, moral principles can show that not to do something that a particular culture demands as a social responsibility could result in one being judged as rude or immoral. Pojman (1998) believes that morality is necessary to stave off social chaos and he offers a set of rules that, whilst restricting society's freedom to some extent, are for the benefit and well being of society:

- To keep society from falling apart.
- To ameliorate human suffering.
- To promote human flourishing.
- To resolve conflicts of interest in just and orderly ways
- To assign praise and blame, reward and punishment, and guilt.

The evolution of morality

An examination of history will show that that moral rules develop and evolve over a period of time. There are many examples of these changes such as women's rights, gay rights racism and slavery. The most interesting example is slavery, in which it is now almost universally agreed that the institution of slavery is immoral. Yet almost up to modern times there were slave owners who considered themselves to be highly moral and honourable citizens.

Nowadays, only small minority of animal rights advocates consider it immoral to kill animals for food or use them in medical research. In future times, will the present majority who disregard animal rights be considered to be as immoral as those who formerly accepted slavery?

The morality of slavery and animal rights is fundamentally related to the question of who are members of the social group to whom the rules of morality apply. One way in which the evolution of morality can be viewed is as the expansion of the concept of society, defined as the group to whom one's moral rules apply from family, to clan, to city, to country, to all persons.

The next section takes up the notion of guilt and develops it in terms of how the conscience an individual may guide her or his decision-making.

Conscience and decision-making

Pojman's (1998) reference to guilt refers to an individual's feeling as a result of decision-making that may be outside the frame of that society's values, that is a *conscience*.

> **Ethical dilemma**
> A challenging moral problem is sometimes referred to as a dilemma. A dilemma is a choice between courses of action (usually two), which are equally unacceptable.

Conscience is defined by the Concise Oxford Dictionary (Collins, 1988) as: "A moral sense of right and wrong" (p. 2000). While this definition doesn't seem to be very different from the Oxford Dictionary's definition of morality, it is commonly used to express the feelings of guilt one may have in being associated with something that is considered to be of low morality. Since the medical profession, as a profession like engineering that makes decisions that impact on people's lives, uses the term conscience in their regulations, a brief examination of the manner in which it is used is considered important.

Conscience plays an important part in medical ethics and is legislated by law in the British Health Regulations (Royal College of Nursing, 2001). While the word conscience itself is generally related to personal views of right or wrong, in the medical profession it also caters for one's religious or moral beliefs concerning such issues as contraception and abortion. The conscience aspect plays a significant part in the role of a nurse when undertaking the nursing care of a person receiving medical treatment. The British Abortion Act recognises that members of the medical profession hold personal views and beliefs, as do all members of the public. Consequently, while nurses concerned are not expected to be a critic of a personal decision by a patient, the British Abortion Act has a stated conscience clause, where any nurse has the right to refuse to take part in abortions on the grounds of conscience. However, the RCN (2001) makes it clear that the ruling is "not expected to affect any duty to participate in treatment which is necessary to save the life or to prevent permanent injury to the physical or mental health of a pregnant woman" (p. 1).

The engineering codes of ethics are not so clear about conscience issues, but an engineer may at some time have to consider their conscience, and this can be largely influenced by their core values. This relationship is explored next.

> **Examples of conflict:**
>
> - Work in a socially harmful industry such as tobacco and gambling.
> - Work in a industry you do not believe is beneficial to the environment.
> - Work in an area where the work is against your religious beliefs.

The relationship between conscience and values

It was interesting that the RCN allows a person to use their conscience to influence their decision to participate in a particular task within that profession, with the provision of such a safeguard to the nursing staff.

However, not all professions have such legislation and there are likely to be times in anybody's working career where the work they are asked to do is in conflict with their values. Conscience will be called into play. For example, it may be against a person's principles to work in: a socially harmful industry such as tobacco or gambling; an industry they do not believe is beneficial to the environment; or an area where the work is against their religious beliefs.

A specific example, described by Lacey (1987) in a book on the history of the Ford Motor Company, is that of company engineers being expected to participate in building a car that they knew was unsafe. These are issues of conscience and moral principle, but when a conscience issue involves an activity that is in the worker's view morally corrupt, such a reluctance to comply or obey has the possible danger of some vindictiveness for refusing to take part. For example, when the Ford Motor Company was prosecuted as a result of the unsafe car, a Ford engineer confessed during the court-case that refusal to participate would have almost certainly resulted in dismissal. Sadly, decisions of conscience or corrupt behaviour can sometimes end in tragic circumstances.

Conscience and moral integrity

Sometime during a person's working life one could be asked, or in fact ordered to do something which is either unethical, or against one's values and better judgement. The individual's *conscience* will be called into play here, and only the individual can decide what action is appropriate to take. When such a person acts consistently within moral convictions, and resists any attempt to act otherwise, the person is said to have *moral integrity*.

To this point, the ideas of values and conscience as unwritten rules that guide decision-making have been outlined. Etiquette is another form of unwritten rule that shapes decision-making and is clarified next.

Etiquette and decision-making

Etiquette differs from morality. Etiquette is an expectation that determines what is thought to be polite behaviour, rather than what is correct behaviour. In this way, etiquette differs from morality and conscience because it determines style and form, rather than principled behaviour. Etiquette can represent the expectations of a particular culture or society in terms of how one is expected to dress on certain occasions, greet and mix with other people, how one celebrates and how one should express appreciation, gratitude and condolences. That is, it generally describes how one is expected to carry out social transactions.

It can however be morally wrong to not to observe etiquette, particularly if it is an accepted cultural custom. To wilfully violate etiquette by ignoring such a custom could be considered as moral impropriety. Etiquette does have quite a profound influence in a work place or in an academic environment and it includes the expectations of behaviour and the expectation of how one gets along and addresses other staff members. For engineers etiquette is a potential influence on how they interact with clients and subsequently on the ways available to them for explaining and discussing aspects of their brief that require judgements including ethical judgements.

Dignity and decision-making

Dignity refers to the fundamental worth of a person, of animals or of nature, and to treat someone with dignity is to treat them with respect and without embarrassment, with the right not to be interfered with or not to be harmed unnecessarily. In working relationships people have the fundamental right to be treated with dignity, although in many societies that fundamental right is forfeited when one breaks the law. Having established the importance of the relationship between morality, conscience and etiquette, the next section investigates morality in practice.

Questions to consider

1. What examples can you find of etiquette within your own peer groups?
2. What examples of values can you find in your peer groups?
3. Have you found the expectations of etiquette can vary from one culture or country to another?
4. Can you think of situations where it is important to consider dignity when making a decision?

Chapter 6
Moral Theory in Practice

The necessary development of moral theory

For Jewish, Christian and Muslim societies, the justification of morality is the Word of God as expressed in the Bible and Koran and by using such an authoritative text which contains many basic moral premises, the rules of conduct are deducted logically from those texts. However, in European and North American societies in the past century, the decline of belief in religious authority has undermined this approach to moral theory for many people (Preston, 1996). This change in moral beliefs is due to several factors, and human beings now hold a wide variety of beliefs, which may have led more people to doubt that any one religion is authoritative, with a diminished belief in the authority of religious texts.

Due to this rejection of religious authority by many people as the basis of morality, it becomes necessary to find another basis for moral beliefs. One of the few statements about contemporary moral philosophy which is unlikely to encounter opposition is that no moral theory enjoys wide acceptance.

A moral theory gives an account of the underlying justification for all our correct moral judgements. The role of moral theory is to give us g*uidance.* In cases in which we're unsure what to do we can see what to do by applying the underlying moral principle. A moral theory should also *explain* why our correct moral beliefs are true, and *challenge* those that are not.

However, it is probably impossible to unite all moral theories and beliefs into a single coherent theory that will suit everybody (Texas A & M University, 2002). In practice, a decision may suit some people, but not all. When a decision is made by society, there will sometimes be the question that accompanies it:

- Who benefits?
- What is the justification for the decision?
- On what basis is the decision made?

Decisions based on morality can be compartmentalised into areas depending on who benefits from the morality and at present the most widely discussed theories of morality in the British-American literature are *utilitarianism, deontology* and *social contract* theory.

Jeremy Bentham proposed the utilitarian approach to ethical decision-making in his *Introduction to the Principles of Morals and Legislation* (1789) and this theory was further elaborated by John Stuart Mill in several books, such as *Utilitarianism* (1863). Bentham defines utility as that which tends to produce benefit, advantage, pleasure, good, or happiness. Utilitarianism is based on two premises which are not always sufficiently separated in discussions of the theory. The first premise is the belief in *consequentialism*. Specifically, that morality is concerned with the effects of actions on the happiness of individuals. The second premise is a belief in a maximization principle. Specifically, the right action is the one which has as its consequence the greatest happiness of the greatest number. It is not easy to realise in today's society what a radical departure the first premise was from the conventional wisdom of its time. The second premise is a foundation of today's use of cost-benefit analysis.

Consequentialism

Consequentialism describes the decision-making process within the class of moral theories where ethical decisions are made on the basis of predicting the consequences of the decision, and the good that may come from it. The Encyclopaedia of Philosophy (Fieser & Dowden, 1999) explains consequentialism as a normative theory, one that maintains that an action is morally right if the consequences are more favourable than unfavourable. Essentially, the theory requires the decision maker to weigh the consequences of an action in terms of good and bad. The decision is made on the basis of whether the total positive outcome outweighs the total negative. If the good consequences are greater, then the action is morally proper. If the bad consequences are greater, then the action is morally improper.

Consequentialist theories are also called teleological theories, from the Greek work telos, or end, since the result of the action is the sole determining factor of its morality

Most consequential theories are more precise than the above generalisation. The Encyclopaedia of Philosophy (Fieser & Dowden, 1999) for instance takes consequentialism back to include two of the ethical theories identified by Preston (egoism and altruism). It lists three theories as contending consequentialist theories, each differentiated in terms of the groups of people affected by the consequences of the decision:

> ***Ethical egoism***: an action is morally right if the consequences of that action are more favourable than unfavourable only to the agent performing the action.
>
> ***Ethical altruism***: an action is morally right if the consequences of that action are more favourable than unfavourable to everyone except the agent.
>
> ***Utilitarianism***: an action is morally right if the consequences of that action are more favourable than unfavourable to everyone. (p. 1)

Egoism:

What's in it for me?

Altruism:

What in it for everybody else but me?

Utilitarianism:

What's in it for all of us?

Essentially, these three theories measure the worth of a decision by its results, but the consequences of egoism, altruism and utilitarianism can all be viewed as morally correct, depending on the particular viewpoint taken.

As a basis of decision-making, all three can be defended on the basis of human instinct.

Of course, one may take the consequentialism argument under any of the three above guises to the extreme, and so the theory could be considered flawed and open to abuse by justifying the means by the outcome. For example, Ward (1998) explains consequentialism such that, while the best action produces the greatest good for the most people, it is possible to select a course of action which is harmful or unjust to an individual or group, as long as the benefits to others outweigh these negative effects.

Indeed, historically, the moral justification under the consequentialism of ethical egoism has been used to attempt to justify actions such as torture and slavery and war crimes. For example, during World War II, the actions of the German occupying forces in Europe have been well documented. In this instance it was deemed justifiable by the German hierarchy to execute 10 local inhabitants of an occupied country for every one of their occupying forces that was killed during the occupation. The consequentialist outcome justified the means for the German forces, but the process was repugnant, and is not supported by most people.

Drawbacks to consequentialism

1. According to ethical egoism, acts of lying, stealing and even killing would be morally permissible so long as
   (a) the agent benefited
   (b) He or she wasn't caught.

   However, it is contrary to our common society to refer to such acts as moral.

2. Ethical altruism also clashes with our common moral intuitions in that most believe that one's own interests usually count for something!

3. According to utilitarianism, it would be morally wrong to spend our spare time on leisure activities such as watching television, when the time could be better spent in ways to produce a greater social benefit, such as charity work.

Utilitarianism

Utilitarianism is the underlying justification for every legitimate moral judgement by the importance of promoting well-being or preventing suffering. Utilitarianism requires the maximisation of the total benefit to a particular decision, even if it means disadvantaging an individual. Each person's well-being matters equally regardless of race, gender, national boundaries, etc. The right action is the one that promotes as much well-being as possible, or alleviates as much suffering as possible, giving equal weight to each person's welfare or suffering.

Utilitarianism is the most common form of consequentialism, which stresses the pleasurable outcome of the choice, and provides a persuasive argument in debates about social policy. Mills (2002) argues that criteria for determining what is right or wrong should be founded in the ultimate happiness that is liable to be derived from that action. From this he derived his utilitarian greatest happiness theory:

> Questions of ultimate ends are not amenable to direct proof, and therefore that whatever can be proved to be good, must be so by being shown to be a means to something admitted to be good without proof. (p. 13)

Of course, this view of utilitarianism may be controversial and attract criticism. For example, a critic might argue that there are other things we desire besides happiness, such as virtue. In defence, Mill (2002) responds, "that everything we desire becomes part of happiness. Happiness, then, is a complex phenomenon composed of many parts, including virtue, love of money, power, and fame" (p. 1).

Preston (1996) distinguishes two types of utilitarianism. These are *act-utilitarianism* and *rule-utilitarianism*. Act-utilitarianism stresses that in evaluating an action a person must consider everyone affected, and not just the people directly involved in the situation. For example, the decision to use a particular type of fuel requires a careful consideration of the environmental effects of its consumption on the future generations, in addition to the people in the present-day society who might directly benefit from the use of this resource.

In contrast, rule utilitarianism stresses the following of rules which are devised to provide beneficial consequences, such as never kill except in self-defence. Rule-utilitarianism requires that there first be a set of established rules. The objective of the rules is to provide the greatest good for the greatest number of people. Preston (1996) suggests that these rules are not absolute in the sense that such rules may at times require an interpretation for a particular circumstance in which the decision has to be made, although the general principle of ethical behaviour should be to behave according to the rules as they are prescribed.

The German philosopher Kant (cited in Fieser & Dowden, 2004) raised several objections to utilitarianism. The main objection raised by Kant is:

> Utilitarian theories actually devalue the individuals they are supposed to benefit. If we allow utilitarian calculations to motivate our actions, we are allowing the valuation of one person's welfare and interests in terms of what good they can be used for. It would be possible, for instance, to justify sacrificing one individual for the benefits of others if the utilitarian calculations promise more benefit. Doing so would be the worst example of treating someone utterly as a means and not as an end in themselves. (p. 1)

The problem with act-utilitarianism is the focus on the uniqueness of specific situations and the subsequent choices. Each situation is different, and the decision made for one situation may not be appropriate for another situation. In Kant’s view there is no universal law that can be applied for act-utilitarianism. Put another way, Kant's objections to utilitarianism are that utilitarian theories:

> Are driven by the merely contingent inclination in humans for pleasure and happiness, not by the universal moral law dictated by reason. To act in pursuit of happiness is arbitrary and subjective and is no more moral than acting on the basis of greed, or selfishness. All three emanate from subjective, non-rational grounds. The danger of utilitarianism lies in its embracing of baser instincts, while

> rejecting the indispensable role of reason and freedom in our actions. (Fieser & Dowden, 2004, p. 3)

As is evident, consequentialism has its limitations in practice and appears to be flawed at its very root, because justice can be dispensed with if it produces the appropriate benefits. An opposing view to decision-making is not to consider the consequences, but to simply consider whether an action is right or wrong. This process is designated non-consequentialism.

Ethics of respect

Conversely to utilitarianism, the ethics of respect for persons focuses on actions resulting from a decision that are beneficial to, and maintain the respect of each individual as a moral agent, even if it means promoting a decision that is less than the total preference for satisfaction (Texas A & M University, 2002).

It would be normal to weigh these two methods of decision-making against each other, and if the two theories converge in a common solution, then we can have confidence in the decision and resulting course of action. If, however, the theories don't converge, then a decision must be made as to which of these two possible decisions has priority (Texas A & M University, 2002). A system of advanced prediction would be useful in weighing up the consequences.

Non-consequentialism

Non-Consequentialism is the process of decision-making, which considers not the consequences, but what is right and wrong (Encyclopaedia of Philosophy, 2002). The difference between the consequentialist and non-consequentialist viewpoints may be illustrated by the current concern with the abortion issue. A consequentialist approach is to consider the outcome and consequences to all parties concerned if the child is born, whereas the non-consequentialist approach is to consider what is morally right for the foetus as a human individual, rather than the possible consequences of the birth. In engineering decision-making, these two opposing considerations may be present when considering decisions that affect the environment, or the consumption of the Earth's natural resources.

Deontology

An excellent example of non-consequentialism is deontology, where deontologists perceive morality as independent of utility (Buckeridge, 2001). Deontological theories of morality take as their premise the belief that human beings have an intuitive knowledge of right and wrong. Associated with this approach is the belief that human beings have certain rights, and that actions which adversely affect such rights are morally wrong. Historically, one immediately thinks of the rights to life, liberty, and the pursuit of happiness. Currently, one is aware of the demands for woman's rights, gay rights, and a variety of economic rights. Since most of us do have strong feelings of right and wrong, there surely is a psychological basis for the deontological approach to morality. Deontologists argue that morality should be considered in terms of some overriding principle or obligation. Rather than measuring the value of an action by its consequences, deontological theories assert that an action is intrinsically right or wrong. The greatest proponent of monistic deontology was the eighteenth century German philosopher, Immanuel Kant.

Kant offers a basic monistic deontological philosophy that:

1. An act must be done from obligation before it has any worth.
2. No action has moral worth exclusively from the effects brought about by that action.
3. An act's moral value is due to the maxim from which it is performed, rather than its success in realising some desired end (Fieser & Dowden, 2004).

An interpretation of this statement could be that unless it is accompanied by a motive of obligation, even benevolence may be morally unworthy. Obligation is the necessity of an action performed from respect for law, and necessity often comes from a country's laws.

Social contract theory

Social contract theory as developed by Hobbes, Locke and Rousseau takes as its premise that there is an agreement between an individual and society in which the individual agrees to submit to the authority of the government and its laws in return for the government's protection of the individual's life and property. These theories were primarily concerned with the moral obligations of citizens and governments.

In terms of engineering decision-making, some issues will probably always attract debate from the consequentialists, and non-consequentialists, although it is unlikely that these groups identify themselves as such. These could include engineering decisions that have an impact on the environment or the use of the Earth's unsustainable resources.

One question here is how the law comes into these two opposing viewpoints. While a social contract is an obligation to obey laws, we need to consider such a justice system in terms of one's rights.

