Constructing a Culturally Empowering Mathematics Learning Environment for EFL Engineering Students

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This thesis is presented for the Degree of Doctor of Mathematics Education of Curtin University of Technology

November 2010
Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any person except where due acknowledgement has been made.

Signature: [Signature]
Date: 2021-01-01
Abstract

The emergence and evolution of constructivism since the early 1980’s has provided education and educational research with a new paradigm. The acceptance of this viewpoint has allowed educators greater scope as the criterion of epistemological and ontological truth / reality has been replaced by the more pragmatic approach of (practical) viability. This approach has, in turn, freed teachers to offer learning experiences which are useful and relate to previous experience and understanding of students rather than presenting rigorous and epistemologically correct information dissemination experiences.

One area that has embraced constructivist principles in an effort to provide more relevant and cosmologically pertinent learning experiences has been the profession and learning of engineering.

This thesis examines how engineering teachers can provide relevant learning experiences that recognize and connect with student past learning experiences and which meet the needs of modern learners, such as engineers, and in doing so develop these learners as problem solvers, communicators and team players who are aware of the wider implications and issues pertinent to the 21st century.

In addition to looking at the problems faced and at how this researcher believes some of the issues can be resolved at the classroom and faculty level it also maps out the emergent transformative journey of this teacher-researcher that has emerged in the doing of this research, as I progress from what has been termed teacher mastery in the technical domain of human interest to what I perceive as the emancipatory.
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- Over what levels does the value of mathematical competence extend?

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Introduction

An Introductory Conclusion

It might seem strange that I begin with a conclusion. It certainly seems strange and somewhat disconcerting to me given that I was educated in a primarily positivist, objectivist culture, trained as a young teacher in the Tylerian tradition (Tyler, 1950) of setting out my curriculum / lesson plans with very specific goals and objectives, and structured linearly with very definite introductions, bodies and conclusions. That I should now put this aside may be disconcerting, but to do otherwise would be inaccurate and non-representative of the feelings, emotions, values and experiences that I wish to convey. This is because I have come to realize during the course of this research that the reality of my experience is far from linear and is hardly explicable though explanations or diagrams of cause and effect. Indeed, every idea I have triggers multiple recollections, all of significant value to me, my life and to this research. Rather than linear, if I had to describe the experiences generated by this research, at best I could call them cyclic or recursive (Doll, 1993). Sometimes they seem almost chaotic, but within that chaos I sense and sometimes almost successfully reconstruct some kind of order (Prigogene, 1996). Sometimes, I offer this newfound order as part explanation and description of this research, and sometimes I tear it down as I try to further understand and explain more clearly. In very many ways it is the construction of this order that now motivates this research and generates the enrichment of great personal experience or transformation that I sense I am undergoing. As a consequence of doing this research I have changed greatly and believe I will continue to change. I’m sure I always have been changing, but now I have a sense of recognition and of being that I didn’t have before.

This is my reason for beginning with a ‘conclusion’, although the term is not really used correctly here, at least not from the classical empiricist tradition. I have been working on this research for a significant number of years and I can’t see it ever ending. It has become my labor of love. When, at times, it becomes onerous I stop and reflect upon what I have done (Schon, 1990) and eventually refresh myself with what I see are new insights. Even when I finally hand something across as a
dissertation I know it will be like this ‘conclusion’, a temporary pause to explain myself before I move on (or at least come back around).

The idea I am trying to convey here is that I have changed enormously since commencing this research and so has the research. There have been times when I wanted to pull it all apart, throw it away and start again. But I believe that would be a mistake. So much of this research now is about my personal transformation, about how this research has changed me and, I believe, made me richer as an educator and as a man. I keep some of my meanderings for this reason. Others no reader will ever see.

As you will see from the introduction in Chapter 1, my goal in doing this research was to develop a teacher training resource to assist many teachers in my area (subject and geographic) who are in need of professional development support. I had been recognized and rewarded as a good teacher and felt this was not an unreasonable place to start a doctoral study. As an unfolding part of my study I began to question my practice. Was I such a good teacher or was I just good at adapting to my specific environment? Perhaps, like Erlwanger’s Benny (Noddings, 1990), my methods were, while meeting my own needs, limited in their scope and applicability within a larger frame of reference. I began to test my ideas and actions and ask further questions of myself, my students and my teaching colleagues.

What I found out later was that, whereas my methods were applicable and well received within my frame of teaching reference, there were pertinent questions to be asked about the modernist frame of my teaching reference (Ernest, 2000; Schon, 1991; Slattery, 1995). It was at about this stage that I questioned my motives and approach even more deeply as I recognized significant similarities between my goal of constructing an effective mathematics learning environment for EFL students’ and Fredrick Taylor’s efficiency (time and motion) studies with a ‘good man’ named Schmidt (Doll, 1993). My similarities to Taylor, and indeed Schmidt, made me question my motives and understandings even further, and after discussion with my mentor and supervisor, Dr Peter Taylor, I decided to change the title and goal of my research to constructing a culturally empowering mathematics learning environment for EFL students. While this answered a lot of personal questions as to what I was doing and why I was doing it, I had a conflict of interests. While I have a very deep,
if sometimes unstable personal philosophy, as a practicing teacher I am aware of the huge gap that exists between most educational research and its actual execution (a good choice of the word, in my opinion) in the classroom.

At that stage, still strongly influenced by my modernist paradigm, I still wanted to produce something useful and applicable that my teachers could use day to day. As a matter of fact, I still do. But my problem was that I had become aware of the limitations of my modernist paradigm and its possible negative impact on teaching and learning, and, in my viewpoint, on our culture and our global environment. As a consequence I was placing myself across two conflicting paradigms or their derived cultures. I was thinking in many ways as one embracing a post-modernist philosophy but I was still conditioned to act and evaluate using ingrained modernist approaches and values.

Driven by the ongoing need to do my job as a mathematics lecturer and meet the expectations of my employers and my clientele at The Petroleum Institute, Abu Dhabi, I had (and still have) adopted the working philosophy of the pragmatist which will be evident in the upcoming chapters of this work. It becomes clear as this thesis progresses that I adhere to the constructivist guiding principles of eclecticism and viability (Cobb, 1992; Ernest, 1991; Taylor, 1998; Tobin, 1993; von Glasersfeld, 1995); and that while I do not fully discount the existence of an objective reality (somewhere out there and in here), I believe I have no way of ever identifying what it is – to me, the very act of identification or recognition is subjective.