Justice and rights

The practice of moral decision-making is not always a simple and straightforward process, and the concept of justice is one of the major obstacles to utilitarianism and its subsets of theories. The utilitarianist Mill (2002) considers "equality is the dictate of justice, except when expediency requires inequality. Justice implies what is not only right to do, but it is morally wrong not to" (p. 14). Making a reasonable interpretation of this statement, one could argue that justice implies something which is not only right to do, and wrong not to do, but which some individual person can claim as a moral right.

> **Rights**
> A *moral right* is a morally justified claim.
>
> A *legal right* is a legally justified claim.
>
> A *Human* right belongs to all people competent to exercise them.
>
> An *Alienable right* may be given or taken away, *inalienable rights* cannot.
>
> *Absolute* rights cannot be outweighed by other factors.
>
> *Prima facie* rights can be outweighed by other factors.

However, to reduce the decision-making process down to a simplistic right or wrong can be viewed as subjective. For example, how does an individual:

- Rank personal values, let alone anyone else's?
- Maintain impartiality when assessing the interests of others?
- Distinguish between moral obligations and personal ideals?

Historically there have been many clashes with the laws of a country based on moral principles and human rights, particularly when another group disadvantages one group within a society. Human beings are not always at liberty to do as they wish because personal actions often inspire consequent reactions and sometimes overreactions that can cause social chaos. These actions need regulating by way of laws and morals. Laws and regulations have affected individuals and well as groups of people, such that throughout history the question has always been how we should behave and the rules for proper behaviour (Mehlinger, 1986). In this way, morality is topically related to the law.

Unfortunately there are many examples of laws that have been passed over the centuries that are now considered quite immoral, such as slavery. As Davis (2001) points out “the public opinion supporting such laws could not have been much less irrational or immoral than the laws themselves” (p. 4). Consequently this human decision as to what is rational or moral to do is not always based on public opinion or law. Well-publicised examples abound throughout history of public division about laws with moral underpinnings. Preston (1996) cites as an example, Martin Luther King’s campaign of civil disobedience against segregation in the United States in the 1950s and 1960s. This was based on the premise of: “there is a moral duty not to cooperate with unjust laws. Similarly, thousands of young people in the Vietnam War period defied the conscription laws on moral grounds” (p. 22).

This argument between justice and rights is certainly not a new one and can be traced back to documentation by Plato of discussions with Aristotle. Plato believed that we should elect a government democratically and they will make the laws. We then have a moral obligation to uphold and obey those laws. Alternatively Plato’s student Aristotle questioned if we should follow these laws if they were unjust. In more recent history, Mahatma Gandhi’s philosophy and practice of moral resistance to unjust laws is known to have influenced the moral crusades of King in the United States and Mandela in South Africa. Both of these men campaigned to put their civil rights case before the public by defying or protesting against unjust laws (Preston, 1996).

Essentially, the difference between morality and the law is that the law is enforceable by punishment, but only the sanction of conscience and reputation enforces morality (Pojman, 1998). However, Russell (2002a) argued that there is relativity to morality when law enforces it.

In the enforcement of unjust laws and directives, a decision-maker can be required to answer for and take responsibility for decisions and actions as if he or she had actually made that personal choice. As an example, it is widely documented that at the post Second World War

Nuremberg trials, some defendants' claims that they were just following orders was judged unacceptable in some instances.

To sum up, laws can often encompass issues with a moral basis. Individuals are then constrained to make judgements by these laws and are sometimes treated as though they had free choice. Moral decision-making can also be subjective, and the basis for a moral decision can vary extensively. One approach to the basis of moral decision-making is to use one's own individual values and morals as the reference, which leads to the practice, known as existentialism, and is discussed next.

Existentialism

Existentialism is a philosophical movement of the 19th and 20th centuries that promotes the theme of individual existence, and places an importance on subjectivity, individual freedom, and choice. Existentialism emphasises the existence of the individual as a free and responsible agent determining his or her own development. In essence, existentialism stresses the responsibility of one's existence on one's self. Eirmann (2002) offers a comprehensive definition:

> Freedom of choice, through which each human being creates his or her own nature, is a primary theme. Because individuals are free to choose their own path, existentialists have argued, they must accept the risk and responsibility of their actions. Kierkegaard held that a feeling of general apprehension, which he called dread, is God's way of calling each individual to commit to a personally valid way of life. Similarly, 20th-century German philosopher Martin Heidegger felt that anxiety leads to the individual's confrontation with the impossibility of finding ultimate justification for his or her choices. (p. 1)

As well intentioned as existentialism sounds in theory, the main point to note here is that one must also take the responsibility for one's decision-making in this manner.

Hinchcliff (1997) despairs that it is unfortunate that responsible behaviour and justice are not prescribed in life as a prerequisite for human behaviour. It is this lack that he sees as the basis for teaching about ethics. He explains:

> We seek to introduce ethics because of our deep concern that we must do something to improve the plight of society in this age of disillusionment and apprehension. (p. 231)

Interestingly, the terms *moral* and *ethics*, which come from the Latin *mores* and Greek *ethos* respectively, both derive their meaning from the idea of custom (Pojman, 1998). Ethical decision making in engineering is the main focus of this study. To this point, the chapter has provided an outline of morality and a range of possibilities for the basis of moral decision-making. As the subject of morality drifts towards ethics we find Pojman (1998) comparing morality and the law in terms of ethics: "many laws are instituted in order to promote well-being, resolve conflicts of interest and/or social harmony, just as morality does, but ethics may judge that some laws are immoral without denying that they are valid laws" (p. 4).

The nature of ethics and the codes of ethics as guides to the ethical decision-making of engineers are discussed in the next chapter.

Questions to consider

1. Should engineers only develop products that are environmentally harmless?
2. Should customers be allowed a choice?
3. Is technology deterministic, i.e., is there a relationship between technology and the environment, such as air pollution?
4. Is the practice of conservation a technology?

Chapter 7
Ethics in Decision-Making

The concept of engineering ethics

Technology is a formidable force which can be used to make the world a better place, and in the age of modern technology and applied science it has become appropriate to think about how to behave morally with science and technology, for example:

- How to prevent harm to others.
- How to improve the quality of life.
- How to solve some of our most difficult social problems.

The concept of *engineering ethics* is an aim to introduce moral values as part of engineering research, development and practice.

A definition of ethics

The Concise Oxford Dictionary (Collins, 1988), defines ethics as: "the study of human conduct and the rules and principles that ought to govern it" (p. 380). In relation to engineering decision-making for this study it can be given relevance as the theoretical analysis of moral values and judgement, particularly in a professional capacity.

Preston, (1996) further describes the principle of ethics:

> Ethics is concerned about what is right, fair, just or good; about what we ought to do, not just what is the case or what is most acceptable or expedient … ethical claims prescribe, rather than describe. They are concerned with how people ought to behave and suggest how social and individual behaviour can be improved. (p. 16)

Ethical behaviour can be:

- clearly defined for an organisation or profession by a written set of guidelines, or
- may constitute a set of unwritten rules of acceptable social behaviour, such as in sport.

Ethics is the provision of a value system, which is very often a guide to proper conduct in society or the work place, rather than the imposition of a set of rules like the Road Code, and it enables professionals to be influenced and guided in their decision making. Ethical guidelines can very often be informative and descriptive, rather than authoritarian and prescriptive.

In this modern day and age, rules, regulations, compliance issues and codes will often bind you in practice. However, very often in a competitive business world, moral perception becomes increasingly important as we endeavour to grasp mutable, vague and indeterminate situations in which the rules and clear criteria can be very difficult to determine. This moral perception and imagination allows engineers to create and explore possible alternatives beyond the knowledge and constraints of the actual situation. Johnson (1993) connects moral imagination to value criticism and growth:

> Our ability to criticise a moral view depends on our capacity for imagining alternative viewpoints on, and solutions to, a particular moral problem. In order to adapt and grow, we must be able to see beyond our present vantage point, and grow beyond our present selves (p. 203).

Ethical decision-making is an application of the moral theories discussed so far, but the object of this study is to explore the application in terms of a professional capacity.

The confusion between morals and ethics;

Values: Your own subjective principles including worth and desirability.

Morality: What is considered right and wrong.

Etiquette: What is considered good mannered and polite.

Ethics: The study of morality.

A distinction needs to be clarified between morals and ethics when considering issues in engineering ethics. When this distinction is made, the term *morals* is taken to refer to generally accepted standards of right and wrong in a society and the term *ethics* is taken to refer to more abstract principles which might appear in a code of professional ethics or in a textbook in ethical theory. The terms moral philosophy or moral theory are used to refer to a set of abstract moral principles, just as appropriately as the term ethics. In a practical sense very often the words are used interchangeably. Both of the terms refer to standards of right conduct and the judgments of particular actions as right or wrong by those standards.

However interchangeable these terms may be, moral and ethical statements need to be distinguished from statements in etiquette and law. A rule of etiquette often uses the word should, and may guide one's conduct, for example on manners expected in another person's home. However, an ethical judgment has an important difference when compared to statements of etiquette, as moral and ethical statements are generally thought to have greater importance than statements of etiquette. Most of us probably feel that a violation of a rule such as *an engineer should protect the safety of the public* is much more serious than a violation of a rule such as *you should not come late to work*.

Moral and ethical statements should also be distinguished from laws. The fact that an action is legally permissible does not establish that it is morally and ethically permissible. Suppose an engineer discovers that his or her company is emitting a substance into the atmosphere that is not currently regulated by the law. Suppose further that the engineer reads some scientific literature that indicates the pollutant causes respiratory problems and may cause other more serious health problems. Should the engineer reveal this information?

The mere fact that emitting the substance is legally permissible does not also mean it is also morally permissible to do so. Just as legality does not imply morality, neither does illegality imply immorality (Texas A & M University, 2002). So the question is why should an engineer be ethical?

Why be ethical?

In an ideal world, the rules of society would cover any eventuality, and all of society would agree knowledgeably. However, in reality this ideal is not always achievable, and realistically, the formal rules and regulatory systems put in place by a society are not always wholly adequate to guide people in all the complexities of decision-making. Very often judgement will be required, and ethical decision-making is a way of bridging the gap between the formal and informal type of decision. It could be described as an informal system of decision-making with clear moral guidelines.

Ethics is seen as a cumulative effort to understand and to control individualism with the associated tendency to pursue selfish goals by manipulative and deceitful means. It is necessary to control this self-regarding human characteristic in order to live peacefully as an extended group of people. To a large extent, ethical behaviour is the balance between self-interest and group responsibility, and is largely a learned skill, rather than an instinct.

For example Pojman, (1998) stated, "the most salient characteristic of ethics is that it is grounded in reason and human experience" (p. 4).

Randerson (1991) observes that very often the nature of decision-making in society will be of an existentialist nature by default, in that:

> What we believe about people and society … we each get on and do our own thing, whether as individuals, families or companies, and let others get on with their own thing. There are a few basic road rules to prevent major foul-ups, but for the most part we each look after our own interests. (p. 2)

This existentialist theme of individual existence may be typical of some sections of society, but the ideal is the altruistic approach, in which the various groups within society need the goodwill of each other to prosper. Randerson (1991) is a proponent of this altruistic approach to ethical behaviour. He suggests it as an ethical starting point to guide ethical behaviour because while individual endeavour and responsibility is important, it needs to recognise that we are all part of a wider community, and we should conduct our affairs in a way that recognises the need to consider the well-being of others who can be adversely affected by our actions, just as we can by theirs.

Such a consequential approach to ethical behaviour can be clearly defined for an organisation or profession. Rather than the imposition of a set of rules, professionals may be provided with a written set of ethical guidelines providing a value system, which is normally a guide to proper conduct in an organisation or work place for the benefit of all. It enables professionals to be influenced and guided in their-decision making and conduct.

Ethical guidelines can be in the form of advice, and in informal situations ethics may constitute a set of unwritten rules such as the peer pressure among a group. Ethical guidelines can very often be informative and descriptive, rather than authoritarian and prescriptive and as such, would be quite different from legal commands. They are not always perfect or free from self-serving interest, but the objective is to define strategies that best serve every person's wishes to achieve and be an accepted member of society.

Origins of ethical reasoning

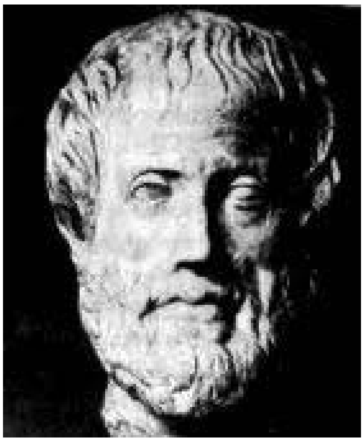
This section investigates the key issues of ethics. The research of Adair (2002) explains the roots (or origins) of ethical theory as being in religion, philosophy and logic [bracket added]:

> Each [ethical theory] has a unique approach to determining ethical behaviour based on the ideology upon which the theory is founded. Some of the theories have their roots based on religion, others in philosophy and logic. (Appendix, p. 1)

Of course, philosophy is a vast area in itself, but put simply, philosophy is the art of wondering, or the capacity to think about our thinking. There are many aspects to philosophy and Preston (1996) includes:

- Metaphysics: the study of reality.
- Aesthetics: the study of values in art or beauty.
- Epistemology: the study of knowledge.
- Logic: the science of reasoning.

According to Preston (1996), the ethics we practice usually rest on metaphysical and epistemological assumptions, consciously acknowledged or unconsciously held, "so philosophy helps us clarify some of the assumptions which form the basis of our ethical judgement" (p. 21). Put another way, the decisions one makes depend on one's moral viewpoint! As such, the use of philosophical logic and reasoning to make an ethical decision is not a process guaranteed to produce identical outputs, as it is expected to in the field of microelectronics. Nevertheless, as Pojman (1998) points out, "the most salient characteristic of ethics is that it is grounded in reason and human experience" (p. 4). Unlike the logical decision-making theory promoted by the fictional character Mr Spock, Pojman warns that when moral differences are caused by different fundamental moral principles, "it is unlikely that philosophical reasoning will settle the matter" (p. 6). Reasoning will not solve an issue if the moral justification is at variance.



Aristotle (384 – 322 B.C.)

Such an unsolvable moral issue could for example be the difference in viewpoints between the pro-abortionist and the anti-abortionist. One defends the life of the foetus, in the belief that it has an eternal soul and thus possesses the right to life, while the other denies that anyone has a soul.

Furthermore, ethical decision-making, particularly in commerce and industry, may not be made so much on the moral philosophy, but rather on the basis of self-interest. Others may consider the altruistic approach to a decision, with greater consideration of others. It seems therefore that philosophy can have different moral viewpoints. One way to solve such an altercation in moral viewpoint leads to the consideration of *virtue ethics*.

Virtue ethics (as defined by ancient philosophers)

Virtue ethics are a product of the classical Greek thought. Foremost amongst the ancient Greek philosophers who developed this moral code were Plato (d. 347 B.C.) and Aristotle (384-322 B.C.). Virtue ethics is defined as the cultivation of socially valued traits, or virtues of character is seen as the most noble of pursuits. Aristotle viewed ethics as part of the politics of how an individual lives best, and politics of how a group lives best. Rather than an ethical conduct as a result of pure reason or abstract principles, Aristotle perceived ethics as being derived from beliefs embedded in social practice and conduct. Virtue ethics is founded on a link between one's ethical approach and one's moral theory. Aristotle (Preston, 1996) included the following list of moral qualities he considered part of his virtues theory "courage, temperance, magnificence, pride, good temper, friendliness, truthfulness, wittiness, shame and justice" (p. 58). The virtues and the practice of virtue ethics are developed through practice and experience, and can be a result of a person's up bringing, training, self-discipline and self-control throughout their life. Preston (1996) stresses the importance of moderation and self-control in virtue ethics, and gives the example of virtue as the "means between extremes" where for example, "courage is the mean between foolhardiness and cowardice" (p. 58).

When making ethical decisions based on virtue, such as personal judgement and reason, Preston (1996) offers three key issues to consider.

The three key issues of virtue ethics

Preston (1996, p. 26-34) considers there are three key issues to consider when understanding ethics, all of which can be viewed as context-dependent. They are detailed as follows.

1. Egoism and altruism

The terms *egoism* and *altruism* describe the manner in which our ethical decision-making is inspired. These terms clearly distinguish two apparently opposite influences on the decision-making process. Egoism involves decision-making on the basis of a personal preservation, with the perceptions of our own well-being and self-interest being paramount. Egoism is acting out of self-interest. Altruism is decision-making where we are motivated at least occasionally by the consideration of, and a sense of duty towards others, and acting for the benefit of others.

Egoism is a human behavioural pattern of self preservation which is sometimes called looking after number one. It may often be found in individual decision-making, but also may include collective decision-making, which can include an entire race or nation. For example, it is common practice for many countries to impose of import tariffs on foreign imports to protect a countries local manufacturers or farmers, and this would be considered ethical egoism. Altruism on the other hand is to put others first, and it is quite common for parents to put the good of the family before their own aspirations or needs. Many parents go without a personal need to educate their children. Altruism has also earned many an individual a medal for bravery such as the Victoria Cross or Medal of Honour.

Ethical egoism has been referred to as a psychological principle of motivation called *psychological egoism*, on the basis that all human actions without exception are ultimately motivated by selfish interests (Encyclopaedia of Philosophy, 2002b). An ethical theorist could argue that egoism is an unalterable fact of human nature so that any moral obligation operates within the confines of human nature and makeup. Essentially, egoism recognises the selfish motivations of the individual. Alternatively, ethical altruism makes an appeal to the kinder side of human nature. The altruism theorist will argue that our sense of altruistic moral obligation is the feature of normal human nature because human beings are instinctively benevolent (Encyclopaedia of Philosophy, 2002b). The distinction between these two apparently opposing motivations can be illustrated with two examples:

- Egoism accentuates self-promotion,
  for example, the promotion of self-interest in any moral conflict.

- Altruism promotes the benefit of others,
  for example, the tendency of animal behaviour to sustain the survival of the species.

2. Freedom and determinism

The second of Preston's issues to do with ethics is to do with freedom and determinism. Children for instance can be encouraged through training, rewards and punishment to make morally correct decisions. As they progress through life there will be codes of ethics or peer-group behaviour to influence or determine any decision-making process. Alongside this freedom exists, and there will be countless situations throughout life to determine and chose a particular path, where the ethical choice is available to be made.

Preston (1996) however asks the question "what freedom do we have to make ethical choices?" (p. 29). When making an ethical decision, do we actually have the freedom of choice, or is the decision inevitable and pre-determined to such an extent that freedom is an illusion? His argument is that there is a balance because if all ethical decisions could be predicted, there would be no moral significance in any decision and ethical decision-making would cease to exist.