Consequently, my beliefs and my practices, as you shall see, are post-epistemological and ontologically neutral. I have no need of a deep theoretical foundation for what I see as knowledge and I have no desire to determine what I think and do as ‘real’ in terms of an objectively defined reality. What I understand and what I do is real if it meets my criteria of viability, namely, if it does what I would like it to do.

This perspective of course, generates problems and contradictions if one sees oneself as traversing two apparently conflicting paradigms and their subsequent cultures of interpretation and practice. One such area of philosophical and practical conflict
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arises with respect to the research questions which I initially phrased and depicted in modernist and objectivist terms.

1. What am I really trying to teach in Foundation Mathematics?

2. What are the perceived benefits for my students of learning the mathematics we teach at the Petroleum Institute?

3. What is mathematical competence in the context of my students and in the eyes of my colleagues at the Petroleum Institute?

4. How do I define and measure the mathematical competencies of my students and my colleagues?

5. Do I hold the same professional beliefs and values as my teaching colleagues and administration at the Petroleum Institute? Is my interpretation of mathematical competence the same as that held by my colleagues and/or my students?

6. Over what levels ‘of being’ does the value of mathematical competence extend?

7. What innovative pedagogical practices - teaching strategies and management protocols - employed by this Foundation Mathematics teacher are culturally empowering for both me and my students?

8. What beliefs and values are manifested through the learning of mathematics?

9. How do cultural differences – ethnic, gender, generational, socio-economic – influence the effectiveness of teaching and learning strategies? What strategies can be adopted to produce successful cultural border crossings?

10. How can educational technologies, such as graphics calculators, computers, the world-wide web, assist the process of constructing an empowering learning environment?
It is clear to me now that I cannot come up with one correct and illuminating answer for any of these questions. At best I can record and report the opinions of my many stakeholders, including my own and leave it to my readers to draw their own conclusions. At this stage of my transformative journey I envisage such a report as comprising a number of stakeholder responses to these and other related questions as extracted from interviews and questionnaires.

By working and reporting in this way I am claiming my right to work across two (or more paradigms) in a complementary and epistemologically plural way rather than in a conflicting manner (Cronje, 2000; Dawson, 1999). I am pragmatically recognizing the need to work and communicate ideas and actions using objectivist modernist definitions and processes while emerging from this paradigm towards a postmodern world of greater context, variability, learner empowerment and emancipation.

This, for me, is a process of great jubilation, of my own liberation and empowerment as a teacher learner. It is a coalescing, a convergence, a sense of coming back to somewhere I once began, with a greater sense of awareness and understanding. So much of what I read, see, experience is coming together with past questions and experiences to validate what I am doing, and at the same time to generate more perturbations in the form of newer subtler questions.

While I believe in infinity and eternity and that I have always been, I can trace what I am experiencing now as a teacher-learner back to the early 80’s when, as a fledgling Mathematics and Science teacher and as an inexperienced husband, I had to assimilate and accommodate a wide range of new stimuli into a life that had previously seemed fairly uncomplicated. In addition to developing a professional philosophy that fitted with my personal experiences, I was searching for an explanation and a solution to a quite unexpected, influence on our lives, the onset of a chronic and debilitating illness within my wife. The inability of Western medical science to diagnose my wife’s problem had forced us to turn to Eastern philosophy, meditation and diet. As students of karate-do this was not a big step for either of us, but for someone schooled in a Western scientific manner (educated in very much a European / Greco Roman tradition of dualism and reductionism), I did have questions I needed answered and so I read widely on the subject to connect what we were attempting (in many ways successfully) to what I had previously believed.
The two most memorable books I read from this period were ‘The Dancing Wu-Li Masters’ (Zukav, 1980) and ‘Tao of Physics’ (Capra, 1975). I found these books inspirational as they more than adequately connected the Western world of my upbringing to the newly adopted (holistic) Eastern world, of the yin and the yang, in which we sought salvation. In particular, these and subsequent readings offered explanations for many of the (metaphysical) questions I had formed while sitting in Applied Mathematics, Physics and Chemistry lectures. As a consequence of these readings and my unfolding life of love, acceptance and compromise with a wife who was eventually diagnosed with Multiple Sclerosis, I continued to read and ask questions on the nature of being, and developed a relatively non-Western, non-modernist point of view (especially, I have been often told since, for a mathematician). Since then I have read numerous popular books on the subject of the nature of the universe and of ‘reality’ in an effort to cross the cultural borders that exist between my professional life world and my personal world. Notable inclusions have been $E = mc^2$ (Bodanis, 2000), A Brief History of Time (Hawking, 1989), The Turning Point (F. Capra, 1982) and The Web of Life (F. Capra, 1997). The more recent works of Frijof Capra have further inspired me and led me informally to the works of Ilya Prigogene (Prigogene, 1996) on self-regulating systems, and Francesco Varela and Umberto Maturana on autopoietic systems.

These works gave me a foundational belief for what I was doing in embracing constructivism. Their idea of self-regulating systems or ensembles which respond to perturbations by re-equilibrating themselves seemed to me to reflect my own behavior and that of my students when responding to instances of challenge such as resolving issues of cognitive conflict. Indeed it provided me with an acceptable basis of explanation for the variations in human behavior that had been sorted and classified in terms of the trivial, radical, social, and critical forms of constructivism. To me, all are scenario or case dependent examples of a learner re-establishing his or her equilibrium.

It is these experiences and the influence of these readings and other related works that have inspired the research I have done and will continue to carry out (some within these pages).
While I started out with the intent of providing a teacher resource to assist colleagues in need of support and direction, I now realize it was also a means of confirming, or at least realizing for myself, my own deeper reasons for doing what I do and how I do it when I teach mathematics.

The ongoing pages of this research thesis comprise further justification based on my personal and professional experience for my thinking in this way and for presenting my story in its semi-narrative, semi-autobiographical and auto-ethnographic form.

As such this thesis is a bricolage (Denzin, 2005; Kincheloe, 2001) - a collection of samples, examples, anecdotes, possibly even outbursts, aimed at offering my readers some useful strategies they can adapt to their own learning situations and offering myself something for further reflection and ongoing appraisal within the terms of my own goals, aspirations and ideals.