3. Relativism and absolutism

Thirdly, decision-making is very often relative to one's circumstances. What is ethical in one situation may be viewed very differently in another society. In a small village environment, (particularly if the village or community is remote), one's understanding of morality will be influenced to a great extent by the collective consensus of the micro-culture one lives in. Alternatively, in the modern society of a large city or country, we can live in a multi-cultural environment, with a multiplicity of lifestyles and values. Consequently Preston (1996) points out that "views on ethics tend to be relative to the culture or sub-culture to which one belongs" (p. 32). The differences in viewpoint influenced by culture are known as *cultural relativism*. The practice of a particular cultural group in cultural relativism does not quite constitute *ethical relativism.* Ethical relativism is a viewpoint that is applicable to a particular culture, circumstance or even an individual. Ethical relativism is used when considering several different ways to describe the relativity of the ethical question or decision:

1. Ethical subjectivism - a situation where a person’s behaviour can depend on whether they believe they are right or wrong. Is it a matter of opinion?
2. Cultural relativism – ethical judgement may depend on a particular culture, and may not easily transfer to another culture. Here it is not the person’s opinion, but the context of the culture and social reality they are in that is judged as important.
3. A code of behaviour - may be used to describe an ethical expectation within an organisation.

The alternative to relativism is *absolutism.* Sometimes known as universalism, absolutism is the principle of applying a universal set of morals to which all humans should adhere.

The banning of whaling would be such an example of ethical absolutism, if the conservationist nations could get everyone in the world to agree! One way of attempting absolutism would be the introduction of a universal code of ethics.

Ethical dilemma further defined

An ethical dilemma is.

1. A serious problem
2. Moral in nature
3. Two or more alternative courses of action
4. Each of the alternatives is to some extent painful

Graduates must also have the will to act upon such a moral conviction, and given the complexity of the decisions that engineers need to make, impacting as they do on the local and sometimes national community and environment, it would seem important the engineering graduates become aware of these dimensions of ethics.

An ethical event or issue?

Before this chapter begins describing the ethical decision-making process, the author would like to clarify the difference between an ethical event and an ethical issue. An ethical event refers to something which has taken place or occurred in the past. The event may have been the cause of an enquiry and somebody may have been paid compensation.

An ethical issue is and issue of ongoing ethical importance, but is as yet unresolved. The ethical issue may have started as an ethical event but such an event may then have resulted in an on-going controversy. The main difference between ethical event and ethical issue is that the event is historical in nature and the issue is very often as yet unresolved.

The decision-making process

Engineering undergraduates learn to apply their technical skills with higher-order intellectual problems where decision-making involves the application of engineering principles through the manufacturing or enabling process in the design of systems and the selection of suitable engineering components. However, engineers are also called upon to apply their skills in a wide variety of legal, institutional, and environmental settings, which may include technology-driven social change. The overriding factors of their wisdom in engineering decision-making should include a sound knowledge and application of regulations, and public safety (Institute of Professional Engineers of New Zealand [IPENZ], 2005). In addition, the following steps in the decision-making process should help identify the best solution to a problem (Smith, 1996).

1. *Recognise the problem*; define the problem in terms of goals, scope and meaning.
2. *Set objectives*; Set the objectives for the desired output.
3. *Research*; gather as much information that is possible that is relevant, accurate, complete, and timely.
4. *Identify and evaluate all alternative solutions*; in terms of feasibility, acceptability, risk, benefits, possible negative outcomes, environment, short term consequences, long term consequences, moral principles, honesty, equality, dignity and fairness to others.
5. *Evaluate the options*; identify the positively and negatively effected parties.
6. *Select the best option*; select from an engineering, environmental, sustainable and economic prospective.
7. *Implement the option*.
8. *Evaluate the results*.

Resolving moral issues, dilemmas and problems.

These steps are a rather simplistic guide to good to decision-making, when an engineer may is faced with a contentious issue or *dilemma* not covered by regulations or the soundness of design (Keirl, 2003). Realistically engineering cannot have always a functional sense without a relational human input, and the identity and power relationships are shaped by the technologies with which we interact. The raison d'etre of technology, power and empowerment can be subject to attribution, distribution and ownership in equitable or inequitable and often contested ways and before solving such a problem, it is important to understand what type of issue is being dealt with (Keirl, 2003). Rabins, Harris, Pritchard, & Lowery (2003) go further than the simple system offered by Smith, and divide a contentious issue into factual claims, disputed conceptual issues, or at times a moral issue. All three types of issue are likely to be encountered in the progress of an engineering career.

It is important to distinguish between these three types of issues, as they are normally resolved in different ways.

Resolving a factual Issue

A factual issue is one where a claim of fact is made, but doubt is expressed as to whether a claim is truthful, and is resolved by investigation and empirical research (Rabins et al., 2003). Examples of factual issues could be claims such as:

- A claim for a new cure for some disease.
- A new invention that is claimed to perform a particular function.
- An individual claim of an identity.
- An individual claim to experience or qualification.
- A company claim that a product does not harm people or the environment.

These issues can be quite complex to resolve and it can sometimes be quite difficult to establish the facts.

Resolving a conceptual issue

A conceptual issue leads to debate in terms of the scope, concept or meaning of an issue, and is resolved by coming to agreement over the proper definition or scope of a term that describes the issue. Such an issue found in the abortion debate, is whether an unborn foetus is a human person (Rabins et al., 2003). If one argues that a foetus is a potential person, the conceptual question becomes whether that person has rights. Such conceptual issues can be many and varied and difficult to resolve. For example: What is the definition of a bribe? What is a conflict of interest? Is the legal financial support of a political candidate with the expectation of later favours a bribe?

Resolving a moral issue

A moral issue (sometimes referred to as a dilemma) involves a dispute which may require the application of moral principles. The solving of moral problems requires a degree of problem-solving and decision-making that can be either analytical or imaginative (Texas A & M University, 2002):

- Analytical mode of thinking – sort the problem into component parts.

- Imaginative mode of thinking – use creative thinking to find a solution.

The analytical mode is normally a helpful activity in finding solutions to problems, but typically conflicting moral and ethical problems require an imaginative mode of finding new creative ways to solve conflicting moral problems.

Issues that arise in a moral debate often require resolving by the application of one or more moral principles. There can be two common problems in resolving a moral issue. A relevance problem and a conflict problem (Rabins, Harris, Pritchard, & Lowery, 2005).

Resolving a relevance problem

In a relevance problem, the decision-maker is not sure whether the moral principle applies or is relevant in this situation. Resolving can depend on the prior resolution of a conceptual issue. Then, by comparing similarities and differences between cases in which the application of a concept is clear and similar cases where the application of a concept is unclear, some conclusion may be drawn.

Resolving a conflict problem

In a conflict problem, the decision-maker can be faced with two or more moral principles that can apply to the situation, and yet the two principles require different and incomparable solutions. Conflicts between competing obligations, both of which appear to be valid, are common features of moral decision-making. The conflicts that give the most difficulty in decisions are not those that compete between good and bad, but those that are competing goods, both of which cannot be fully realised. For example, should we allow a permit to opencast mining when it will provide the locals with work, but may threaten to eliminate marine life in the area?

We can consider several ways to solve the problem, but first of all, will the decision break any laws? If the decision has been made to move from the legality aspect, considerations at this point can include:

1. Finding a solution that satisfies both parties, where it may be possible to satisfy both moral principles in a modified form.
2. Considering who will be hurt?
   a. Who will benefit?
   b. What are the long-term consequences?
   c. What are the short-term consequences?
   d. How does the short-term solution affect the long-term interest?

3. Consider the result of a decision in terms of moral principles, fairness to others, honesty, equality and dignity. Is it possible to take a lower-level option into consideration? Very often one must also consider whether the decision is one that may enhance or damage a career (especially one's own career).

Taking the above considerations into account, a decision-maker may need to make a hard choice. Very often a challenging moral problem will constitute a dilemma, a choice between courses of action (usually two), which are equally unacceptable. In such cases where no middle ground is possible, at the risk of upsetting or alienating one party, the decision-maker(s) must make a choice.

However, there is not always a guarantee of certainty of the decision.

Decision-making and certainty or uncertainty

Generally, there will be one of four outcomes resulting from a decision (Forsberg & Kaiser, 2002).

1. Decisions with certainty – there is only one possible outcome.
2. Decisions with risk – where it is necessary to assess all the possible outcomes and assess the probability of each outcome.
3. Decisions with uncertainty – the possibilities of each outcome may be known, but the probability for each is not known.
4. Decisions under ignorance – there is no predictability of an outcome.

Very few engineering decisions based on a moral solution have only one possible outcome (1), and engineers should rarely if ever make decisions in which the outcome is unpredictable (4). When making a decision in which risk is involved, the main concern is to determine an acceptable level of risk, and good engineering decision-making with consideration of safety should always guide the process.

However, very often when making a decision based on values it is hoped that the result of a decision will realise a desired value. Such an expectation can be based on what the facts of the situation are, and the way the proposed action will influence and interact with the surroundings. If the consequences of the decision lie in the future, the consequences of the action can be uncertain. There are two ways of dealing with the uncertainty, firstly claim that the moral status of the action should be determined by the intention rather than the consequences, and secondly, try to determine the outcomes of the actions and the probability of these, and then determine the respective probability of the result of the action being positive or negative. Forsberg and Kaiser (2002) suggest that not dealing with uncertainty is considered culpable ignorance involving an attitude of precaution and offer the following steps for decision-making with uncertainty:

The maximum principle – choose a course of action that maximises minimum benefit.

1. The minimax principle – choose a course of action that minimises maximum loss.
2. Wait and see strategy – postpone the decision until further information is available.
3. No-regret strategy – choose the course of action that would be right for any possible outcome. (p. 10)

The precautionary principle in decision-making

The precautionary principle of a cautionary attitude is recommended as a sound guideline by Forsberg and Kaiser (2002) when a decision is likely to have any of the following traits:

1. Considerable scientific uncertainties (e.g. health or environmental consequences).
2. Scenarios where there may be possible harm (e.g. based on scientific reasoning).
3. Uncertainties which cannot be reduced without increasing the ignorance of other relevant factors.
4. The potential harm is sufficiently serious or even irreversible for present and future generations.
5. Delayed action could make countermeasures more difficult at a later date.

Ethical consideration of the decision

Finally an ethical check of the decision is taken from Kallman and Grillo (1993, p. 64).

Ask yourself the following questions on the ethics and professionalism of your decision:

1. List the stakeholders who are those with something to lose or win in this case.
2. Should someone have done or not done something earlier?
3. Who benefits here? Who is harmed here? There could be multiple answers.
4. Apply three important ethical tests to your decision, and evaluate a decision from the perspective of each of these tests.
    a. Use the *Golden Rule Test* which asks whether you would be willing to accept the consequence of your action if you were the one affected.
    b. Use the *Rights Test* and ask yourself whether anyone's rights, such as the right to free and informed consent and the right to equal treatment are being violated by this course of action.
    c. The *Utilitarian Test* asks whether a course of action produces the greatest overall good for the greatest number of people, regardless of what it does to a few individuals.
5. Ask yourself how this situation could be prevented from occurring again.

Discussion Point: What action would be considered by your employer to be a conflict of interest?

Question to consider

When you work in industry and commerce, you may have to question the value of what you are doing, or have been asked to do. In an unethical situation your conscience may be called into the equation and decision making process. Consider this high profile example of such an ethical decision;

> In 1973 the special Watergate Prosecutor Joworski ordered President Richard Nixon to hand over tapes of conversations in the White House. Nixon ordered his Attorney General to dismiss the Prosecutor. The Attorney General resigned, rather than execute such an order.

Chapter 8
Modern Engineering Decision-Making

The decision-making process

Graduates who leave a tertiary institution and enter the engineering or technology industry will at times find themselves required to make a professional decision, and naturally, their engineering knowledge will play a part in the process, and be called upon often. One of the most common decision-making processes will involve decisions that are bound by the regulations, and of these, graduates can reasonably be expected to have a good knowledge. Obviously, this knowledge will be complemented and enhanced through progressive instruction as part of their employment. There will however, almost certainly be times when the decision-making process will call upon their values, and sometimes, just plain common sense. Consequently, the general background to decision-making in our society, as it has evolved has been explained, along with reasons for the inclusion in most societies of both formal laws or regulations, and informal or unwritten rules.

Engineering decision-making

In the field of engineering in general, a high standard of personal integrity is now expected of any engineer, particularly for those engineers in a position with responsibility. There can be pressures and responsibilities on a modern engineer who is faced with the responsibilities of good engineering decision-making. Some of this decision-making will require knowledge of ethics and in terms of value judgements and ethics, the decisions of all practising engineers may not always be the same. Such decisions and decision-making policy could possibly vary from one company to another by way of company policy, or by individual attitude.

As has been stated before in this respect, Frazer and Kornhauser (1986) point out that there was a time when it was believed that if everybody understood science and technology, then we would all make the same decisions on any issue. But quite often scientists and engineers who are equally well informed on a particular scientific or engineering issue can have very different views and opinions on that issue. In fact, this difference can sometimes contrast idealism and realism (Frazer & Kornhauser, 1986).

Naturally, realism very often places constraints on idealism, and in industry and commerce, compromises and tradeoffs between the two are often made (Randerson, 2002). As Sir Gerard Brennan, speaking as Chief Justice of the High Court in Australia, pointed out to his colleagues decision-making in the corporate and professional world today places much emphasis on billable hours. New financial targets are set year by year, and percentage increases regularly expected, and sadly, ideals do not always survive.

> Idealism
> What is the ideal solution?
>
> Realism
>
> What is a realistic solution in practice?

Frazer and Kornhauser (1986) believe that all individuals are entitled to their personal opinion and their own set of personal values, but members of a profession such as engineering must learn to master and practise the art which is their profession, which is indispensable to the progress of society, and the skill and knowledge of the profession must be available to the service of the state or the community. To ensure that decision-making is in the best interests of the public that these professionals serve, there needs to be some sort of regulatory mechanism, in the form of rules and regulations. In the absence of a particular rule or regulation, judgements based on values or morality need some guidelines to good decision-making, and it is very easy to lose sight of the concept of this need.

Primary causes of engineering disasters

The primary causes of engineering disasters are usually considered to be:

- Human factors, including both ethical failure and accidents.
- Design flaws, many of which are also the result of unethical practices.
- Materials failures.
- Extreme conditions or environments.
- Most commonly and importantly, combinations of these reasons.

A recent study conducted at the Swiss federal Institute of technology in Zurich analyzed 800 cases of structural failure in which 504 people were killed, 592 people injured, and millions of dollars of damage incurred. When engineers were at fault, the researchers classified the causes of failure as follows:

Insufficient knowledge 36%

Underestimation of influence 16%

Ignorance, carelessness, negligence 14%

Forgetfulness, error 13%

Relying upon others without sufficient control ... 9%

Objectively unknown situation .... …7%
Unprecise definition of responsibilities 1%

Choice of bad quality 1%
Other ....……………3%

The consequences of poor decision-making in engineering

The consequences of poor decision-making in engineering can be far-reaching, and sometimes catastrophic. To illustrate this decision-making, the concept of risk management, and the necessity for an ethical decision-making process in engineering, a case study of the

Challenger space shuttle disaster is presented next. This case study has been chosen to highlight the pressure that a professional engineer can face in decision-making.

Case study

NASA – A culture of budgets, schedules, politics, risk and death.

News Item – Monday June 19th 2006 (Press, 2006)

> Shuttle cleared to fly again, but some experts argue against lift-off. U S National Aeronautical Space Administration (NASA) managers have picked July 1 to launch the first space shuttle in almost a year, despite recommendations against a lift-off attempt by the space agency's chief engineer and safety officers. The decision to launch Discovery on a trip to the international space station was made after two days of meetings by NASA's top managers at the Kennedy Space Centre. During the poll of top managers, representatives from NASA's Office of Safety and Mission Assurance, and the Office of the Chief Engineer recommended against flying until further design changes were made to the external fuel tank. Despite their recommendations the dissenting managers did not object to making the launch and the NASA administrator Michael Griffin said "The Administrator … has the obligation to decide. That's what I do … our staff officers have the right, have the obligation, have the utter necessity to tell us exactly what they think. But all of it is only advice". (p. B1)

NASA has already lost two space shuttles, the Challenger in 1986 and the Columbia in 2003. Much has been written about these two disasters, and most of the analysis one reads have a common thread, a judgement that NASA's catastrophic outcomes are mainly due to political interference and a systematic failure of engineering management practice. The culture of NASA and the background to these two disasters is examined, and of particular interest in this case study is the relationship between the management and the engineers in these two disasters.

The Challenger Space Shuttle o-ring decision

Cape Canaveral, Florida, USA.

28th January 28, 1986

On 28 January 1986, the Space Shuttle Challenger was launched for the last time and exploded less than two minutes after the lift-off resulting in the deaths of all seven crew-members on board. The failure of the solid rocket booster o-rings to seat properly allowed hot combustion gases to leak from the side of the booster and burn through the external fuel tank. This outcome arose as a consequence of ethical decisions made by the engineers and management. Much of the material presented regarding the Challenger is drawn from the work of Davis, (1991) and Texas A & M University (2002).

Background

In the late 1960's, NASA envisioned a reusable space transportation system, which could transport people and cargo to low earth orbit (LEO) and then land back on Earth to prepare for another mission. All previous spacecraft were designed to fly only a single mission, and this was the world's first attempt to produce a reusable spacecraft which could be used repeatedly to reduce both the engineering and hardware costs.

From its inception the Space Shuttle program had been plagued by exaggerated expectations, lack of funding, inconsistencies and political pressures. As a contrast, the previous Apollo programme had benefited form high visibility profile, a clear objective, and powerful political backing, assisted by the 1961 declaration of President Kennedy that the United States would land a man on the moon before the end of that decade. However, the space shuttle program was not as fortunate as Apollo, as it had neither a clear direction nor consistent political backing.

Throughout the development of the project NASA had suffered from a highly constrained budget, and in order to retain Shuttle funding, NASA had been forced to make a series of major design concessions. Consequently they sacrificed the research and development necessary to produce a truly reusable shuttle, and instead accepted a design which was only partially reusable by eliminating one of the features which made the shuttle attractive in the first place. Numerous design changes were made to reduce the level of research and development required, including the use of solid rocket boosters (SRBs) instead of safer liquid fuelled boosters because they would require a substantially reduced research and development effort to bring them into operation.