With each item I offer an explanation as to why I have designed or chosen it for use in my classroom. As well as being a useful resource aimed at teaching (perhaps) some fundamentals of mathematics in a form that assists all learners (especially those challenged by learning in a different language and cultural context), each has what I consider to be a deeper intent. In addition to addressing the technical – (the technical and technological aspects of learning mathematics for understanding) and the practical – (the management issues of establishing a communicatively effective classroom, faculty and institution), each attempts to engage or enter the critical domain of the emancipatory. Each is my attempt at democratizing the learning process that I am familiar with. Each is my attempt to emancipate and to empower myself, my colleagues and my learners. For this reason each example or strategy carries the intent to challenge, engage and hear the voice - on many levels - of the learner as co-owner of the learning process.

I have less and less time, and yet I have more and more to say. I’ve reached the moment when the movement of my thought interests me more than the thought itself.

[Picasso speaks – from Life with Picasso; Francoise Gilot, 1964]
In attempting to realize such idealistic goals I have already briefly mentioned the significance of my own evolution as a teacher and as a human being. Later in these pages you will see the emergence of my innermost voice as I reflect upon old and new experiences and make connections between the two as part of the cyclic nature of this research and my own professional and personal development. In Chapter 10, for example, I will talk further about the double-stranded nature of this research, the mapping of my own personal growth as background to my offerings of practical day-to-day samples and examples of what I see as an effective and empowering learning environment.

As these examples of curriculum and strategy are, to me, the embodiment of this research I make no apologies for their number or their placement. While some could be relegated as an appendix, I believe most are highly relevant and represent the enactment of my teaching and personal philosophy, both as statements of (arguably) good teaching practice and as specimens or questions held up for scrutiny and examination (by my readers) in the context of their own philosophy and practice. They also act as focal points for my reflection as I examine my own teaching and, more and more, my own thinking, values and beliefs in respect to how I envisage and enact my professional and personal goals.

**A Structural Outline**

Having said all of the above, I now shift to the more practical as I provide a brief introductory outline of this thesis, to assist my readers as they navigate its pages.

In Section I (Chapters 1 – 3) I situate the research by describing the scenarios within which it is located. This includes a brief look at the stakeholders (including the researcher), the environment and the prevalent cultures that influence its being and the nature of the research itself.

In Chapter 1, I begin at the beginning of the writings of this thesis. I discuss my original reasons for formalizing my ongoing and personal research-in-action and for subsequently writing a document of teacher musings and strategies aimed at assisting fellow teachers of mathematics (and other subject areas). A significant part of this chapter is used to introduce myself as a person and as an educator so that my readers can better understand who I am and where I am coming from when I describe myself.
as a neo-pragmatist or as an emergent postmodernist. Hopefully, as a result of this reading, they will also be more understanding (and forgiving) of any contradictions that exist within these pages.

In Chapter 2, I speak from 10 years practical and research experience of and within the United Arab Emirates to describe what I see as the changing educational environment and the cultural influences that both accelerate and obstruct national progress towards what they see as a more modern style of education. This includes an introductory look at my own college, The Petroleum Institute, Abu Dhabi, and how it fits within the matrix that is the UAE educational environment.

In Chapter 3, I look at those external cultures that have such a profound influence upon the environment and my own work and within the Petroleum Institute, namely the cultures of professional and academic engineering. Of particular significance here is the large scale moves (worldwide) by bodies such as ABET and Engineering Australia to reform engineering education and to produce engineering graduates, and indeed engineers, who are globally and cosmologically aware and responsible (Beder, 1999; Godfrey, 2003). It is indeed a large part of this reform that structures and guides my own attempts at classroom reform and self transformation.

In section II (Chapters 4 – 6), I provide an overview of the research method used, including a definition of many of the terms I use to describe the stakeholders and also to explain what I believe is emerging as the research takes place.

In Chapter 4, I choose and justify my research methods and I formulate those questions I believe pertinent to this research.

In Chapter 5, guided by my earlier chapters I begin to situate my research (methods) within the context of these scenarios and physically within my classrooms and related faculty areas within the Petroleum Institute. As part of this process I formulate what I see as the major research questions guiding this researcher, as a teacher and administrator at the Petroleum Institute.

Knowing that there is a significant degree of subjectivity involved in presenting my findings, my interpretations and my viewpoints I have opted for a semi-
autobiographical auto-ethnographic approach, treating my findings as more a set of field-notes than some definite line of argument and proof.

The resultant research is an emergent construction, a ‘personal (autobiographical) narrative’ and an (ethnographic) in-the-field report ‘pieced-together from a set of representations that are fitted together according to the specifics of a complex situation’.

(Denzin, 2000), (see Chapter 5).

It is at this stage the duality of my research emerges as I first consider the evidence of my own professional and personal transformation (Mezirow, 1990 b), the guiding principles for this transformation, and the concept of emancipation (Habermas, 1972; Young 1990).

In Chapter 6, I look more deeply at the underlying theory that guides and defines much of this research. I describe what I mean when I claim to be a constructivist and a pragmatist, and I look further at the critical theory of Jurgen Habermas and what it means to me.

In section III (Chapters 7 – 9), I use my own teaching / learning environment at the Petroleum Institute and surrounding, interacting zones of influence to model - develop and describe holistically - what I perceive to be a culturally empowering mathematics learning environment in progress for EFL students. I further note that this will be the environment to which I will refer when I eventually attempt to plausibly answer those earlier research questions that I posed.

In Chapter 7, I describe, discuss and attempt to justify the existence of what I believe to be the culturally empowering mathematics learning environment that exists within my classroom at the Petroleum Institute. As part of this I describe the strategies and the practical examples that I and other colleagues, use to set up, maintain and sustain what we perceive as emancipatory learning.

In Chapter 8, I look at how a culturally empowering classroom environment can be supported ‘in the field’ by means of faculty policy, procedure and management protocols. In particular, I consider the idea of enacting or role-modeling empowerment by working within a collegial unit where the teachers themselves are
empowered. I refer here to my own positive experiences with the philosophy and practice of TQM (Total Quality Management), and explain how I use this as an administrator and team leader at the Petroleum Institute.

In Chapter 9, I expand my interests and enquiry out beyond the borders of the Foundation Mathematics Program. I look at the interaction between this program and others, particularly at how we (in mathematics) have collaborated with colleagues from the English faculty and the Engineering programs. I look at how these colleagues have contextualized and or mathematized their regular curriculum, such as the STEPS program, to provide wider access and experience for our students to work and think mathematically. In addition to explaining what is happening within the Petroleum Institute I also describe how the teachers at the Petroleum Institute have reached out to the wider educational community of the Gulf region and the world engineering educational community by way of the METSMaC conferences. In addition to describing these events I provide and discuss examples of student work activities for further discussion and analysis.

Having established what I believe is a relatively clear picture of a relatively effective/culturally empowering mathematics environment and a matrix in which to embed (relate) my further findings and conclusions, I set about the task of finally answering my original research questions.

In Section IV (Chapters 10 – 12), I attempt to address and answer, wherever possible, the 10 research questions I posed at the beginning of this dissertation.

In Chapter 10, I address research questions 1 and 2 related to what I and my stakeholders believe are the benefits of teaching and learning mathematics. In an attempt to find a suitably relevant answer I look at what it is we, as teachers, believe we are teaching when we teach mathematics and I also look at student responses to what it is they see is happening in our classrooms and also what they think is beneficial in what we are all doing.

In Chapter 11, armed with my findings from Chapter 10 survey results, I attempt to define just what it is we mean by mathematical competence and how this can be related to engineering studies and the requisite mathematics.
In Chapter 12, I look at ways and means to develop student competence while at the same time empowering them as learners and members of their various sub-cultures.

Finally in the conclusion to this research, I discuss what I have found from doing this research and how I believe it has affected me as a researcher and a teacher administrator by doing this research.
Section I: Research Scenarios

Situating the Research

In this section I situate the research by describing the scenarios within which it is located. This includes an account of the stakeholders (including the researcher), the environment and the prevalent cultures that influence its being, and the nature of the research, itself.

In Chapter 1, I explain my original reasons for wanting to write a teacher support document to assist fellow mathematics teachers with their own professional development and the development of viable and effective teaching/learning resources. I introduce myself as a person and as an educator, describing past and present influences upon my life in an effort to give my reader an understanding of how, what and why I view this research and how I reach some of my conclusions in later chapters.

In Chapter 2, I speak about my 10 years working as a mathematics teacher and administrator in selected colleges and universities within the United Arab Emirates. In doing so, I describe what I see as a changing educational environment and the cultural influences that shape national progress towards an (arguably) more modern and relevant form of education. In particular I focus on my own college, The Petroleum Institute, Abu Dhabi, and how it has changed as an important component of the UAE education environment.

In Chapter 3, I examine the cultures of professional and academic engineering and how they significantly impact upon the Petroleum Institute and upon my day to day role as mathematics teacher/coordinator within the Foundation Program. In particular, I consider why, how and where professional associations such as the Accreditation Board of Engineering and Technology (ABET) and Engineering Australia are attempting to direct engineering education so as to reform engineering education and produce engineers who are globally and cosmologically aware and responsible (Beder, 1999; Godfrey, 2003).
Chapter 1

The Researcher

"Men learn while they teach." - Lucius A. Seneca

"To teach is to learn twice." - Joseph Joubert

Introduction

In this Chapter I begin at the beginning of the writings of this thesis. I discuss my (original) reasons for formalizing my ongoing and personal research-in-action and for subsequently writing a document of teacher musings and strategies aimed at assisting fellow teachers of mathematics (and other subject areas). A significant part of this chapter is used to introduce myself as a person and as an educator so that my readers can better understand who I am and where I am coming from when I describe myself as a neo-pragmatist or as an emergent postmodernist. Hopefully, as a result of this reading, they will also be more understanding (and forgiving) of any contradictions that exist within these pages.

My initial goal in starting this research was to develop a ‘teacher support’ document (founded upon the wisdom of my experience as a mentor teacher). Rather arrogant when I think about it, but my intentions were good, even if my beliefs were somewhat misguided. I have had a lot of teaching experience, I have mentored a lot of inexperienced teachers, I have trained numerous experienced teachers (in innovations to teaching) in my role as Mathematics consultant-support person, and I have presented to packed and empty ‘houses’ at numerous Mathematics and Computer Education conferences – so I believed I had something to offer. There is a definite need for teacher support/professional development activities here in the Gulf Region of the Middle East, and I figured that I was as qualified as anybody else to address this need.

In producing a guide of recommended practice and philosophical musings, I was in fact doing exactly as I had been trained to do, but there was a problem: I wasn’t
exactly doing what I believed in. I was attempting to pass on the ‘truth’ to those who needed it. Fortunately, during a presentation to teachers at the 2006 Higher Colleges of Technology (HCT) Mathematics Conference in Abu Dhabi, I realized that my truth wasn’t everybody’s truth. I was seriously distracted by a fellow mathematics teacher who correctly pointed out that what I was suggesting – based upon my own successful teaching experience – was not working for him in his teaching environment. To make matters worse my efforts to suggest numerous alternatives for him moved me far from the original theme of my talk and turned what was designed to be a lecture demonstration on best teaching practice into an open forum far sooner than I had planned. In hindsight this was not such a bad thing! Although in the eyes of my audience it probably was. Trained as mathematics teachers, and educated in the modernist / objectivist mode, it is likely that they had expected a well structured, smoothly flowing presentation designed to transmit new ideas and procedures that they could digest, manifest and evaluate under their own teaching conditions. Even by my own teacher evaluation criteria, my time management was poor and I fell far short of delivering / achieving my planned outcomes.

My ‘problem’ was, and still is, that I am a connected learner (Clinchy, 1996; Dawson, 1999). I rarely reach a final conclusion because I am prepared to listen, learn and take in new ideas that in turn encourage me to modify and remodel my schema / learning beliefs and values. Even in the case of this research I have no sound idea as I write of what position I will present, define and defend. I only know that I have some questions and fundamental beliefs and that I will leave the outcomes of their coalescence to unfold in the pages of this dissertation. From a theoretical perspective I draw on (neo)pragmatism (Polkinghorne, 1992) and constructivism (Tobin, K., & Tippins, D., 1993; von Glasersfeld, 1990a, 1990b, 1995). I am willing to assimilate new ideas and ways of doing and knowing into my perspectives, and I have many questions related to my work as a teacher of mathematics to guide me into and provide for this process of assimilation.