To increase its political stability and guarantee a steady customer base, NASA had enlisted the support of the United States Air Force. The attraction was that the Air Force could provide the considerable political influence of the Defence Department and had many satellites which required launching. However, Air Force support did not come without a price. The Shuttle payload bay was required to meet Air Force size and shape requirements, which placed key constraints on the ultimate design. Even more important was the Air Force requirement that the Shuttle be able to launch from Vandenburg Air Force Base in California. This constraint required a larger cross range than the Florida site, which reduced the total allowable vehicle weight. This weight reduction was achieved through the elimination of the air breathing engines in the original design, resulting in the limited safety and landing versatility of the vehicle by necessitating a single-pass non-powered landing. Ejector seats were also removed from the design. Consequently, the resulting vehicle design was not as envisioned in the original concept, and the resulting vehicle had some serious design flaws, one of which caused the loss of the Challenger.

What is important to the chain of events that led to the Challenger disaster was a construction technique designed by the sub-contractors, the engineering company Morton Thiokol who were responsible for the construction of the booster rockets for the space shuttle. Thiokol had pioneered the o-ring concept in the shuttle rocket construction. This enabled the company to build the huge rockets used for the shuttle in Utah and transport each rocket by rail in a number of pieces to the Space Centre three thousand kilometres away in Florida. This innovative construction concept was much more efficient than building on-site at the Space Centre, allowing Thiokol to underbid the competitors, and was awarded the contract for the shuttle booster rockets.

The pressures on NASA in 1985

In spite of all its early difficulties, the Shuttle program looked quite good in 1985. A total of 19 flights had been launched and recovered, and although many had experienced minor problems, all but one of the flights could rightfully be categorised as successful. However, delays in the program as a whole had led the Air Force to request funds to develop an expendable launch vehicle. Worse still, the French launch organisation Arianespace, had developed an independent capability to place satellites into orbit at prices the Shuttle could not hope to compete with unless they received greatly increased federal subsidisation, which at the time appeared not likely to occur as Congress was becoming increasingly dissatisfied with the program. The shuttle was soon going to have to begin showing that it could pay for itself and NASA believed an increase in the number of flights was the solution. As 1986 began, there was extreme pressure on NASA to proceed with their intended Space Shuttle flight programme.

For the shuttle program, 1986 was to be the year of truth. The shuttle programme was falling behind its ambitious launch schedule, and the U.S. Congress was increasingly critical of the programme. NASA needed to prove that it could launch a large number of flights on time to continue to attract customers and retain congressional support. Unfortunately, 1986 did not begin well for the shuttle program and with the Columbia flight 61-C experiencing a record four on-pad aborts and three other schedule slips. Finally, on mission 61-C, Columbia was forced to land at Edwards Air Force Base rather than at Kennedy Space Centre as planned. The delays in Columbia's launch and touchdown threatened to upset the launch schedule for the rest of the year.

The landing of Columbia at Edwards required it to be ferried back to the Cape, but several key shuttle parts had to be carried back immediately for urgent use on the other vehicles. These parts included a temperature sensor for the propulsion system, the nose-wheel steering box, an air sensor for the crew cabin, and one of the five general-purpose computers. At the time of the Challenger explosion, NASA supposedly had four complete shuttles. In reality there were only enough parts for two complete shuttles, and many shuttle components were passed around and reinstalled in the shuttles with the earliest launch dates. From a reliability point of view, every time a device or system was removed or inserted, the shuttles were exposed to the likely-hood of servicing-induced problems.

In addition to problems caused by the flight of Columbia, the next Columbia flight scheduled for March also put pressure on NASA to launch the Challenger on schedule. The March flight of Columbia was to carry the ASTRO spacecraft and NASA wanted it to reach Halley's Comet before a Russian probe arrived at the comet. In order to launch Columbia in time for Halley's Comet, the Challenger had to carry out its mission and return to Kennedy by January 31.

The recent success of the Space Shuttle program had left NASA in a *Catch 22* type situation. Successful shuttle flights were no longer news because they were almost ordinary. However, launch aborts and delayed landings were more news worthy because they were much less common. Consequently NASA had much to gain from a successful Challenger flight. Publicity was an extremely important tool to NASA in its quest for continued funding, and the unusual t*eacher in space* mission had generated much more press interest than other recent shuttle flights. Furthermore, if the launch went ahead as scheduled, the President of the United States would be able to announce the first teacher in space as part of his annual state of the union message the following evening.

For the Space Centre this would provide very good publicity at a time when the shuttle program was under such political pressure (Davis, 1991; Pritchard, 1992). Hence the reasoning behind the haste to launch appeared to be political, as in addition to general publicity gained from the Challenger flight, NASA was aware that a successful mission would play well in the White House. The value of an elementary teacher giving a lecture from orbit was obvious and the anticipated benefits of ensuing publicity were clear to NASA and President Reagan.

The chain of events to launching

On the Monday (the day before the launch), the attempt to launch the Challenger had been delayed by a faulty door sensor, a stripped bolt and high winds. After closing the hatch the external hatch handle could not be removed. The threads on the connecting bolt were stripped and instead of cleanly disengaging when turned the handle simply spun around. Attempts to use a portable drill to remove the handle failed. Technicians on the scene asked Mission Control for permission to saw the bolt off. Fearing some form of structural stress to the hatch, engineers made numerous time consuming calculations before giving the go-ahead to cut off the bolt. The entire process consumed almost two hours before the countdown was resumed.

Meanwhile, the wind at the Cape had been steadily rising, and Chief Astronaut John Young flew a series of approaches in the shuttle training aircraft and confirmed the worst fears of Mission Control. The crosswinds were in excess of the level allowed and the launch opportunity had been missed. The flight would have to wait until the next possible launch window, which was the following morning. Everyone concerned with the launch were quite discouraged, especially since extremely cold weather was forecast for Tuesday, which could further postpone the launch.

Tuesday, January 28:

After the cancelled launch on Monday morning there was a great deal of concern about the possible effects of weather. The predicted low for Tuesday morning was -4^0 C, far below the nominal operating temperature for many of the Challenger's subsystems. It was expected that as the sun came up and the launch time approached both the air temperature and the vehicle would warm up, but there was still concern that the ambient temperature would not be high enough to meet the normal launch requirements. NASA's Launch Commit Criteria stated that no launch should occur at temperatures below 12^0 C. There was also concern over any permanent effects on the shuttle due to the cold overnight temperatures.

All NASA centres and subcontractors involved with the Shuttle were asked to determine the possible effects of cold weather and present any concerns. In the meantime Kennedy Space Centre went ahead with its freeze protection plan. This included the use of anti-freeze in the huge acoustic damping ponds, and allowing warm water to bleed through pipes, showers, and hoses to prevent freezing.

The weather for Tuesday morning was to be clear and cold. Because the overnight low was forecast at well below freezing point there was doubt that Challenger would be much above freezing at launch time. The Launch Commit Criteria included very specific temperature limits for most systems on the shuttle. A special wavier would be required to launch if any of these criteria were not met. Although these criteria were supposedly legally binding, Marshall Space Flight Centre administrator Larry Mulloy had been routinely writing waivers to cover the problems with the SRBs on the recent shuttle flights.

The engineers at Morton-Thiokol were very concerned about the possible effects of the cold weather. The problems with the SRBs had been long known to engineers Roger Boisjoly and Allan McDonald, but both felt that their concerns were being ignored. They felt that the request by NASA to provide comment on the launch conditions was a golden opportunity to present their concerns. They were sure that Challenger should not be launched in such conditions as those expected for Tuesday morning. Using weather data provided by the Air Force, they calculated that at the 9:00 am launch time the temperature of the o-rings would be only 29^o F (-0.5^o C). Even by 2:00 pm, the o-rings would have warmed only to 38^o F (4^o C).

On the evening of 27 January 1986 Robert Lund, the vice-president for engineering at Thiokol, had earlier in the day presided over a meeting of engineers that had unanimously recommended against the launch. On the evening of the 27th the Space Centre had been worried about the ice already forming in places on the boosters, but Lund's worry was the successful sealing of the booster segments by the o-rings. He had informed his company president Jerald Mason of the recommendation, and Mason had consequently informed the Space Centre. The Space Centre's safety record up to now was very good and would not allow a launch unless all the technical people approved. Consequently, Lund expected the flight to be postponed.

Lund had not approved the launch because of the expected freezing temperature at lift-off. A detailed examination of the o-rings used in earlier take-offs showed that the rings tended to erode in flight, and data gathered after each flight indicated that the worst erosion had occurred on the preceding lift-off, which had been the coldest lift-off to date at 53^{o}F (12^{o}C). The evidence suggested that the erosion of the rings increased as the rings lost their resiliency and the resiliency decreased with temperature. The concern was that at a certain temperature, the rings could lose so much resiliency that one would fail to seal. A ring failure during take-off could cause catastrophic failure resulting in an explosion of the shuttle. Unfortunately, almost no testing had been done below 40^{o}F (5^{o}C) and no data were available about the temperature at which such failure would be a certainty.

The design validation tests originally done by Thiokol covered only a very narrow temperature range. The temperature data-base did not include any temperatures below 53^{o} F (12^{o} C). The o-rings from Flight 51-C which had been launched under cold conditions the previous year showed very significant erosion. This was the only data available on the effects of cold, but all the Thiokol engineers agreed that the cold weather would decrease the elasticity of the synthetic rubber o-rings, which in turn might cause them to seal slowly and allow hot combustion gas to surge through the joint.

The engineers at Thiokol recommended to NASA that Challenger not be launched until the o-rings reached a temperature of 53^{0} F. The NASA management were flabbergasted, and demanded that Thiokol prove that launching was unsafe. This was certainly a complete reversal of normal procedure. Normally, NASA required its subcontractors to prove that something was safe. Now they were requiring their subcontractors to prove that something was unsafe. Faced with this extreme pressure, Thiokol management asked its engineers to reconsider their position. When the engineers stuck to their original recommendations not to fly it will be seen that the Thiokol management eventually overruled them and gave NASA its approval to launch.

During this time Rockwell, the company who manufactured the Orbiter, also had concerns about launching in cold and icy conditions. Their major concern was the possibility of ice from either the shuttle or the launch structure striking and damaging the vehicle. Like Thiokol, they recommended against the launch, and they too were pressed to explain their reasoning. Instead of maintaining their original strong recommendation against a launch, the Rockwell team carefully reworded their statement to say that they could not fully guarantee the safety of the shuttle.

In its desire to fly out its manifest, NASA was willing to accept this statement as a recommendation! The final decision to launch, however, belonged to Jesse Moore. He was informed of Rockwell's concerns, but was also told that they had approved the launch. During this ensuing debate the engineers and management from NASA chose not to even mention the original concerns of Thiokol. It was to transpire after the disaster that as the warnings and concerns were communicated up each layer of responsibility at NASA they became diminished.

The Space Centre’s official reaction to the Thiokol recommendation was one of surprise, as they were keen to launch. They were reported to have been appalled by the basis on which the no-launch recommendation occurred. However, the Space Centre would not launch without Thiokol's approval and they urged the Thiokol president Mason to reconsider the decision. He re-examined the evidence and decided the o-rings should hold at the expected temperature. Joseph Kilminster, Thiokol's vice-President for shuttle programs, was ready to sign a launch approval, but only if vice-President Lund approved.

As an engineer, Lund’s justification for the decision had been quite clear; safety came first. The temperature predicted for lift-off the next morning was freezing (32^{o}F or 0^{o}C), and with the lives of seven astronauts at stake, to Lund the decision seemed to be simple and logical.

At this point Robert Lund carried the entire burden as the only impediment to the launch. Lund's first response was to repeat his earlier objections. Mason subsequently asked him to *think like a manager* rather than an engineer. Mason’s exact words according to Davis (1991) were reported to be: "take off your engineering hat and put on you management hat" (p. 2). As a result of such pressure by his manager, Lund changed his mind, and late on the Monday evening the decision to push onward with the launch was made. Despite the very real concerns of some of the engineers familiar with the actual vehicle subsystems, the launch was approved. No one at NASA wanted to be responsible for further delaying an already delayed launch. Everyone was aware of the pressure on the agency to fly, and a great deal of frustration from the previous launch attempt remained. Somehow, the potential rewards had come to outweigh the potential risks, and quite clearly, there were many reasons for launching Challenger on that cold Tuesday morning.

Pre-launch events

Although the decision to launch on Tuesday had been made late on Monday evening, it was still possible that some additional unforeseen circumstance might force NASA to postpone the launch. However, the decision to launch had been made, and none of the current concerns were going to stand in the way. A *press on* mentality was firmly established by NASA staff and even if all of Florida froze over, the Challenger would launch.

The pre-launch inspection of Challenger and the launch pad by the ice-team was unusual to say the least. The ice-team's responsibility was to remove any frost or ice on the vehicle or launch structure. What they found during their inspection looked like something out of a science fiction movie. The freeze protection plan implemented by Kennedy personnel had gone very wrong. Hundreds of icicles, some up to 40cm long, clung to the launch structure. The handrails and walkways near the shuttle entrance were covered in ice, making them extremely dangerous if the crew had to make an emergency evacuation. One solid sheet of ice stretched from the 60m level to the 75m level on the gantry. However, NASA continued to cling to its calculations that there would be no damage due to flying ice shaken loose during the launch.

The launch

As the SRBs ignited, the cold conditions did not allow the o-rings to properly seat. Within the first 300 milliseconds of ignition, both the primary and secondary o-rings on the lowest section of the right SRB were vaporized across a 70^0 arc by the hot combustion gases. Puffs of smoke with the same frequency as the vibrating booster are clearly present in pictures of the launch. However, soon after clearing the tower, a temporary seal of glassy aluminium-oxides from the propellant formed in place of the burned o-rings as the Challenger continued skyward.

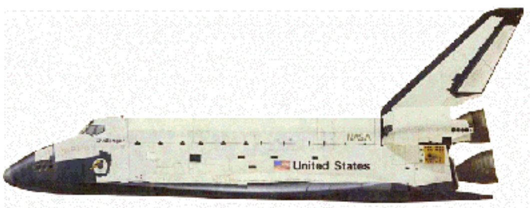
Unfortunately, at the time of greatest dynamic pressure, the shuttle encountered an extraordinary wind shear. As the Challenger's guidance control lurched the shuttle to compensate for the wind shear, the fragile aluminium-oxide seal shattered. Flame arced out of the joint, struck the external tank and quickly burned through the insulation and the aluminium structure. Liquid Hydrogen fuel then streamed out and was ignited and the Challenger exploded.

When the remains of the cabin were recovered, it became apparent that most of the crew survived the explosion and separation of the Shuttle from the rest of the vehicle. During the 2 minute 45 second fall to the ocean at least four of the personal egress packs were activated and at least three were functioning when the Challenger struck the water. While the ejector seats in the original specifications probably would have saved their lives, the high-speed impact with the water produced a force of 200g which undoubtedly killed all the crew.

Safety and ethical issues

Many questions involving safety and ethics are raised when the decision to launch the Challenger is examined. Obviously, the situation was unsafe, but the ethical questions are more complex. If high standards of ethical conduct are to be maintained, then each person must differentiate between right and wrong, and must follow the course which is determined to be the right or ethical course. Frequently, the determination of right or wrong is complex, and both sides of the question can be convincingly argued. Some of the issues raised by the Challenger launch decision are listed below:

1. Are solid rocket boosters inherently too dangerous to use on manned spacecraft? If so, why are they a part of the design?
2. Why were air-breathing engines and ejector seats eliminated from the original design?
3. Was safety traded for political acceptability in the design of the Space Shuttle?
4. Did the pressure to succeed cause too many things to be promised to too many people during the design of the Space Shuttle?
5. The rockets were built in pieces to enable transportation from a remote location. Why was the decision made to take the lowest price if unreliability was to be an outcome?
6. Did Morton Thiokol act on its discovery of the faulty operation of o-rings after the previous launch?
7. Did the need to maintain the launch schedule force decision makers to compromise safety in the launch decision?
8. Were responsibilities being ignored in the writing of routine launch waivers for the Space Shuttle?
9. Were managers at Rockwell and Morton Thiokol wise or justified in ignoring the recommendations of their engineers?
10. Is there an implicit contract between engineering practice and the social obligations to society? Is there a definitive division between loyalty to the company and society?
11. Did the engineers at Rockwell and Morton Thiokol do all that they could to convince their own management and NASA of the dangers of launch?
12. When NASA pressed its contractors to launch, did it violate its responsibility to ensure crew safety?
13. When NASA discounted the effects of the weather, did it violate its responsibility to ensure crew safety?
14. Are managers expected to ignore their own engineering expertise, and that of their subordinates, or should they still think like engineers?



Thinking like an engineer

As previously stated, a high standard of personal integrity is now expected of any engineer in a position with responsibility. To return to the o-ring problem, given only the information available to him at the time, should Robert Lund have reversed the previous decision that was the considered professional opinion of his professional engineers and approved the launch of the Challenger Space Shuttle? In retrospect, of course, the answer is obvious. Such a situation requiring a decision of a group of professionals would not be a problem if all the consequences of the decision could be foreseen. If everything were so obvious, risk could be removed from decision-making resulting in an extensively reduced requirement for ethical input to decision-making. But, as previously stated, the reversal of the Challenger launch decision was a direct result of Lund being invited to think *like a manager* rather than an engineer. What then was the difference then between thinking like a manager and thinking like an engineer?

When making a decision such as this one, there are several factors to be considered. Each factor must have some weighting attached to it, and Lund's input from his engineers was his main concern. The engineering concerns including lack of test data, possible unreliability and safety had the highest weighting in Thiokol's assessment. The instruction to think like a manager appears to have shifted the weighting to managerial concerns, such as budgets, schedules and politics. So when does an engineer stop thinking in terms of his engineering education? Does such a manager actually need an engineering education?

The difference between a manager and an engineer

The Davis (1991) investigation of the Challenger Space Shuttle disaster offered one explanation of the difference, in which Davis stressed:

> Managers, it might be said, are trained to handle people, engineers, to handle things. To think like a manager rather than an engineer is to focus on people rather than on things. According to this explanation, Lund was asked to concern himself primarily with how best to handle his boss, the Space Centre, and his own engineers. He was to draw upon his knowledge of engineering only as he might draw upon his knowledge of foreign language, for example, to help him communicate with his engineers. He was to act much as he would have acted had he never earned a degree in engineering. (p. 2)

The question here is what was Mason asking Lund to do? To think like an engineer, Lund had a responsibility to use the technical knowledge he was hired for. Engineers are taught to be pragmatic, logical, rational, sensible and systematic in their approach to problems. As in Lund's situation, Perlman and Varma (2002) point out that "these useful attributes also tend to alienate the engineer from the rest of society. Moreover, they may even confuse the engineer himself" (p. 42). In fact, while engineers may see themselves as problem-solvers, others may not always perceive them in the same light. However, under time constraints, pressures and crisis conditions at that time, an engineer's decision-making process relies considerably on experience.