After reflecting on my recent experience, the goal of this research changed to one of further critical reflective enquiry (Mezirow, 1990a; Pring, 1999; Schon, 1991). My goal is to ask my many questions and seek viable answers within the multiple contexts of my own personal (epistemological, ontological, axiological) beliefs and within the physical and cultural contexts of my working environment. Thus I intend
to investigate my own professional teaching practice (and that of my colleagues) within these multiple contexts, and refine my own teaching practice in accordance with the constructivist ethos of lifelong learning or of the teacher as learner (Ernest, 1991; Tobin, K., & Tippins, D., 1993; von Glaserfeld, 1995) and the Total Quality Management (TQM) principle of continuous improvement (Morgan, 1994).

I further intend this research to be a transformative learning experience (Mezirow, 1990a), that is, a process of going beyond the gaining of factual knowledge to the point of being meaningfully changed by what one learns. Such a process involves questioning one’s own (and others’) assumptions, beliefs and values, through considering multiple points of view, and seeking to verify reasoning.

Lyddon and Schreiner (Lyddon, 2000) when discussing the four themes (foundationlessness, fragmentariness, constructivism and neopragmatism) of the postmodernist worldview describe a Neo-Pragmatist as:

One who replaces the modernist notion of valid knowledge (that is, knowledge that corresponds to an independent reality) with a view of knowledge as viable, or producing an intended effect.

In my own postmodernist view, inquiry into why something works is secondary to inquiry into how well it works. I recognize the value and usefulness of the scientific effort not as leading to universal laws, but as identifying, testing and preserving those practices which produce (intended) results.

Instead of being a search for underlying laws and truths of the universe, science serves to collect, organize, and distribute practices that have produced their intended results. (Polkinghorne, 1992)

It is this inward observation and analysis that I aim to exercise within my professional practice, and which fundamentally drives my initial investigation.

Constructivism has been described as the process(es) by which human beings construct their own (individual) realities based upon their own personal and socially mediated experiences (Ernest, 1995; Gray, 1997; Lyddon, 2000). It follows then, that in doing this research I intend to construct my own understanding, knowledge
and or viable reality of my own professional practice(s) by means of enactment and interpretation within the socially and culturally mediated environs of my classroom, my faculty and my learning institution.

To achieve this and to accurately report my findings, including my interpretation of those observations made by other important stakeholders, I will be writing much of this in an autobiographical and auto-ethnographic style. This compels me to write about myself as well as the physical, cultural and intellectual environment(s) in which this research takes place. I write reflectively about myself because it is through my eyes – attitudes, beliefs and values – that this research and its findings will be filtered and subsequently reported. Such filtering will be done through contrasting my observations and experiences within the Foundation Mathematics Program of the Petroleum Institute, situated in Abu Dhabi, United Arab Emirates, with my previous experiences as Mathematics Lecturer and administrator within the United Arab Emirates and prior to that as Mathematics Head Teacher, classroom teacher and consultant in NSW, Australia.

Consequently, I include a brief description of myself and the forces or events that influenced my life and my choice of careers. Once that is concluded I will continue to describe my current professional environment within the United Arab Emirates, and the Petroleum Institute in particular, so as to give my reader(s) some idea of how I understand, and indeed feel and react to, the influences that bear upon and possibly distort the research I am undertaking.

**About the Author**

I feel that it is important that I identify myself as the author and chief interpreter of this research. However, in terms of the actual reading of the research this section may be considered as unnecessary and could be skipped by my reader.

As I mentioned earlier, much of the dissertation will be written in an autobiographical or auto-ethnographic style in which I will reflect upon my professional world, as exemplified in my day to day classroom and collegial interactions, and view/filter through the lenses of my personal and professional experience.
It was with great interest that I read other research accounts written in this style, and it was with great admiration that I learned of their authors’ struggles to overcome the prejudicial influences of previous generations and cultures as they tried to decolonize imposed and often oppressive belief systems and to reinstitute and re-establish some of their traditional indigenous values and beliefs, both personally and culturally (Afonso, 2007; Luitel, 2006).

My own story is somewhat different and somewhat less colorful. But then, I suppose we all see ourselves as ordinary when viewing ourselves through our own lenses. Whatever I am, I include this account to give you, the reader, and me, the ‘self explorer’, insight into why I understand things as I do and how I interpret the findings of this research.

Before you read further let me remind you one final time that what you read is not essential reading – you may quite easily read and follow the line of this research without it, although I believe it helps.

The seventh of eight children I was born to working class parents in the not so working-class area of Sydney’s North Shore. Unlike my neighborhood friends I had limited opportunities but, compared to my siblings, I was born privileged. My older brothers and sisters had to contend with the poverty brought about by my fathers’ addiction to gambling and the need to share limited resources amongst so many children.

By the time I ‘came along’, the eldest three had grown up, entered the workforce, and were actually contributing to the upkeep of the family. Even so, opportunities were limited. I can clearly recall my older sister, an excellent student with a passion to become a teacher, talking of her dreams to attend university. She had an excellent school record, but despite this chose to finish school in year ten and enter the workforce, much to the protests of two teachers committed enough to approach our parents in the hope of keeping her at school. As a family we were caught in a paradox. My father, who worked in the building trade, was well paid. It was just that his pay rarely came home to us. To the government then we were not in need of help. We just had to help ourselves and unfortunately that meant sacrificing or at least deferring further education for the older children.
I was more fortunate in that a series of events would unravel that would allow me the opportunity to do what the others in my family couldn’t. In 1961 a ‘credit squeeze’ initiated by the Federal Reserve Bank seriously impacted upon the building industry. For my father to find sufficient work we moved to the western outskirts of Sydney. I had, and 40 years later, still have mixed feelings about this move. On the one hand, I remember the severe beatings I copped from the local lads because to their ears I spoke ‘like a pom’ (Englishman). On the other hand, I remember the look of relief on my mother’s face when my father started bringing home his pay envelope. We were too far removed from the race-tracks and the gambling dens that my father had so consistently frequented. Besides, maybe my father figured a new move could bring about a new life. Whatever the reason, he was happy to place a few bets at the local ‘pub’ and unless he had a particularly bad run, we – mum, my younger brother and me - were the beneficiaries of his new lifestyle.

Something else happened to help me out with life, as well. I guess I’d had ‘brains’ as a youngster. My brothers and sisters were all ‘bright’ and, despite their socioeconomic status, they had at different times been placed in talented children’s programs, classes for the gifted and selective schools, but I hadn’t noticeably stood out. Perhaps I was just too young to be noticed, perhaps it was the instability of / in our lives upon a fairly sensitive child, perhaps I wasn’t as talented as my siblings?

But when I changed schools, learning suddenly became clearer. I was still remarkably clumsy and a football coach’s nightmare, but in the classroom the lights literally came on. The fog that I had just accepted as part of my everyday life seemed to lift. As a matter of fact, I never even knew there was a fog until it had gone. My schoolwork and the ever present examination results weren’t just improving they were making ‘quantum leaps’. At nine years of age I became a big fish in a small pond. For the next two years I was Dux of my year and of the school, I represented the school in various local and district cultural and academic events with (significant) distinction. It was nice to be successful.

Sadly, toward the end of my final year of primary school, my mother took ill and completely lost her eyesight. She was devastated! So was the family, but we knew something that she did not. We were told she was going to die. The damage done to her eyes was a consequence of extraordinarily high blood pressure. That same
pressure had damaged her heart and other vital organs. I guess it shouldn’t have been a surprise to any of us really. My mother put up with so much from us all and went without so much more. But you kind of believe life would even things out somewhere, not just continually smash a person down, the way it seemed to do to her. Fortunately for us all, she wasn’t ready to die and lived a productive, and for us, inspirational life for another six years.

By writing the above I am implying that these events impacted upon my life and my learning. I am sure they did, but I can provide as much evidence of puberty and general teenage insecurity affecting my personal and academic performance. Whatever the reasons, I lost direction and in the eyes of my teachers became a typical underachiever. After an outstanding first year in high school where I was placed in the highest classes and awarded ‘A’s in most of my subjects, I began to slide down the scale.

By the end of year ten I had given myself nowhere to go. I wasn’t regarded very highly by my teachers. I was much younger than my peers and, as a result, a follower rather than a leader. I wasn’t encouraged to stay on at school.

I left school at the end of year ten. I joined a bank. They were delighted with the results of my aptitude tests and sent me to work in a suburban branch. After a few months I was transferred to their financial section in central Sydney and trained to do the bookwork on what was literally a spreadsheet. I was never quite sure whether my transfer was due to my mathematical aptitude or my personality which at the time may have made me appear too quiet for customer service. Not that it really mattered. The important thing was that I enjoyed the ‘number crunching’ required for the balance sheet. It was challenging and made me think. I also enjoyed the long train journey to work and the interaction with a few fellow travelers who were making their way to university each day. I decided I could do what they were doing and, more importantly, I wanted to do what they were doing. Even better, I had a means of doing what they were doing.

Despite the improvement in our family finances, it had always been a ‘slog’ for me to stay at school. I was much better off than my brothers and sisters, who had all left school for the workforce by the end of year ten, but I still had less cash and
opportunities than most of the people I went to high school with. From time to time, usually school holidays, I worked as a laborer for my father or sold papers, but someone had to help my mother with things and, as my brother was too young at the time, it was usually me.

Now things were different. My brother was old enough to help out. I had been out working and had the means to save money. I also had a goal. I worked for the remainder of the year and saved every cent I could, and when the next year came around I returned to school. For the next two years I put myself through high school. My love of learning had returned. I reveled in senior high school and at the end of this world of examinations and results I was awarded the school prizes for Mathematics, Science and Economics. I received invitations to numerous gifted student workshops run by the universities and later when my Higher School Certificate results were ‘calculated’ I received scholarship offers for university.

Sadly, my mother did not live to see me finish school. She died a few months before I sat my final exams. After her death my relationship with my father deteriorated and I moved in with some friends to finish my schooling.

I remained focused during this period of upheaval and unhappiness and, as mentioned before, I managed some credible/creditable results; and thanks to the strong economy of the day and a recently installed socially responsible federal government I took a scholarship to attend Sydney University.

I graduated with a Bachelor of Science degree four years later after a few changes to my undergraduate courses and my scholarships, in which I finally switched to a teaching scholarship. After a year of running a Geochemical (Assaying) laboratory I returned to Sydney University to complete my Diploma in Education (Mathematics Teaching). I taught Mathematics, Science and Computing for the next four years before going overseas for a year. During that year I backpacked across the globe and, as well as doing many different odd jobs, I taught casually in some quite exotic places. This experience prompted me to do a Masters degree in Applied Mathematics which I completed in 1984 two years after my return to Australia.
Since this time I have taught Mathematics, Science, Computing Studies and Marine Studies in NSW State Schools. I have also been promoted to Head Teacher Mathematics, Science and Computing and as Acting Deputy Principal, and have acted as a consultant in the role of teacher trainer and consultancy support person for my educational district.

In 2000 I accepted an offer from University of UAE to teach Mathematics and Information Technology in their Foundation Program. Shortly after – owing to the positive response to my teaching methods – I was chosen by a consultancy team brought in from California State University to run the mathematics component of a pilot project attempting to modernize and improve the university’s teaching programs (for accreditation purposes). The success of this venture in turn led to me being promoted to Head of the Mathematics for Arts Track within the Foundation Program.

I left this position to briefly teach in the Mathematics faculty before accepting the offer to teach in my current position as Senior Mathematics Lecturer in the Foundation Program of the Petroleum Institute, where this research is taking place. In addition to lecturing I am involved in part-time consultancy work for private educational resource and training companies which takes me inside schools, colleges and universities in the Middle East, USA, South East Asia and Australia.

It is my desire to continuously improve my own teaching and my teacher training / consultancy support which drives this research.

As my background, detailed above, would imply I am in many ways a traditional mathematician / mathematics teacher. As you have already read, I have passed through many of the ‘gates’ that have blocked other traditional learners or perhaps excluded others because of their non-traditional learning styles / styles of interpretation / modes of presentation. The ‘gatekeepers’ of traditional academia have let me pass, and in many ways my passing through those gates – even if somewhat erratically - has been a source of personal pride and assisted me to elevate a sometimes fragile self-esteem.
I have a love of mathematics. I love its beauty and appreciate its elegance. For me it is like a great piece of music or work of art. But like these, it is also (to me) a human construct. To me, much of its beauty is in its application. I am an applied mathematician.