Alternatively when considering the Space Centre claim that they had a good safety record, does the Space Centre programme rely more on their safety record than engineering advice and excellence? In other words, do they rely upon the antiquated colloquial notion of *if it ain't broke, why fix it*? Was it the case where successful cultures such as NASA become susceptible to hubris and carelessness?

One complication is that rather than design a new product and test it all the way through, Thiokol tested the ability of existing rings to operate, even when damaged. But they tested only to the known limits of damage that they observed from the previous flights, rather than a complete range of conditions that might be encountered.

The ethical question here becomes more finely balanced and reflective of the nature of the National Aeronautical and Space Administration's (NASA) culture. Did NASA make judgements that relied on previous success, rather than potential failure? From an engineer's point of view, in reality, Lund had no test data available to him in order to make a reasonable decision as to the advisability of making a launch below freezing point. It is not normal engineering practice to gather test data, which Thiokol now has as a result of this disaster, with seven people on board a space shuttle.

The o-ring case study illustrates the pressures and responsibilities that can face the modern engineer when the management has a culture prone to the habitual ignoring of engineering recommendations. In this situation, the engineer must weigh risks against the safety of personnel and the public. Such a decision falls within the domain of *risk management* which is discussed next.

Risk management

From a strictly management point of view, there will always be risks. Part of the responsibility of being an engineer is to reduce these as much as possible with foresight. It is obviously very difficult to reduce all risk in an enterprise, and if for example the New York World Trade Centre's twin towers had been built more strongly, more people would have survived the September 11 terrorist attacks. However, if building codes required any building to withstand an extraordinary event such as a missile impact, then building construction would inevitably be more expensive and less productive.

> **Risk**
>
> The likelihood of a danger, hazard or harm.

In Lund's infamous decision, he seems to have taken a utilitarian approach to the problem of the o-ring decision in terms of how he interpreted his responsibilities as an engineer. But cost, efficiency, schedules and politics are not the only relevant factors in making a recommendation about potentially risky operations, and while one influence was in the context of a strong political element, a code of ethics should always prescribe a guide to certain behaviour, despite any particular context. The U S National Society of Professional Engineers (NSPE) code of ethics, for example, clearly prescribes the relevance of the public health and welfare in any context of engineering decision-making.

It appears that the administration took the egoistic approach, while the engineers as a group, had originally felt obligated to the altruistic approach in their decision to launch in the Challenger shuttle disaster.

Following the disaster President Reagan appointed the *Rogers Commission*, to investigate the accident. This commission of enquiry found that the organisational culture and decision-making processes embedded in NASA were a key contributing factor to the accident. The commission was explicit that NASA managers had failed to deal with the flawed design of the o-rings, had ignored warnings from engineers about the inadvisability of launching on an unusually cold day, and had failed to adequately report these technical concerns to their superiors. The Rogers Commission offered NASA nine recommendations that were to be implemented before shuttle flights resumed

Risk assessment

The result of many disasters is that technology is controlled by hindsight. The fundamental principle of risk assessment is to control technology with foresight.

The Columbia disaster February 1 2003

More recently in 2003 another seven astronauts were killed in a space accident involving the space shuttle Columbia, which broke up on re-entry into the Earth's atmosphere after losing part of its wing protective shield while launching. Again the administrators had not listened to their engineers!

Usborne, (2003) reported that independent investigators of the Columbia disaster condemned NASA for failing to learn the lessons of the Challenger disaster 16 years previously. The report accuses NASA of: "a self-protective culture at the heart of the organisation … that culture meant that its management accepted increasing levels of risk to the point where they accepted some flaws as normal in the shuttle system" (p. B1).

A key issue of this engineering research arose with this second space shuttle disaster, where the official investigation report condemned NASA's top officials for "showing a lack of concern about technical problems engineers brought to their attention" (Usborne, 2003, p. B1).

A post-launch photographic analysis had indicated to engineers that a large piece of foam broke away from the external fuel tank and struck the leading edge of the left wing at an estimated velocity of 500 miles/hour. The debris was collected and carefully assessed as to what likely damage may have been done. The debris assessment was presented to the mission management team, who believed there was insufficient evidence to justify a threat to the safety and survival of the Columbia. During the time of the flight, engineers continued to exchange e-mails with the NASA managers with their concerns for the safety of the crew, but the managers did not respond. The Columbia was subsequently destroyed as it re-entered the Earth's atmosphere.

These two tragic disasters suffice to show us that even a seemingly simple engineering decision can bring an engineer face-to-face with deep questions about the environment, safety and public welfare and involve complex assessment of the risk to and from a wide range of variables. When considering these risks, the responsibility of engineers to behave in an ethical manner can take the term ethics into quite a narrow utilitarian focus within the vast area of ethics in general. In essence, the American NSPE code of ethics clearly has the expectation that public safety, health and welfare must come first in any engineering decision. The suggestion is that risks should ideally be eliminated first through a consequential approach to any particular decision.

Safety
A process which limits the risk of an accident below an acceptable level.

Perlman and Varma (2002) described the rationale for the tragic decision in the Challenger shuttle disaster as the paradigm of all paradigm cases. They illustrated the case as being:

> Famous for indicating how the professional judgements of engineers – based as they are on positive calculation from scientific fact, may in some manner be supplanted by the professional judgements of managers – based as they are on positive calculation from shifting facts such as costs and schedules. (p. 45)

Risk assessment considers the probability or likelihood of some resulting harm. This can be difficult to do and may require arbitrary judgements to put a value on the magnitude of probability of the risk occurring. There is also the secondary result of a risk becoming an event. If, for example, a machine is judged to have, say, a 0.001% probability of failure, the result of failure may be purely economic and involve only the cost of replacing the faulty component. So the level of risk may be considered acceptable. But if the faulty component fatally injures a worker, is that level of risk still acceptable?

This example shows that the probability of an event occurring can be meaningfully quantified by calculation but that it is impossible to predict the outcome in real life due to the unpredictability of chance. Generally, when a risk involves subjects of high importance, such as the loss of human life, risk assessments need to be calculated more stringently. It is also interesting to note that risks tend to be re-assessed after accidents of high consequential result. One antidote for carelessness is the concept of *highly reliable organisation* (HRO) adopted by many successful engineering organisations. In such organisations there is a constant awareness of the possibility of failure and a resulting concentration on the complexity of the day to day problems. The consequential effect of this engineering culture is the quick response to incipient problems, open communication and a deep respect of the expertise of skilled staff. In such a culture, attention is given to the avoidance of concentrations of power and corruption by the existence of independent units within the organisation with countervailing powers.

In NASA there was no such HRO culture, and both shuttle disasters, and the Apollo disaster before it proved NASA's culture to be a lethal one. Sadly, it serves to illustrate ethical events as an experience for students to learn from, and the hindsight of such ethical decision-making examples can thus help to develop an ethical and moral perspective in a prospective engineering future.

Indeed, some of this decision-making will require some knowledge of ethics and in terms of value judgements and ethics, the decisions of all practising engineers may not always be the same. Such decisions and decision-making policy could possibly vary from one company to another by way of company policy and values, or by individual attitude and values. So what was Lund's professional obligation to both the company and to society? This study clearly illustrates some of the competing factors involved in the decisions an engineer might need to make and highlights the need for engineers to have a comprehensive understanding of their ethical responsibilities given that the consequences of their decisions can impact on people's lives.

Negligence

Failure to be sufficiently careful in a matter in which one has a moral responsibility to exercise care is *negligence*. Some careless mistakes are negligent, as for example when a surgeon sews up a patient with surgical instruments inside. Others are not, as when one spills coffee down the front of one's shirt.

Social responsibility versus legal liability

Over the last few decades litigation associated with engineering design has escalated enormously. One of the questions that have increased the intensity of debates is whether social responsibility or legal liability should have priority. Where do a design engineer and his or her company's responsibility end and the subcontractors, manufacturers and consumers begin?

The relationship between social responsibility and legal liability is complicated by the fact that quite often laws are only enacted after a disaster. How can an engineering company justify its actions based on current legal definitions? If a company's design has adverse affects on the public welfare, of necessity laws are enacted to ensure that appropriate safety standards are met in the future. At the very least, legal suits are filed so injured parties can be compensated and the culprits penalised. This phenomenon has become particularly critical regarding litigation involving engineering design and product liability.

The public has become increasingly aware that the benefits of industrial progress must be balanced against the growing need to protect the public from damages caused by some products and by-products of technology. Naturally, the spirited public debate puts engineers at the centre of the controversy between product safety and social responsibility on the one hand and legal liability on the other. This can lead a professional to a conflict in obligations.

Further examples of unethical decision-making

Technology has a human element, which can result in tragedies. Some of these tragedies can occur through unethical behaviour, or quite simply a lack of conscience. For example:

(a). *The Cave Creek Disaster*

A combination of poor workmanship, poor communications and not following the design led to the deaths of many tertiary students.

(b). *The Russian Submarine Disaster (Kursk)*

National pride and politics prevented the possible saving of lives.

(c). *The Chernobyl Incident*

The Chernobyl Nuclear Power Station killed many people, and could have been prevented by the engineers concerned. The result of this disaster is that technology is controlled with hindsight. We must strive to control technology with foresight.

(d). *The Space Shuttle Disaster*

The human element involved in the o-ring decision was that they had never been tested at zero degrees. Pressure brought to bear on engineering staff cost the lives of seven astronauts.

(e). *The Ford Motor Company's Pinto*

The executives made a decision that it was cost effective to pay the people who sued the Ford Motor Company, rather than fix an unsafe car that was causing people to be burned to death.

The realities of ethical conflict

Unethical and socially harmful industries have certain benefits to the staff employed and the investors:

- The pay benefits are usually typically higher than the normal market rate.
- The investment returns can often be above the industry average.
- These industries often offer employment in otherwise high unemployment areas.

Sometimes a company will be deliberately unethical in order to not miss an opportunity. The window of competitive advantage very often outweighs the time it would take to answer the difficult questions. Unfortunately, there can be serious career shortening consequences to workers who object to unethical practices within a company, and such staff are usually branded *whistle blowers.* Very often the accountability to management will outweigh any conscience and convictions of accountability to society.

However, society does have a say in these matters. Whenever it appears that any business is putting its interests, or those of its investors and owners, ahead of what people generally believe the business should be doing, the business as a whole can be labelled by society as unethical or socially irresponsible.

Conflict in obligations - whistleblowing

Whistleblowing can be viewed as a symptom of the struggle that engineers and other professional and non-professional workers have with conflicting obligations. A whistleblower is an employee who discloses information concerning abuse or neglect within an organisation for which he or she works, which, in the opinion of the whistleblower, harms or threatens public interest. In practice, whistleblowers are often punished by their employer while the abuse or neglect is allowed to continue. Consider the following dilemmas that an engineer could face as an employee.

1. An engineer is employed by a company who are knowingly dumping dangerous materials without permission in a manner likely to threaten the public and the environment.
2. An engineer is employed by a company that promotes a product by the publishing of false or highly misleading test data.

Questions to consider

1. How should we determine the engineer's and his or her company's social responsibility?
2. Is it their job to act as society's protector?
3. How did the instruction “Take off your engineering hat and put on your management hat” alter the weighting in the decision-making.
4. Could the engineer’s career prospects be an added weighting to the decision at this point?
5. Should social responsibility precede any discussion of legal liability?
6. Should a design engineer take every precaution to ensure that his or her company's product is safe before it enters the market?

Chapter 9
Codes of Ethics

Ethics in science and engineering

Theories and laws, many of which can be tested and proven experimentally, usually support the learning of science and engineering. However, the learning of ethics involves activities, ideas, cultures, relationships and meanings rather than objects and the theories which involve starting points for a discussion, would usually, in a more empirical discipline, be rejected as unverifiable. Engineering has many grey areas, where compliance is not necessarily compulsory, and profitability can drive companies, scientists and engineers into to shoddy or bad codes of practice. It is not intended one should conclude that scientists and engineers, as a group, possess low ethical standards. There may well have been engineers and scientists, who have behaved unethically or unprofessionally with regard to the interests of society, and to make mistakes is a human trait, but the objective of engineering practice is to improve the living standards of society rather than degrade it (Buckeridge, 2001).

> **Accountable**
> Can be used with a moral connotation, that one is morally required.
>
> More often it used to describe the fact that a person or organisation is required to answer to a particular party by some rules or organisational structure.

Nevertheless, there is a growing demand by our society of the need for a set of principles to which members of a profession can be held accountable, but the previous section has clearly shown that ethics is subjective, in that ethical decision-making will vary according to one's viewpoint. Such a viewpoint can be influenced through personal values, morality and upbringing, and also whether the decision-making is motivated by self-preservation (egoism), or the desire to serve the interests of others (altruism). One can also be influenced by the wider society including all forms of news and entertainment media. However, in industry and commerce, ethical decision-making is not always left to individual interpretation, and realistically, in a commercial or industrial environment a governing policy and accountability to the management may outweigh the moral convictions of accountability to society and the consumers.

Society now has an expectation of people being socially and morally responsible, and setting good examples of appropriate practices. Consequently, as Sir Norman Barry (1997), cited in Barnett, (2001) said:

> Because of their alleged privileged position, business enterprises are expected to go beyond the constraints of normal morality and to act positively for the public good, even if it should be very costly to them to do so. The pursuit of profit has to be legitimised by external moral criteria (p. A12).

Through such a growing awareness and demand in society for a set of principles in which members of a profession or industry can be held accountable, there is an expectation that professionals will serve employers, clients and the general public with integrity. Throughout industry and commerce most professional bodies now have codes of ethics that provide guidance in times of uncertainty. Most professional societies assist the members of their respective professions with any value-laden decision-making by issuing a set of guidelines by way of a code of ethics, giving their management and employees clear guidelines to the ethical decision-making process, which is organised to suit the best interests of the profession and the society it serves. Usually the associated professional body formally articulates these codes, which formalises the expectations of the professional in decision-making.

In recent decades there has been a widespread development of professional codes of ethics which are an expectation of the moral and ethical behaviour of professional people. Such responsible professional conduct should include client autonomy, justice, beneficence, honour and the avoidance of hurtful or illegal practice. These codes are generalised principles that provide a basis from which any dispute resolution can begin. A code of ethics is also intended to ensure that those with specialised knowledge and skills will use these skills properly, serving their employers or employees, or their customers and society, with integrity and loyalty. Essentially any professional code of ethics is based on a set of core values, and these core values are almost always subject to an overriding responsibility to the public interest, which may also include professional virtues such as veracity, integrity, public and client interests, fidelity, benevolence and humility. These professional guidelines are designed to assist practitioners and workers to become fully professional employers and employees, and responsible members of society.

The benefits of such codes of ethics include:

- The promotion of personal integrity.
- Clear standards to fall back on.
- Guidelines of acceptable behaviour towards employers, customers and other professionals.
- A benchmark of behavioural expectation for the public, employers and employees.
- A clear message to everyone in a profession of the standards expected.

While a code of ethics will almost certainly be formulated and laid down by the professional body to which a professional belongs, a code of ethics can also be prescribed by an employer. A company or institution staff member may not belong to a profession, and may be guided by the company code of ethics, whereas professionals may find themselves obliged by both professional and workplace codes.

The trend towards a code of ethics

Codes of Ethics, or Articles of Professional Conduct have evolved since the Hippocratic Oath for Physicians around the 5th century BC. In more recent times, professional codes of ethics originated in the fee-taking professions (Lieberman, 1994), and one could argue that the original Hippocratic Oath of doctors laid down what would now be seen as a code of ethics. The Hippocratic Oath was thus a code of conduct for a high level of professional honour, responsibility to the patient, and respect for the patient's private life (Haden-Guest, 1951). However, while both the medical profession and the engineering profession have codes of ethics, such codes are differentially binding, and while doctors are required to take a modern version of the Hippocratic Oath, scientists and engineers are not bound by such a formal oath.

Over the last sixty years the major professions have regulated their own affairs with varying degrees of outside interference or public scrutiny, and the internal focus of ethics was very often a matter of etiquette or professional conduct (Coates, 2000). Some less than generous people outside the profession accused the professions, that a code of ethics was designed to shield a profession rather than advocate professional responsibility to clients or society. In the 60s and 70s there was a move in the professions to codify professional behaviour and to eliminate the paternalistic views of the public, and this social transformation has probably been more pronounced in engineering more than in any other profession (Coates, 2000).

The professions and a code of ethics

A profession is a group of skilled people within an occupation that organise themselves into a formal body, not unlike a union, to serve the interests of its members and those of society (Davis, 2001). The research of Davis (2001) explains that a code of ethics usually appears when an occupation becomes a profession and it is normal for a profession to put their code of ethics into writing and formally adopt it at a general meeting of that society or professional body. A code of ethics is primarily a code of convention between professionals, and Davis believes that "a profession is a group of persons who want to cooperate in serving the same ideal better than they could if they did not cooperate" (p. 3).

An example of a code of ethics with these attributes is the code of ethics of the U.S. National Society of Professional Engineers (NSPE, 2002), which is available at http://www.nspe.org/ethics/eh1-code.asp. The clear intent of the guidance in the professional conduct of the members can be seen in this code of ethics, which attempts to cover all possible areas of value-laden decision-making within the profession.

The codes of ethics developed by some tertiary institutions are yet another instance of a code of ethics. Normally tertiary institutions have an Academic Statute to lay down rules specifically designed to influence the behaviour of staff and students, covering many areas such as plagiarism, dress and behavioural expectations on the campus. There are however, some areas where the decision-making process is not clearly defined, and interpretation of the law less clear, and although an employee's behaviour may be quite within the laws of the country, it could at

> **Conflict of interest** A person has a conflict of interest when in a position of trust, is required to make a decision on behalf of others, but also has interests or obligations that might interfere with the exercising of a fair judgement.

times be judged unethical by peers because of an apparent *conflict of interest*. For example, the behaviour of staff and students, while not illegal, can constitute a conflict of interest with the university. Consequently, tertiary institutions usually give quite clear directions in the expectations to staff and students through a code of ethics.

In this way, a code of ethics can quite clearly define the university expectations of the staff and outlines areas where a conflict of interest could arise. These conflicts are clearly laid out within the broad areas of working for another organisation, personal relationships with colleagues or students and the accepting of gifts.