I do not consider myself elite although some would argue that I have received privileged treatment, something unavailable to others with different backgrounds, learning styles, mathematical skills. I do, however, recognize that difference exists between learners. As a teacher of mathematics to engineers I see a need for ‘checks and balances’ to identify those not suited mathematically for that profession. I do, however, consider the use of these as gateways secondary to their role in identifying learner needs and redirecting learners to pathways more suited. I support the need for continued classification (as opposed to stratification) and encourage inclusion leading towards the optimization of all learning styles and the empowerment (mathematically) of all learners.

*The chief aim of empowering mathematics is to transform gate-keeping mathematics from a discipline of oppressive exclusion into a discipline of empowering inclusion.* (Stinson, 2007)

Unlike some of my fellow doctoral students coming from nations colonized by Western / European powers, my own culture, to the best of my understanding, has not been supplanted, but has always been immersed in Western scientific tradition. I have not had my own cultural identity devalued nor my traditional beliefs, values and ideals replaced by those alien to my traditions (i.e. concept replacement). This is mainly because in terms of ethnicity I am the colonist. My struggles to accommodate and assimilate new ideas and values have occurred within and between other less significant cultural subsets. For me, Western science has been more liberating than oppressive. While I recognize the significance of the cultural dispossession and conceptual colonization experienced by so many, and clearly from the parlous state of the planetary environment, I recognize the immense dangers that Eurocentric scientism holds, I have not experienced this firsthand. Consequently, I see Western science as a dangerous but necessary tool (among others) to be used to eventually
repair the damage done by those who possess an almost absolute belief in and reliance upon the technical ethic.

On my personal scale, I know my own life-worlds have been confused, compromised and occasionally overwritten as I tried to make sense of such non-intuitive ideas as proposed by the seemingly divergent worlds of Newtonian Mechanics, Relativity and Quantum Physics. I am sure it was these periods of cognitive conflict that contributed immensely to the development of my own scientific beliefs and personal beliefs/philosophy.

Luitel and Taylor (Luitel, 2007) propose a dialectical perspective in which a culturally contextualized mathematics education can co-exist with and enrich the learning of traditional mathematics. This is how I view myself as a learner/educator at this point in my autobiography. Through the research that is unfolding as I deeply reflect and write this page – writing as discovery (Richardson, 2000) - I seek ways to contextualize what I interpret as being Western scientific thought and method, embodied in mathematics, and to connect it, at least dialectically, with the beliefs, values and practices of my host culture(s).

In employing this dialectical perspective a mosaic of multiple natures of mathematics forms in our discursive landscape. (Luitel, 2007)

Fortunately for me, as pragmatic as my environment at the Petroleum Institute is, and for that matter, as pragmatic as the seemingly hybrid culture of the Emiratis appears to be, the idea of a useful, ‘hands on’ mathematics is appreciated and is contextually relevant. This affords me a viable starting point for my transformative quest, although it is important that I first describe in more detail this cultural matrix in which I appear immersed.
Chapter 2

The Educational Environment of the United Arab Emirates

Introduction

In this chapter I draw upon ten years of experience as a professional mathematics educator within the Middle East to describe how I see the educational environment in the United Arab Emirates. While much of this description is drawn from my own personal experiences and observations much also is supported or elaborated upon in popular and scientific literature written about what is called the ‘Gulf region’ of the Middle-East (AlSuwaidi, 2001; Heard-Bey, 1982; Ward, 2005).

Prior to the discovery of oil there existed a rich cultural heritage within the separate Emirates that comprise the United Arab Emirates. However, little structural development existed here or generally within the region. Basic infrastructure was either lacking or totally absent. In the case of education, in 1962, when oil production started in Abu Dhabi, there were only 20 schools and less than 4,000 students nationwide (Heard-Bey, 1982).

The discovery of oil provided the necessary finances for change. By the time the seven Emirates unified to become the UAE in 1971, education had grown to around 25,000 (predominantly male) students in primary and high schools around the country.

Today the UAE Ministry of Education oversees a comprehensive education system for both sexes, with free education for nationals in governmental schools, colleges and universities. A thriving but expensive private system provides for a large percentage of the student population, including local and expatriate students. Many of these schools offer foreign language education and follow the national and international curricula of their expatriate communities, such as the English (O and A levels), USA (GPA system), Australian, French, German and Urdu systems, as well as the International Baccalaureate.
The Ministry of Education and Youth has initiated a developmental strategy, to be implemented over the next 20 years, aimed at ensuring development of methods and programs that adhere to international standards, with a particular focus on learning in English language and on introducing the latest IT resources.

Much has been achieved since the early 1970s but efforts are now being made to improve the educational environment for all pupils, in line with a re-evaluation of the role of government. In particular, Abu Dhabi Education Council (ADEC) is spearheading privatization of the education sector in Abu Dhabi.

Ninety-five per cent of all females and eighty per cent of all males enrolled in their final year of secondary school apply for admission to a higher education institution in the UAE or study abroad. Nationals can attend government tertiary-level institutions free of charge, and a wide and rapidly increasing range of private institutions, many with international accreditation, supplement the public sector. (Excerpt from the official UAE website UAE Interact http://www.uaeinteract.com/education/)

In 1971 higher education was unavailable within the UAE and so students aspiring to further their studies needed to go overseas (usually to the UK or the US).

Within a relatively short period of time – 35 years – the UAE Ministry of Education has established infrastructure for a diversified system of higher education. Already the UAE has one of the highest participation rates in the world, with 95 percent of females and 80 percent of males enrolled in the final year of secondary school applying for admission to local and international universities and colleges. In addition to local universities, such as the University of the United Arab Emirates and Zayed University, many well known international universities, such as Wollongong University (Australia), The Sorbonne (France) and Middlesex University (UK), have opened campuses in the country. Other institutions, such as the Petroleum Institute, have opened with a specific purpose and have drawn heavily on international education and industry expertise.
The Petroleum Institute (http://www.pi.ac.ae)

The Petroleum Institute was founded by Emiri decree in 2000, and admitted its first class in fall 2001. Financed and governed by Abu Dhabi National Oil Company (ADNOC) and its international partners (Shell, BP, Total, and Japan Oil Development Company), the Petroleum Institute was established to provide the UAE and its oil and gas industry with engineers educated and trained to the highest international standards. To achieve this end, the Colorado School of Mines was contracted to provide academic guidance and support, and to assist in the process of achieving international accreditation.