An analysis of the codes that have been briefly outlined here illustrates an important point in relation to codes. This is that professional codes of ethics tend to be domestic and specific in nature. This situation can be explained by the fact that there are essentially two different types of ethical codes. Lieberman (1988) distinguishes between these two situations as where the professions tend to have a code of ethics formulated and laid down by its own professional body such as the NSPE, and the situation where workers who do not belong to a professional body have a code of ethics prescribed by their employer such as tertiary institutions and hospitals.

Ethics in commerce

Many engineers working in industry will find themselves involved in the commercial world of business. Ethics is now becoming and important feature of modern business practise (Randerson 1991; Hinchcliff, 1997).

The term *business ethics* can be used to mean acting in business in an honest manner, obeying the law and observing normal codes of practice (Randerson, 1991). While one would expect these rather narrow aims to be the minimum standard aspired to by commerce, most people can think of an example where business actions and decisions have fallen short of these ideals. Drake (1989, cited in Randerson, 1991) who worked as a Chief Executive Officer (CEO) in Australia in the l980s stated:

> The advanced thinking on ethics is that a company is not just there to make money; it is there to make money as an end product of serving society well. Corporations that do this in an ethical manner are the ones that will succeed over time, and create wealth and pass wealth from generation to generation, and be living evidence of creativity and a contribution to society. (p. 1)

Randerson (1991) believes that corporate responsibility tends to broaden the range of business concerns beyond mere conformity to the law, to the active promotion of practices that promote the well being of staff, customers and the wider community.

Contract
In ethics, a *contract* can be an explicit agreement, which is freely entered into. A *legal contract* is a legally binding agreement between two parties. Failure to fulfil a legal contract is called a *breach of contract*

It is common practice in New Zealand for many commercial or industrial organisations to have a mission statement, and quite often such a mission statement is available for public observation. Randerson (1991) views such public statements as a commendable step towards an ethical framework for such an organisation, but he expresses concern that very often such statements contain only a generalised commitment to excellence, quality and fairness. While such aspirations are commendable, Randerson (1991) believes that mission statements rarely give any specific direction as to what such concepts should mean in day-to-day practice, and hence, a set of more detailed working principles such as a code of ethics is required to give a more substantial content to the mission statement, and an understanding of how to put it into practice.

Engineering codes of ethics

The main thrust of this study is about engineering ethics, and this section now examines the concept of an engineering code of ethics, and the shift in the obligations upon engineering professionals over time. What was once a convention for gentlemanly conduct and company loyalty amongst a group of professionals has become a much more serious statement of intent regarding an engineer's obligation to public welfare and the risks that engineering have on the environment and Earth's resources.

The engineering obligations of a code of ethics

Engineering is considered to be a profession, and it is like other professions considered being self-regulating. Members of the profession in each country organise themselves into a professional association which normally adopts a code of ethics which is relevant to the profession, and membership is necessary for registration as an engineer.

A code of ethics is not a set of laws inscribed with divine wisdom in a stone tablet to be obeyed by all. A professional code of engineering ethics is a set of rules that is supposed to win the support of engineers. No law binds engineers to abide by the code of ethics of their professional organisation, such as the law legally binds lawyers. Nor do the obligations of an engineer rest on anything tangible such as a promise, vow or oath. The convention between professionals is not a contract, but without such a legal contract there is still an obligation to the profession, and Davis (1991), describes the responsibility of the professional code [emphasis added]:

> What lawyers call a *quasi-contract* or a contract implied in law: that is, an obligation resting not on an actual agreement (whether express or tacit) but on what is fair to require of someone given what he has voluntarily done, such as the benefits that go with claiming to be an engineer … no law binds all engineers to abide by their profession's code. (p. 4)

However, in terms of responsibility, Davis (1991) points out that it is common practice that anytime a party, including an engineer, enters into a contract, the legal responsibility appears in any contract signed, and the engineer's rights and responsibilities are defined with reference to the language of the contract.

As such, modern codes of ethics provide us with a guide, rather than hard and fast rules on what to do. Luegenbiehl, (1991, cited in Davis, 2001) complains, "there are no rules at all … the guides provide almost no guidance. All they do is remind engineers to look for some things" (p. 12). Luegenbiehl goes on to claim:

> Codes of engineering ethics, in their present form, should not be utilised as a set of rules … the attempt to provide such a set of rules is not justifiable … codes of ethics should be replaced by a set of guides for engineering decision making. (p. 11)

In effect, this makes a code of ethics a matter for one's private conscience, not a matter for majority vote. Even though modern engineering codes of ethics give precedence to public health, safety and welfare, when a conflict of interest arises, the decision-maker is to interpret the rules so that “the conflict disappears” (Davis, 2001, p. 14). Davis suggests that the codes should not be so complex that that they are complicated to interpret. They simply require a clear set of priorities. But clear priorities also have costs, among them being rigidity and complexity.

In terms of rigidity, Davis (2001) uses the United States Army as an example where the decision-making rules are usually quite clear. But the complexity issue is difficult. For example, to write a code of engineering ethics with enough detail to cover every eventuality would result in a lengthy and complex document.

Consequently, even long codes of ethics are relatively quite short compared with legal documents that attempt to cover every possibility in a decision-making process. So what is the specific intention of a code of ethics?

A code of ethics tries to provide broad generic, widely applicable, rules of behaviour or practice in a profession such as engineering. The coverage of every possibility in detail would be as complex as a legal document, but a code deliberately tries to take away the influence of context, and provides a set of broad guiding principles with a general principle of behaviour, regardless of the context of the particular issue facing the decision-maker. For example in the o-ring accident, it does not matter what pressure the engineer was brought under to launch, the code would hold the engineer to a principle of professional obligation. In this case, political pressure was a feature, or a weighted factor, where NASA wanted to launch before the President's state of the nation speech, and the decision was ultimately made in that context. It is not inconceivable that under other circumstances, or at another time, this political context would not be an issue, and the safety aspect would have influenced the engineer more strongly. The principle of a code of ethics is to decontextualise the issue, so that the political context of the decision would not be a feature that over-ruled safety.

The next section traces the origin of codes of ethics, and briefly outlines their development.

The origins of codes of ethics in the United States

The research of Perlman and Varma (2002) traced engineering codes of ethics back to the USA based Institute of Electrical and Electronic Engineers (IEEE), a professional organisation which prepared a code of ethics soon after its foundation in 1912, and which, after a great many revisions was finally adopted. According to Perlman and Varma (2002) this code of ethics was to stress *gentlemanly conduct* rather than concern for the public welfare: “traditionally the engineer was to be honest, impartial, avoid conflict of interest, not criticise a fellow professional, and not compete for commissions on the basis of price” (p. 41). Mitcham (1994) has also traced the origins of engineering codes of ethics in the United States, and states in his research:

> The early ethics codes in professional engineering - such as those formulated in 1912 by the American Institute of Electrical Engineers … and by 1914 by the American Society of Civil Engineers (ASCE) - defined the primary duty of an engineer to be of service as a faithful agent or trustee of an employing company. (p. 154)

This appears to be a deontological approach to the self preservation of the professional group or company as a whole, and Mitcham (1994) believes that what is missing from early codes is reference to the altruistic idea that engineers should have a responsibility for public health, safety and welfare of society. Herkert, (2001) disagreed, and dismissed Mitcham's claims as a popular myth. Herkert maintained that because the statement Mitcham quoted came first, it does not necessarily make it a primary claim. Herkert quoted much more of the same code of ethics in the ASCE code, and he surmised that the use of the phrase "avoiding conflict of interest" (p. 10) is consistent with, and may be interpreted as serving the public interest.

However, it is certainly evident that the early codes of ethics had a major emphasis centred on professional competence and confirmed integrity, while more recently, the changing social expectations have supported efforts within the engineering profession to turn the focus outwards.

The changing social expectations

As new technology has brought with new ethical dilemmas, the US Institute of Electrical and Electronic Engineers (IEEE) has begun to assume some responsibility for the uses and effects of technology, and to consider the inherent conflicts and tensions within modern technology (Varma, 2000). Accordingly, Perlman and Varma (2002) observed:

> There have been attempts to update engineering codes of ethics to correspond with modern engineering practice. In 1990, the IEEE adopted a new code of ethics for its members as a guide to ethical practice of engineering. The ten rules of conduct that comprise the IEEE code cover ethical topics that range from attending to the welfare of the public to concern for the professional development of colleagues. (p. 41)

The Santa Clara Declaration

Modern codes of ethics are now concerned with issues such as the environment and the sustainability of the Earth’s resources. Concerning this latter aspect, Thring (1992) maintained “we need a Hippocratic oath for all engineers and applied scientists, which will refer to their responsibilities for all the consequences of their work” (p. 224). Thring traced the concern for these responsibilities back to the Santa Clara Declaration, which appeared in the periodical Technology and Culture in April 1970. Thring (1992) cites the declaration:

> The undersigned Engineers and physical and social scientists, participants in the National Science Foundation Conference on ‘Engineering and the Technological Society’ at the University of Santa Clara, California, are concerned with the harmful impact of technology on environments, culture and values. We are particularly disturbed by the failure of Engineers and other professionals to exercise significant responsibility for the social consequences of technology. (p. 225)

Such was the concern about the social consequences of technology back in 1970, that 31 professors in attendance signed this declaration. The momentum for ethical behaviour was gathering at the time, and, as an example, in America in 1973 the IEEE produced a committee report on the social implications of technology. Unger (1973, cited in Thring, 1992) reported 18 fundamental canons in this report in the IEEE Newsletter. Rather than reproduce the report in its entirety, three significant recommendations are quoted that relate to the broader social issues whilst the others would be considered an engineer’s normal responsibilities [brackets added]:

1. The engineer has proper regard for the safety, health and welfare of the public in the performance of his [her] professional duties, and he [she] will regard his [her] duty to the public welfare as paramount by notifying the proper authority of any observed conditions, which endanger public safety and health.
2. The engineer does whatever is practicable to ensure the safety and reliability of products for which he [she] is responsible and accepts responsibility for personal errors.
3. The engineer makes a reasonable effort to inform himself [herself] as to the possible consequences, direct and indirect, immediate and remote, of projects he [she] is working on. (p. 29)

Modern ethical behavioural expectations in the engineering industry

An important objective in engineering is to improve society and its environment, and modern engineering embraces environmental issues such as sanitation, health, sustenance and transportation. However, the lifestyle of the world’s industrialised nations requires a high use of energy and the use of fossil fuels, together with the dangerous disposal of industrial chemicals and waste products has been such that the environment has gradually deteriorated, and this deterioration is evidenced by environmental changes such as water pollution, air pollution, acid rain and global warming.

For example, the Institution of Professional Engineers of New Zealand [IPENZ] (2001) state that:

> Although scientific debate continues about whether or not climate change and global warming are occurring, there is general agreement that the concentration of greenhouse gases in the atmosphere is increasing. In particular the concentration of carbon dioxide, a by-product of the combustion of fossil fuels, has increased by about 50 percent since the time of the industrial revolution. (p. 1)

These problems outlined by the IPENZ mean that, for the good of society and the sustainability of our resources, engineering education must include a global perspective on issues such as resource limitations, cultural contexts, environmental and social impacts, particularly with respect to engineering and technology.

Institution of Professional Engineers of New Zealand (IPENZ)

In New Zealand a code of engineering ethics is published by IPENZ, which is the professional body, representing professional engineers from all disciplines in New Zealand. The objectives of the institution are listed on their web site at http://www.ipenz.org.nz/ipenz/. The ethical objectives of the institution are to develop and promote ethical engineering practices benefiting the wider community.

IPENZ believes that the respect which the New Zealand society accords the engineering and technology professions in this country must be earned and maintained by its members, by the constant demonstration of a strong and consistent commitment to ethical values. IPENZ maintains a code of ethics which is particularly appropriate for engineers, and which is published for the information of the public. These ethical values include aspects of the relationship between technology and society such as a duty of care to protect life and to safeguard people, a commitment to society well-being and the sustainable management and care of the environment. This code (see Appendix A) is believed by IPENZ to be appropriate and responsive to the changing expectations of both society and the engineering profession and the global standards to which the institution subscribes.

These and other professional ethical commitments are additional to the obligations of which every member of society is accountable and required to observe, such as obeying the law, and reflect the additional responsibility expected of all professionals. IPENZ state that they enforce the code of ethics impartially. Vesilind and Rooke, (2001) point out that although codes of ethics state as their first canon comments along the lines of “the engineer shall hold paramount the health, safety and welfare of the public" (p. 162), there can at times be exceptions to this unequivocal statement, where an engineer may choose not to hold the health, safety and welfare of the public paramount. However, by the use of the word shall in the IPENZ canon the item is enforceable by IPENZ.

The problem with such a code of ethics is that it gives a decision-maker no weighting to the input. A complex decision will usually have a number of factors involved, and funding for example can be a factor, as in the case of the o-ring decision. A balance and the weight given to those factors in a particular situation can vary quite a lot, and a code of ethics can be quite stark in the framework, in that it may not show the reality of the situation in terms of such weighting. In hindsight, the ethical and moral aspects of a decision can be quite simple to interpret and offer an opinion, but when dealing with real-life complex situations, many factors may influence decisions. For example, it would be unlikely that anybody involved with the 1995 New Zealand Cave Creek disaster made their decisions for a bad reason, and it does not appear that there was any malicious intent, rather just that no one person took responsibility for the whole project. In fact, it is difficult to decide who was actually responsible. Alternatively, in the o-ring decision, the responsibility did come down to one person, and while a code of ethics should have helped with the decision, there were many factors that had to be weighed up by one person, and the weighting factors in Lund's mind may never be known.

Question to consider

1. How have the engineering codes of ethics moved from their original concept to a modern code of ethics? What is the change of focus?
2. Why has engineering been more exposed to public scrutiny than some other professions?
3. Who does the engineer serve? The client, the employer, professional colleagues, society, law, justice, nature?
4. What were the weighting factors in the o-ring dilemma?
5. Would an engineering code of ethics helped?

Chapter 10
Ethics in Engineering Research

Introduction

The ethics of research has been an important concern ever since the inception of the scientific revolution and this chapter gives a general guideline to the ethical aspects of research in engineering. The term *research ethics* is used broadly to include many ethically significant issues that arise in research, from fair apportionment of credit among members of a research team, to responsible behaviour in submitting or reviewing grant applications. Responsible research conduct also includes laboratory safety which is classed as a matter of research ethics. Furthermore, even though many governments and professional institutions have regulations regarding the treatment of human and animal research subjects, which may predate the increased attention and regulation of matters of research integrity, the responsible treatment of research subjects is still a matter of research ethics.

Any undergraduates or graduates considering undertaking a research project within a university need to check with their university for the *ethics approval* requirements of that university. When in doubt, ask a staff member or check the research section of the university website.

These concerns as to how one conducts research have been exacerbated in recent years through the publicity surrounding high-profile cases involving ethically questionable claims including recorded cases of misconduct and malpractice in research. The publicity surrounding cases of medical and scientific fraud, fraudulent claims of research, and the inappropriate or biased sponsorship of research have resulted in many facets of society becoming aware of the importance of research ethics and the need to address ethical problems in research. Consequently, research ethics is now an important and integral component in engineering education, and there are now strict procedures that must be followed within most research and educational organisations. A professional researcher will normally be required to observe the requirements of the code of ethics stipulated by the company or institution that employs them, and additionally, must also observe and adhere to ethical behaviour laid down by the code of ethics of the profession to which one belongs.

Furthermore, a university student who is engaged in an engineering research project within a university must observe expectations in the standards of behaviour and research conduct expected of the professional engineering association, any company they are associated with in the research and the university they are studying with.

Ethics approval in universities

It is standard practice in universities when involved in social research, that is qualitative or quantitative research that involves human participants, will require ethical approval from the university ethics approval committee *before the research commences*. Anybody undertaking a research project at a university which involves human participants, either as a student or a staff member, will need to establish the procedures and apply to the university's ethics approval committee in the university where they are researching for ethics approval. Comprehensive information and guidelines are offered at universities to assist researchers with information concerning the guidelines, procedures and application processes for acquiring ethics approval. If in doubt, ask for advice.

Universities require an application to be filled out early in the research process. Essentially, the ethics approval committee will require convincing that a researcher is competent and trustworthy to carry out research on humans. The application form requires many questions to be answered and researchers are expected to use a clear language that the committee will understand, without the excessive use of technical jargon.

The importance of the ethics approval is that when gathering research data involving people there may be ethical expectations and moral issues to be considered in advance. This can include a researcher's obligations with respect to those involved in, or affected by any investigations in the research.

Procedural research ethics

When conducting research there are certain ethical procedures which must be followed. There are many ethical issues which may arise in the process of research, and researchers are advised to consult other researchers or teachers when an ethical dilemma arises. Furthermore, many organisations may have a formal code of practice outlining the importance of conducting research in an ethical manner, while other organisations may have an informal expectation of such research practice. In either event, prospective researchers are expected familiarise themselves with such expectations. A code of ethical practice may cover some of the following concerns in research ethics that may be encountered by a researcher in the process of research procedure. As a general guideline, the concerns are divided into three areas; behaviour towards Human subjects, data collection and the presentation of research results (Cohen, Manion, & Morrison, 2000).

1. Standard of behaviour towards human subjects involved in research

When research involves people the following listed problems usually require careful consideration by the researcher if ethics approval to proceed with the research project is to be granted by an ethics approval committee in a learning institution..

1. Anyone asked to take part in a research project must know the identity of, and understand the background of the researcher.
2. The research problem to be investigated needs to be made clear to the participants and leave no mystery as to exactly what it is the research project will be looking for. The purpose of the research and the procedures must be fully explained to the subjects before any data collection takes place.

3. The participants must receive a thorough truthful explanation beforehand of any risks and dangers involved in the consequence of their participation in any research project and the researcher needs to have respect for vulnerability of some participants.
4. Participation in the research must be voluntary, or what is known as *informed consent* and it must occur as the result of free choice, without compulsion or obligation. Furthermore, the participants must give their informed consent to participate in the research by a signed agreement to participate, with a full understanding that they may withdraw from the project at any time, or complain of unethical behaviour during the research to a higher authority.
5. The nature of the participants, their relationship with the researcher, and any possibility of being disadvantaged by participating in the research should be carefully considered.
6. The researcher must respect the rights and privacy of participants, and needs to carefully consider the procedures to be adopted to avoid raising the anxieties of those researched.
7. The participants have the right to see the result of any data collection or interview transcripts that involved them and the participants should understand what is to be done with the data.
8. Any publication of the data must not cause the participants any embarrassment.
9. It is important to consider and preserve the interests, privacy and dignity of the participants.
10. The research participants must not be exposed to pain, physical or emotional injury, invasion of privacy, humiliation, physical or emotional stress.
11. The participants should not be identifiable or traceable when the results are made public, and the anonymity and confidentiality of the people researched must be preserved. If someone is referred to anonymously such a description must not be traceable.

2. Standards of practice in the collection of data

The collection of research data involves a substantial amount of careful planning and researchers need to very carefully consider the following points regarding the standards expected in the gathering of research data.

1. The nature of the research and the efforts required to obtain valid research data requires careful consideration and planning. Lack of planning can result in useless data and wasted time.
2. The methods of data collection must also be carefully considered in order to avoid the collection of invalid data.
3. The research needs to be full and adequate, and not just an interview with a few people who happen to agree with you. Similarly, when collecting test data, the data must be full and complete, and not just a presentation of selected results that happen to agree with your hypothesis.
4. The data collected may be commercially sensitive, confidential or highly personal to participants and arrangements must be considered for the continual security of the data until it is eventually destroyed.
5. Any issues and procedures pertaining to the copyright and intellectual property status of any material gathered in both the print and digital environments needs to carefully acknowledged and referenced.

6. The presentation of other people's work without reference, to be represented as your own work is plagiarism and must be avoided.

3. The presentation of results

In any research project a researcher has the right to academic freedom, which includes the university philosophy and ethos of openness and intellectual curiosity. Notwithstanding such a working culture, there are some guidelines that should be followed if the research is to be accepted as viable, trustworthy and authentic by the scientific and engineering community (Cohen et al., 2000).

1. Any research project report, presentation, dissertation or thesis must be presented in a professional manner that is befitting, and is expected by the profession, organisation or institution. This includes the use of modern word processors, publication, referencing and presentation techniques, including the professional production of all charts, tables and diagrams.
2. The research and any ethical consequences of that research should be seen from the research subject, the professional, organisational or institutional point of view.
3. Any research project report, presentation, dissertation or thesis should not contain inappropriate language, slang or colloquialisms. The report writing is expected to be of a high standard and quality normally expected in the scientific and engineering professions.
4. The researcher must take responsibility for maintaining any confidentiality.
5. Stringent efforts should be made to ensure that the research results are valid and trustworthy.
6. The evaluative procedures must ensure that the judgements in any conclusions are reasonable, and the research results do not contain unjustified suppositions or exaggerated, unproven and false claims.
7. It is critical that any evaluation of results is not made on irrelevant grounds such as superstition, race, religion or sexual orientations.
8. All researchers who participated in researching the project have the right to be acknowledged.
9. There should be no author or researcher credited with the project who did not contribute, or had no right to claim any ownership of the project.
10. Any information or work quoted or taken from another researcher, author, source or publication by either written or electronic means must be fully and properly referenced or credited. To take the writings, graphic representations or ideas of another person and represent them as one's own without proper referencing is known as plagiarism, which is a form of intellectual property violation.

11. Researchers must be familiar with the copyright laws of their country and strictly adhere to the requirements during the production of a research project, report, dissertation or thesis.

The expectations of professional conduct in research

A researcher is expected to produce or participate in trustworthy research, and produce trustworthy results. In practice a researcher may encounter everyday ethical issues that can arise in research, in which there is an expectation of the conduct of a researcher, which may in some organisations, be stipulated in the previously mentioned ethical code of practice.

In addition to such a code of practice, there are expectations of professional conduct in research. At all times during a research project, the professional behaviour of a researcher should be guided by the appropriate professional code of ethics, which may include a code of ethics stipulated by the organisation for which the research is being undertaken or sponsored by, and/or the professional code of ethics of the professional organisation to which the researcher belongs. In the case of an undergraduate student, the code of ethics of the profession to which the student aspires to belong should also be taken as a guide. These codes of ethics are an essential component of the constitution and make-up of professions, and although they may be quite vague in their prescriptions of ethical behaviour expected of professionals, these codes of ethics usually give general guidelines in ethical practice.

A Researcher must avoid any conflict of interest with a company or university, and is expected to have respect for property including university property and intellectual property rights. Furthermore, engineering researchers should understand that they are part of a wide socially and professionally responsible scientific and engineering community, which tends to have a very strong general consensus about what ethical values, behaviour and standards are acceptable within that community, and what is not acceptable. Researchers should familiarise themselves with these standards, and must at all times endeavour to share the ethical values and concerns, and the accepted practice of the scientific and engineering community. As an example of self regulatory behaviour in research, Jones (1994) offers researchers a self-restraint guide when using the Internet, a resolve never to send a comment that they would not be happy to have posted on their office door!

When undertaking research one is also expected to have a social and cultural sensitivity that is appropriate for the community in which the research is being undertaken. For example, in New Zealand a researcher is expected to have a sensitivity and commitment to the principles of the Treaty of Waitangi/Te Tiriti O Waitangi, and a sensitivity to the many cultures that make up the society of New Zealand.

Academic honesty and academic integrity

Normally an engineer begins the career path in a university environment, and should be well aware that behaviour such as cheating on examinations and lab reports, or the plagiarism of course papers and homework assignments are the most often cited violations of academic integrity or academic honesty.

In many respects, violations of academic integrity are indistinguishable from violations of research integrity and research outputs can be challenged either by society, or the scientific and engineering communities. The grounds for such criticism can include unfairness, impropriety, plagiarism, irrelevance or inaccuracy. Historically many researchers have received harsh criticism, occasional public ridicule and for a few, the unwanted attention of the Commerce Commission, the Fair Trading Act or legal prosecution by not following the socially and professionally accepted research standards of the scientific and engineering community.

While it is impossible to anticipate every ethical situation that might present itself as a problem during research practice, the general guidelines laid down in this chapter should be a useful guide. It is critical that when a researcher encounters an unfamiliar ethical problem during a research project, dissertation or thesis, that they ask for advice and assistance from their peers, supervisors or senior university staff.

Chapter 11
Student Project Engineering Case Studies

1 - Chernobyl

Chernobyl, Ukraine, 26th April 1986

On April 26th 1986 the number six reactor at the Chernobyl nuclear power station exploded as the result of reactor instability. Before the explosion the instability of the reactor had been increased when the staff maintaining the reactor violated operational safety rules by switching off the reactor protection system. The incorrect safety procedures led to a practically instantaneous catastrophic increase of thermal power resulting in a steam explosion during which the reactor and a part of the building were destroyed. Radioactive materials from the reactor core were expelled into the air and multiple fires formed both inside the reactor hall and on roofs of nearby buildings. An effort to control the damage was made in subsequent days, and a considerable amount of materials were thrown into the reactor well from helicopters to extinguish the burning graphite and suppress radioactive release.

The incident had a catastrophic toll on the surrounding community. Initially, thirty people, consisting of power station staff and members of the fire brigade died after receiving high doses of radiation, and there have been further subsequent deaths that are linked to the disaster. As a result of the disaster the entire population from the surrounding 30-km zone was evacuated. The contaminated area has been measured to be more than 130,000 sq. km, an area where approximately 4.9 million people lived before the accident.

The Chernobyl accident has had an impact on the nuclear energy policies and procedures in many countries, with some stopping their national nuclear energy programs altogether. In USSR the construction of new plants was frozen, and globally, public opinion was directed against nuclear power plants resulting in the closure of some plants. As a result of this incident, a substantial amount of international activity was initiated in the area of nuclear safety and nuclear emergency planning.

2 - Design defects in the Ford Pinto petrol tank

United States of America, 1970's

The Ford Pinto was a compact car built by the Ford Motor Company in the USA. In the 1960's Ford produced the Ford Pinto to compete in the American small-car market with Volkswagen and several Japanese compact cars. Ford designed and brought the Pinto into production in 25 months, a development period which was much less than the usually required period of

approximately 43 months. Before the assembly of the Pinto began, Ford engineers discovered a major design flaw, where in rear-end crash test collisions the Pinto's fuel system was found to rupture and catch fire quite easily. Because assembly-line machinery was already tooled when engineers found this defect, top Ford officials decided to proceed with the manufacture, exploding gas tank and all, even though Ford owned the patent on a much safer gas tank.

This serious design flaw in the fuel tank resulted in the deaths of many people, burnt to death in these cars as a result of rear-end collisions.

The Ford engineers had many opportunities to correct the faulty design of the Pinto, but as deaths and injuries continued to occur, Ford decided that it was not profitable to recall Pintos and argued for the delay in fixing the cars based on a cost-benefit analysis of altering the fuel tanks. Ford conducted a financial analysis on the Pinto and concluded that it was not cost-efficient to correct the design flaw.

3 - Cave Creek disaster

Paparoa National Park, New Zealand, 28th April, 1995

In April 1994, the workers of the New Zealand Department of Conservation (DOC) finished constructing a viewing platform, which was built out over a cliff at Cave Creek in the Paparoa National Park. The platform was built so that visitors standing on the platform could view the headwaters of the Cave Creek as it flowed from an underground cave system 40 metres below.

On the 28th April 1995 a group of students and tutors from the Tai Poutini Polytechnic in Greymouth visited the site as part of a field trip to study the limestone formations and caves in the area. At 11.25 am, as the 18 people moved onto the platform, the platform tipped over and fell down to land on the rocks of the creek-bed below. The people on the platform fell with it, killing 13 polytechnic students and the Department of Conservation employee.

It was later found that the plans for the platform had been designed and approved by people who did not have engineering or design qualifications. The onsite construction of the platform base had been carried out by a working party of DOC staff members. None of the group working on the platform was a qualified builder or engineer. The platform had been built separately and then flown in to Cave Creek by helicopter to be put in place, but the plans for the installation of the platform were not taken to the site, and so were not followed. The bolts which were supposed to tie the platform to the steps were taken to the site, but no drill was taken, so nails were used instead of the bolts. When the steps to the platform were poured some time later they were not secured properly to the platform. This concrete was supposed to act as a counter-weight for the platform to help hold it in place. The steel which was intended to tie the platform to the counterweight had disappeared, and no other steel was ordered or used.

A commission of inquiry found that the Department of Conservation had acted illegally and negligently in constructing the platform, and that there had been a series of mistakes that collectively had led to the collapse of the Cave Creek platform. The enquiry also pointed out that the Department had not been given enough resources to do its job properly. Due to the lack of finance it was found that many projects had been carried out within the restraint of limited budgets. DOC workers were quite used to making do with what materials and tools they had. The project had not met the requirements of the Building Act, which was being extended to cover government departments at the time the platform was being planned and built, there had been no building consent for the platform, and signs stating the maximum number of people to go on the platform at a time had not been put in place.

There were no prosecutions as a result of the deaths, but as a result of the enquiry, compensation of $2.6 million was paid out to the victims' families, and in the three months following the tragedy, 15 of DOC's 106 viewing platforms throughout New Zealand, were closed for repairs.

4 - The Hyatt Regency Hotel walkways collapse

Kansas City, Missouri, USA. 17th July 1981.

On July 17, 1981, the Hyatt Regency Hotel in Kansas City, Missouri, held a videotaped tea-dance party in their atrium lobby. With many party-goers standing and dancing on the suspended walkways, connections supporting the ceiling rods that held up the second and fourth-floor walkways across the atrium failed, and both walkways collapsed onto the crowded first-floor atrium below. The fourth-floor walkway collapsed onto the second-floor walkway, while the offset third-floor walkway remained intact. As the United States' most devastating structural failure in terms of loss of life and injuries, the Kansas City Hyatt Regency walkways collapse left 114 dead and in excess of 200 injured. In addition, millions of dollars in costs resulted from the collapse, and thousands of lives were adversely affected. The cause of the structural failure was found to be faulty engineering construction, which was at variance with the original engineering design.

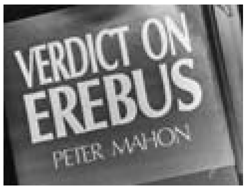
5 - DC. 10 Flight 901 aircraft accident

Mount Erebus, Antarctica. 28 November, 1979

At 12.59pm on 28th November 1979, an Air New Zealand DC10 collided with Mount Erebus in the Antarctica killing all of the 257 aboard, (237 passengers and 20 crew). The Mount Erebus disaster was New Zealand's biggest single tragedy, with one more death than in the 1931 Napier Earthquake.

The 11-hour sightseeing return flight to Antarctica had been operating since February, 1977, and took the passengers on a low-flying sweep over McMurdo Sound, returning to New Zealand on the same day. The flight was considered to be straightforward.

19 days earlier the pilots had attended a briefing session where they were shown the details of the proposed flight plan, which gave co-ordinates for the trip to Antarctica and across McMurdo Sound. This flight plan, when entered into the computerised navigation system, would be flown automatically by the aircraft. On the morning of 28 November the pilots Collins and Cassin entered the series of latitude and longitude co-ordinates into the aircraft computer. Unknown to them two of the coordinates had been changed earlier that morning, which changed the flight path of the aircraft 45 kilometres to the east.



At 12.30 pm when Flight 901 was about 70 kilometres from McMurdo Station, permission was given by the McMurdo radio communications centre to descend to 3050 metres and proceed visually. The actual air safety regulations were against dropping lower than a height of no less than 1830 metres even under good weather conditions, but Collins believed the plane was flying over low flat ground, and to give their passengers a better view Collins advised McMurdo Centre he was dropping to 610 metres. At this point he locked onto the computerised navigational system, but Flight 901 was not where either McMurdo Centre or the crew thought it was and the change in the two co-ordinates had put Flight 901 across Lewis Sound and towards the 3794 metre-high active volcano, Mount Erebus. The air was clear beneath the cloud layer and it is now thought that the white of the ice blended with the white of the mountain leaving no contrast to indicate visually to the pilots that land ahead was a mountain. This condition is known as a whiteout. At 12.49 pm the deck altitude device began to blare a warning to pull up, but there was no time for Collins to save the situation from disaster and six seconds later Flight 901 hit the side of Mount Erebus and disintegrated.

6 - Ballantyne's fire

Ballantyne's Department Store, Christchurch, New Zealand, 18 November, 1947

In 1947 the large Christchurch department store of J. Ballantyne & Co caught fire. At the time the store was open for business and including retail customers, there were more than more than 300 people in the store.

The fire was initially detected when smoke was seen coming from the cellar beneath the furnishing department, and a staff member was instructed to call the fire brigade and tell the owners.

The store was of a rambling nature, made up of seven smaller buildings linked together. There were no fire sprinklers, and the materials used to line parts of the building were wooden match lining and pinex, both of which were highly flammable. Consequently, once started the fire travelled quickly through the store. Eventually there were over two hundred fire fighters and twenty appliances fighting the blaze, but they were unable to make any headway against the fire. Parts of the complex were four storeys high and as some had no access to fire escapes, the fire fighters put up their ladders, but they were too short to reach the upper floor windows. Consequently forty one people died in the blaze.

A commission of inquiry into the disaster was conducted, but no definite cause of the fire could be found. However, the report of the commission pointed to two factors that had made the situation much more serious. Firstly, there had not been enough well-trained officers at the scene of the fire, and subsequently the attempts to rescue the trapped workers had suffered from a lack of co-ordination and leadership. The fire brigade officers had not recognised the potential danger of the fire soon enough to act effectively.

The buildings were unsafe, and did not meet city building regulations, even though they had passed a formal inspection four years earlier. Also it was found that the store management had not taken the risk of the fire seriously enough. There was no emergency evacuation plan and the staff had not been instructed on what to do in the event of a fire. There were no emergency alarms to alert staff, and no way of automatically contacting the fire brigade.

The commission recommended changes in fire prevention and fire fighting throughout New Zealand. It also recommended urgent changes to the building regulations and fire safety requirements to prevent another similar disaster.

7 - Tangiwai railway accident

Tangiwai, Central North Island, New Zealand. 24 December, 1953

On Christmas Eve 1953 the Whangaehu River flooded when the Wellington-to-Auckland express was due to cross the rail bridge at Tangiwai. The bridge collapsed as the train crossed it and 151 people died. 20 bodies were never recovered and were thought to have washed out to sea, 120 kilometres from the bridge.

When part of the wall holding the crater lake of Mount Ruapehu collapsed, a huge flood of water and silt, known as a lahar, flowed down the side of the mountain carrying uprooted trees, rocks and ice into the Whangaehu River. A resulting giant wave of water, mud and rocks 6 metres high hit and swept away one concrete support of the rail bridge at Tangiwai, almost 10 kilometres south of Waiouru.

By the time the express consisting of one engine, nine carriages and two vans, and travelling at about 60 kilometres per hour reached the bridge at 10.21pm, the Lahar had reached the bridge and washed out the central supporting pier. As the front of the train left the south bank, the bridge collapsed and the engine fell, with the momentum carrying it almost to the opposite bank of the river. The first five carriages followed, catapulting upwards before plummeting into the floodwaters. Four of these carriages were broken up by the force of the river waters, with little hope for passenger survival. The sixth carriage remained poised on the edge while a motorist Cyril Ellis and the train's guard, William Inglis, climbed in to warn the passengers and move them to the carriage behind. Soon the carriage broke free from the remaining carriages and fell into the river, where it rolled downstream before coming to rest. Ellis, Inglis and a passenger, John Holman, managed to get all the passengers, except for one, out through the broken windows and onto the side of the carriage from where they made their way to the bank as the floodwater level dropped.

Many passengers from the other carriages in the river struggled from the wreckage and made their way or were helped to the bank. Some were swept further downstream before being able to make their way ashore, and many were drowned or smothered by the thick silt in the river. Many bodies were swept out into the Tasman Sea never to be recovered.

A commission of enquiry found that the lahar or mudflow from Mount Ruapehu was responsible for the disaster, and after the collapse of the crater wall mountain crater lake level had dropped by 6-7 metres, meaning that approximately 2 million cubic metres of water had descended down the mountain into the river and would have hit the Tangiwai bridge with the force of a tidal wave. It is believed that the flooded river would have reached its highest point when the express train reached the bridge. More recent investigations revealed records that the bridge was actually weakened in 1925 by a lahar flow, and train drivers had observed a distortion in the bridge. Records also show that warnings by amateur geologists about the state of the crater wall had been ignored by the authorities.

8 - The Exxon Valdez oil spill

Alaska March 23, 1989.

The 987-foot oil tanker *Exxon Valdez,* the second newest in Exxon Shipping Company's 20-tanker fleet left the Alyeska Pipeline Terminal at 9:12 pm after loading 53,094,510 gallons (1,264,155 barrels) of crude oil, and was bound for Long Beach in California. Less than three hours later, the *Exxon Valdez* grounded at Bligh Reef, rupturing eight of its 11 cargo tanks and pouring 10.8 million gallons of crude oil into the Prince William Sound.

The actual amount of oil spilled in this accident does not rate in the top 50 of the world's largest oil spills, but this oil spill was the largest in U.S. history and covered over 3,000 square miles and over 350 miles of beaches with crude oil. The ecological damage was enormous as was the media coverage.

There were many contributing factors which contributed to the cause of this disaster. As the ship travelled through the shipping lane, an attempt was made to steer the ship between an ice flow and Bligh reef, when the vessel grounded on the reef.

The main issues with the cleanup operation occurred during the critical first few days of the accident. The main contributors to the ineffective cleanup were the inadequacy of the Alyeska Oil Company response and a gross lack of cleanup resources. The response of the Alyeska Pipeline Company was slow and it did not meet the contingency plan set out for an even such as this. Furthermore, the U.S. Coast Guard at the time were incapable of responding to an oil spill, and they did not have the necessary containment equipment in the area to immediately contain the spill.

During the first few days following the disaster, it became increasingly clear that no one in the area was prepared for an oil spill of the magnitude the Exxon Valdez presented them. When equipment did eventually arrive the spill was already well out of control. Due to the scale of the disaster at hand, the mechanical capabilities such as skimming and containment were overwhelmed, and the chemical possibilities also had severe limitations due to the weather in the area.

9 - The Bhopal tragedy

Bhopal, India 3rd December 1984

The Union Carbide company set up a pesticides factory in the rural province of Bhopal in India. In the early hours of 3rd December 1984, a highly poisonous gas called Methyl Isocyanate (MIC) leaked from the plant, and this toxic gas descended upon the surrounding city. It moved along the ground with the appearance of a thick fog, and as it passed through the streets it immediately killed 3800 people as they either slept or tried to escape after being woken by the sirens. It is now estimated that that between 150,000 and 600,000 people were seriously affected by the gas in the immediate periods of a few days, and over 20,000 of those people affected have died in the years that followed.

Following the disaster, there have been several investigations conducted in an attempt to determine the cause of the accident. The Union Carbide company maintains that the gas release was due to an act of sabotage, but this claim has never

been substantiated with any proof. There have been accusations concerning the safety at the plant, which was subsequently shut down after the disaster and abandoned by Union Carbide. The effect from the Union Carbide pesticides plant still continues to pollute the area and no one has been held accountable for the disaster or the clean up of the mess that still remains. There are still tonnes of toxins stored in warehouses on the site which are slowly seeping deep into the ground which has the effect of poisoning the water table.

The reported health effects on the people in the area who survived the inititial disaster of 1984 have been serious, with the poisoning by the groundwater thought to be causing aches and pains, rashes, fevers, eruptions of boils, skin complaints, headaches, nausea, dizziness, exhaustion and lack of appetite. These poisons are also known to cause birth defects in children, and the deposits of lead, mercury and organ chlorines found in the milk of nursing mothers living near the factory has had a serious effect on the health of young babies.

Today, some estimates of those afflicted with illnesses since the 1984 disaster place the number above 500,000 people, and many survivors say they have yet to receive compensation. Critics of the cleanup effort at the site also say that the area still remains a source of lethal toxins.

10 - The Titanic disaster

Atlantic Ocean, 1912

In 1912 the largest liner ever built at that time, the new 46000 ton White Star Liner Titanic was on her maiden voyage from Southampton to New York when the ship struck an iceberg at 11.40 pm. As a result of the collision the ship sank approximately two hours later with the loss of 1517 lives of passengers and crew. Of the 1324 passengers and 899 crew members, only 706 people survived the disaster. The Titanic's crew had received several ice warnings from other ships in the area, and when approaching the iceberg danger zone, the crew kept the Titanic on course at full speed. The night was crystal clear with a calm sea, and with no moon it was very difficult for the ship's lookouts to see an iceberg without waves breaking around an iceberg's base leaving a wake. At 11.40pm crew in the crow's nest rang the crow's nest bell three times to indicate to the bridge that something lay directly ahead.

The bridge officers at the time signaled the engine room to proceed full speed astern. The order was then given hard a starboard. The ship gradually responded to her helm and began to turn to port, eventually striking the iceberg on the side of the ship. As the iceberg glided by, it broke iron rivet heads fastening the steel shell plates causing massive leakage below the waterline. The watertight doors were closed which sealed each of the liner's sixteen compartments, but the first six watertight compartments were opened to the sea and began flooding uncontrollably. The flooding in water tight compartment number six was controlled by the engine room pumps, but the sheer weight of water, in the first five compartments, drew the liner’s bow down. A critical design flaw in the ship was that the watertight compartments not reach high enough and allowed water to flow from one compartment into another such that the sinking of the ship became inevitable.

The Titanic could carry a maximum of 3,500 passengers, and although there were not enough lifeboats to save all the souls on board, the number of boats carried by Titanic actually exceeded the Board of Trade's requirements regarding lifeboat capacities, which were based on a liner's gross tonnage. However, these requirements had not kept pace with the ever increasing size of passenger liners and their ability to carry huge numbers of passengers.

11 - The murders of Harvey and Jeanette Crew

Pukeawa, New Zealand, 1970

This is one of the most famous murder cases in New Zealand history. In June 1970 evidence of the gruesome murders of Harvey and Jeanette Crew were discovered in their Pukekawa farm house, with their baby being the only person remaining in the house. The story thrust Pukekawa into the national headlines, and the bodies were found some time later in the Waikato River. The police involved in the investigation suspected a neighbour of the Crews, a local farmer Mr Arthur Thomas, and to secure a conviction it is believed that they planted evidence. Arthur Thomas was jailed for the killings and served over nine years in prison. Thomas underwent two trials and was convicted both times, followed each time by an unsuccessful appeal, and finally an unsuccessful appeal to the Privy Council. In 1980 a British author David Yallop investigated the crime and published his beliefs in the book *Beyond Reasonable Doubt*. The book was a best seller, in which Yallop and others believed that Arthur Thomas was the victim of mistrial to say the least, and a frame-up to say the most. When scientific proof of the plantings was revealed, an enquiry found that Arthur Thomas had been wrongly convicted and he was eventually pardoned by the Governor-General on 17 December 1980. He was later awarded almost $1 million in compensation. The story was made into a film in 1981 called *Beyond Reasonable Doubt*.

12 - The assassanation of John F. Kennedy

Dallas, Texas, 1963

John F Kennedy was elected the thirty-fifth President of the United States in 1960. On Friday, November 22, 1963, in Dallas, Texas, USA at 12:30 pm Kennedy was fatally wounded by gunshots while being driven a presidential motorcade through the streets of Dallas.

An official investigation by the Warren Commission was conducted over a 10-month period, and its report was published in September 1964. The Commission concluded that the assassination was carried out solely by Lee Harvey Oswald, an employee of the Texas School Book Depository in Dealey Plaza. This conclusion initially met with widespread support among the American public, but polling in recent years shows a majority of the public now hold beliefs contrary to the Commission's findings.

There is now evidence that scientific evidence was destroyed, and in some cases deliberately misinterpreted. An official investigation conducted by the House Select Committee on Assassinations from 1976 to 1979 concluded that Kennedy was assassinated by Oswald, probably as a result of a conspiracy. More recent enquires suggest the unlikelihood of Oswald firing all the shots while others wonder if he actually fired any at all. The assassination is still the subject of widespread speculation, and has spawned a number of Kennedy assassination theories. The different theories place suspicion upon several groups ranging from the Mafia to the CIA, and one investigator even accuses the succeeding President Lyndon B Johnson of being involved in the conspiracy with a consequent cover-up of scientific evidence relating to the case.

13. The Love Canal:

New York State 1892 -1978

The Love Canal is a neighbourhood in the southeast district of the City of Niagara Falls and takes its name from the failed plan of nineteenth century entrepreneur, William T. Love. Approximately four miles upstream of Niagara Falls, Love began digging a canal to harness water to generate power to the industries developing along the seven mile stretch of the river to the mouth of Lake Ontario which would provide ships with a route to bypass the falls.

A few years later Love abandoned his project with only one mile of the canal having been dug.

The Love Canal remained as a recreational area for swimming and boating well into the early 20th century.

In 1920, Love's land was sold and became a municipal and chemical disposal site. From 1942 through 1953, the Love Canal landfill was used principally by Hooker Chemical, one of the many chemical plants located along the Niagara River, and nearly 21,000 tons toxic chemicals were dumped at the site.

In 1953 Hooker covered the site with layers of dirt and the Niagara Falls Board of Education purchased the Love Canal land from Hooker Chemical for one dollar. Included in the deed transfer was a warning of the chemical wastes buried on the property and a disclaimer absolving Hooker of any further liability.

Single-family housing surrounded the Love Canal site and as the population grew, the 99th Street School was built directly on the former landfill. At the time, homeowners were not warned or provided information of potential hazards associated with locating close to the former landfill site. By 1978, the neighbourhood included over a thousand low-income homes and apartments, and the 99th Street Elementary School located near the centre of the landfill. Two other schools, 93rd Street School and 95th Street School were also considered to be part of this neighbourhood comprised of working class families. By this time, many residents were beginning to question health risks and noting already existing inexplicable health problems.

In August 1978, a medical state of emergency was declared at Love Canal and the 99th Street School was closed. Pregnant women and children under the age of two who lived in the immediate surrounding area of the Love Canal were evacuated, and immediate cleanup plans were initiated. President Carter declared the Love Canal area a federal emergency and funds were provided to permanently relocate the 239 families living in the first two rows of homes encircling the landfill. The remaining 10 block areas of the Love Canal were not included in the declaration.

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Appendix A - IPENZ Code of Ethics (2005)

The respect which society accords the engineering professions is earned and maintained by its members demonstrating a strong and consistent commitment to ethical values. These commitments are additional to the obligations, which every member of society is required to observe, such as obeying the law, and reflect the additional responsibility expected of all professionals. It therefore follows that the institution must maintain an appropriate code of ethics, to publish it for the information of the public and to enforce it impartially. This code must be responsive to the changing expectations of both society and the profession and the global standards to which the institution subscribes.

The code of ethics is based on the five fundamental ethical values set out in rule four of the institution as follows:

Protection of life and safeguarding people.

Sustainable management and care for the environment.

Commitment to community well-being.

Professionalism, integrity and competence.

Sustaining engineering knowledge.

The code consists of three parts. The first is a set of five fundamental ethical values. These values are intended to inform members of the high ideals of professional life. Part two provides expanded guidelines. These guidelines are not exhaustive - they are offered as a guide to the understanding and intentions of part one. They should be read with part one as a whole and given a free and liberal meaning. They range from exhortations to excellence to prescriptive directions as to what constitutes ethical professional behaviour. Part three sets out the minimum standards of behaviour against which the behaviour of members will be judged in terms of deciding if they have reasonably complied with the requirement in rule four of the institution to behave ethically.

Members will find in the three parts assistance in deciding the proper response to most of the situations they will meet in their professional life. In the final analysis, the judgement of the member's peers as to what the `reasonable professional' would have done faced with the same situation and applying the same provisions in part three will prevail.

The institution may issue information such as definitions of terminology to further assist members interpret the code. Such information does not form part of the code.

Part 1 - Values

Protection of life and safeguarding people: Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

Professionalism, integrity and competence: Members shall undertake their engineering activities with professionalism and integrity and shall work within their levels of competence.

Commitment to community well-being: Members shall recognise the responsibility of the profession to actively contribute to the well-being of society and, when involved in any engineering activity shall endeavour to identify, inform and consult affected parties.

Sustainable management and care for the environment: Members shall recognise and respect the need for sustainable management of the planet's resources and endeavour to minimise adverse environmental impacts of their engineering activities for both present and future generations.

Sustaining engineering knowledge: Members shall seek to contribute to the development of their own and the engineering profession's knowledge, skill and expertise for the benefit of society.

Part 2 - Guidelines

Protection of life and safeguarding people: Members shall recognise the need to protect life and to safeguard people and in their engineering activities shall act to address this need.

Under this clause you should have due regard to:

1.1 Giving priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.

1.2 Ensuring that reasonable steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

1.3 Drawing the attention of those affected to the level and significance of risk associated with the work.

Professionalism, integrity and competence:

Members shall undertake their engineering activities with professionalism and integrity and shall work within their levels of competence.

Under this clause you should have due regard to:

2.1 Exercising your initiative, skill and judgement to the best of your ability for the benefit of your employer or client.

2.2 Giving engineering decisions, recommendations or opinions that are honest, objective and factual. If these are ignored or rejected you should ensure that those affected are made aware of the possible consequences. In particular, where vested with the power to make decisions binding on both parties under a contract between principal and contractor, acting fairly and impartially as between the parties and (after any appropriate consultation with the parties) making such decisions independently of either party in accordance with your own professional judgement.

2.3 Accepting personal responsibility for work done by you or under your supervision or direction and taking reasonable steps to ensure that anyone working under your authority is both competent to carry out the assigned tasks and accepts a like personal responsibility.

2.4 Ensuring you do not misrepresent your areas or levels of experience or competence.

2.5 Taking care not to disclose confidential information relating to your work or knowledge of your employer or client (or former employer or client) without the agreement of those parties.

2.6 In providing advice to more than one party, ensuring that there is agreement between the parties on which party is the primary client, and what information may be shared with both parties.

2.7 Disclosing any financial or other interest that may, or may be seen to, impair your professional judgement.

2.8 Ensuring that you do not promise to, give to, or accept from any third party anything of substantial value by way of inducement.

2.9 First informing another member before reviewing their work and refraining from criticising the work of other professionals without due cause.

2.10 Upholding the reputation of the institution and its members, and supporting other members as they seek to comply with the code of ethics.

2.11 Following a recognised professional practice (model conditions of engagement are available) in communicating with your client on commercial matters.

Commitment to community well-being:

Members shall recognise the responsibility of the profession to actively contribute to the well-being of society and, when involved in any engineering activity shall, endeavour to identify, inform and consult affected parties.

Under this clause you should have due regard to:

3.1 Applying your engineering skill, judgement and initiative to contribute positively to the well-being of society.

3.2 endeavouring to identify, inform and consult parties affected, or likely to be affected, by your engineering activities.

3.3 Recognising in all your engineering activities your obligation to anticipate possible conflicts and endeavouring to resolve them responsibly, and where necessary utilising the experience of the institution and colleagues for guidance.

3.4 Treating people with dignity and having consideration for the values and cultural sensitivities of all groups within the community affected by your work.

3.5 Endeavouring to be fully informed about relevant public policies, community needs, and perceptions, which affect your work.

3.6 As a citizen, using your engineering knowledge and experience to contribute helpfully to public debate and to community affairs except where constrained by contractual or employment obligations.

Sustainable management and care of the environment:

Members shall recognise and respect the need for sustainable management of the planet's resources and endeavour to minimise adverse environmental impacts of their engineering activities for both present and future generations.

Under this clause you should have due regard to:

4.1 Using resources efficiently.

4.2 Endeavouring to minimise the generation of waste and encouraging environmentally sound reuse, recycling and disposal.

4.3 Recognising adverse impacts of your engineering activities on the environment and seeking to avoid or mitigate them.

4.4 Recognising the long-term imperative of sustainable management throughout your engineering activities. (sustainable management is often defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs).

Sustaining engineering knowledge

Members shall seek to contribute to the development of their own and the engineering profession's knowledge, skill and expertise for the benefit of society.

Under this clause you should have due regard to:

5.1 Sharing public domain engineering knowledge with other engineers so that the knowledge may be used for the benefit of society.

5.2 Seeking and encouraging excellence in your own and others' practice of engineering.

5.3 Contributing to the collective wisdom of the profession.

5.4 Improving and updating your understanding of the engineering and encouraging the exchange of knowledge with your professional colleagues.

5.5 Wherever possible sharing information about your experiences and in particular about successes and failures.

Part 3 – Minimum standards of acceptable ethical behaviour by members

General obligations to society:

1. Take reasonable steps to safeguard health and safety
A member must, in the course of his or her engineering activities, take reasonable steps to safeguard the health and safety of people.

2. Have regard to effects on environment

A member must, in the course of his or her engineering activities, —

(a) have regard to reasonably foreseeable effects on the environment from those activities; and
(b) have regard to the need for sustainable management of the environment.

(b) In this context, **sustainable management** means management that meets the needs of the present without compromising the ability of future generations (including at least the future generations within the anticipated lifetime of the end products and by-products of activities) to meet their own reasonably foreseeable needs.

3. Act with honesty, objectivity, and integrity
A member must act honestly and with objectivity and integrity in the course of his or her engineering activities.

General professional obligations

4. Not misrepresent competence

A member must —

(a) not misrepresent his or her competence; and

(b) undertake engineering activities only within his or her competence; and

(c) not knowingly permit engineers whose work he or she is responsible for to breach paragraph (a) or paragraph (b).

5. Not misrepresent membership status
A member must not (in connection with a business, trade, employment, calling, or profession)

make a false or misleading representation, or knowingly permit another person to make a false or misleading representation, that services are supplied by a member of the institution.

6. Inform others of consequences of not following advice.

(1) A member who considers that there is a risk of significant consequences in not accepting his or her professional advice must take reasonable steps to inform persons who do not accept that advice of those significant consequences.

(2) In this context, **significant consequences** means consequences that involve —

(a) significant adverse effects on the health or safety of people; or
(b) significant damage to property; or
(c) significant damage to the environment.

7. Not promise, give, or accept inducements

A member must not —

(a) promise or give to any person anything of substantial value intended to improperly influence that person's decisions that relate to the Member's activities; or

(b) accept from any person anything of substantial value intended to improperly influence his or her professional engineering decisions.

Obligations to employers and clients

8. Not disclose confidential information

(1) A member must not disclose confidential information of an employer or client without the agreement of the employer or client.

(2) Subclause (1) does not apply if—
(a) the failure to disclose information would place the health or safety of people at significant and immediate risk; or
(b) the member is required by law to disclose that information.

9. Not misuse confidential information for personal benefit
A member who obtains another person's confidential information in connection with one purpose in the course of his or her engineering activities must not use that information for another purpose that is to his or her own personal benefit.

10. Disclose conflicts of interest
A member must disclose to an employer or client any financial or other interest that is likely to affect his or her judgement on any engineering activities he or she is to carry out for that employer or client.

Obligations owed to other engineers:

11. Not review other engineers' work without taking reasonable steps to inform them and investigate.

(1)A member who reviews another engineer's work for the purpose of commenting on that work must take reasonable steps to —
(a) inform that engineer of the proposed review before starting it; and
(b) investigate the matters concerned before commenting.

(2) Subclause (1) does not apply if taking those steps would result in there being a significant and immediate risk of harm to the health or safety of people, damage to property, or damage to the environment.

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