Currently there are about 1000 male and 300 female undergraduate students studying at the Petroleum Institute, divided between the Foundation Program and the engineering programs. By the year 2011, it is projected that the Petroleum Institute will have around 2,500 students, of whom some 750 will be female.

The 2006-2007 academic year sees the launch of the first post-graduate programs. The Petroleum Institute plans to offer a complete suite of Master of Science, Master of Engineering, and Doctor of Philosophy (PhD) degrees in the near future. As the post-graduate program grows, so does the research program with the commitment to excellence in undergraduate education supplemented by a strong commitment to excellence in research and technology development. Research is being leveraged by close cooperation with industry through the ADNOC-group operating companies, the international partners, and with participation from selected foreign universities. (Taken from the Petroleum Institute’s website http://www.pi.ac.ae)

The mission of the Petroleum Institute is to provide students with a world class education in engineering (see Appendix 2.1) and to develop engineers that are leaders in their field and of their nation (see Appendix 2.2).

The role of the Foundation Program is to make this possible by providing Petroleum Institute students with the necessary basics / prerequisites – literacy, numeracy, study
skills, social skills and work ethic – for undergraduate life and eventually as professional engineers.

The Foundation (Advanced University Placement) Program

The mission of the Foundation Program is to enable students to begin successfully their Freshman Year studies at the Petroleum Institute. We regard this as not only in relationship to the subjects students need to know, but more importantly in terms of the study skills, work habits and attitudes students need in order to study successfully at a world-class engineering university.” http://www.pi.ac.ae/fp/index.html

To fulfill its mission, the Foundation Program is designed to prepare students academically to an acceptable level in the subject areas of English Language, Physical Sciences, Mathematics and Computing/Information Technology for entry to the freshman year of study. The objective is to develop in students the necessary integrity, personal and interpersonal skills to become successful students and engineers, to develop students as autonomous learners, and to give them a general understanding of the oil and gas industry.

Depending on English competence, students enter the program in either Foundation 1 or Foundation 2. Foundation 1 is an intensive English Language course which also introduces basic computing skills. Students starting in Foundation 1 take three semesters to exit the program.

At Foundation 2 level, students study English, Pre-Calculus, Physical Science and Computing. Those starting in Foundation 2 take two semesters to exit the Program. Foundation 3 is the final semester of the program and concludes the English, Pre-Calculus, Physical Science and Computing courses. Students must meet minimum standards in these courses before being able to graduate on to freshman studies. Unless students require extra, more intensive English studies, the Foundation Program is a one year program.
Foundation Mathematics

The Mathematics program is designed to prepare students for Freshman Calculus courses, Differential Equations and the mathematical content and concepts of the specific Engineering programs. The curriculum in this course covers pre-calculus mathematics, and problem solving using graphics calculators to model and interpret data in a variety of perspectives. Minimum teaching qualifications required for presenting this course is a Masters degree in Mathematics, Science or Mathematics Education although an additional teaching qualification and classroom experience is highly prized.

Most teachers working on the mathematics program are traditionalist in nature. Lessons are normally delivered as lectures in a small classroom environment containing 15 to 20 students. Emphasis is placed on the use of technology with all students provided with graphics calculators which they use to solve problems, some of which are related to engineering. While the majority of faculty members have a secondary school teaching background – something considered as desirable for teaching students at this level – but there are some with purely academic or industry based histories. Such a varied cross-section of experiences makes for interesting discussion and (probably) does engender a degree of critical reflection in and wide discussion amongst teachers.

In my experience, one of the most interesting and exciting interactions has been the almost pendulum like swings of mathematics faculty members between the pragmatics of delivering an almost pure mathematics course - meant to be more easily assimilated by our students and apparently more convenient for many teachers – and a situated learning scenario encouraging problem based learning which is arguably more student/problem centered and contextual in terms of engineering applications (Springer, 1999) – and appears more relevant and valuable to engineering students.

At this stage there appears no clearly defined or dominant philosophy with both extremes being adopted and applied by all teachers at some stage, in what could best be described as an environment conducive to and engendering a system of
differentiated learning (Gregory, 2002). The desirable outcome for this researcher is that such ongoing debate makes fertile ground for critical reflective research on a personal, faculty and institutional level (Steffe, 1996).

The Political Nature of the UAE

The UAE is not a democracy. The country comprises seven Emirates – Abu Dhabi, Dubai, Sharjah, Ras Al Khaima, Ajman, Fujairah and Um Al Qain. Each Emirate is ruled by a sheikh who traditionally has an extensive ‘royal family’ the members of which take-on governance of the Emirate and who also hold key positions in the national government. The president of the UAE is selected/elected by a council comprised of these sheikhs.

In my experience political power in the UAE is not shared evenly and neither are resources. Members of the royal families have enormous wealth and influence. Seemingly their political power can be brought to bear upon national and private institutions alike to influence decisions, including selection of staff and students, and the processes and priorities of higher education institutions such as the Petroleum Institute.

In fairness, this situation is reportedly not unlike those in many countries in the West, where the wealthy can influence the democratic process. Such is the wealth of many Royal families that reportedly their personal choice of schools and universities for their children often selects institutions that lie outside of the UAE.

A ‘top-down’ culture of political power and influence appears to permeate all levels of Emirati society. This influence can be felt by local schools and universities in relation to the next tier of national students. Whereas the wealthy tend to send their children overseas for university studies and the government provides extensive funding for gifted students to study overseas, family influence can dictate who is accepted at a local university and who is not, regardless of a student’s relative ability or performance in national secondary examinations or related assessment activities.
Population Imbalance of the UAE

UAE locals (UAE nationals or Emiratis as they are known internationally) form a minority within their own country. They are considerably outnumbered by Indians, Pakistanis, Afghans, Phillipinos, Arabs and Westerners who comprise the guest workforce in this country. The Emiratis have progressed in only 35 years from agrarian subsistence to a sophisticated commercial and technical culture, and are still in the process of developing appropriate technical expertise that is already present in many of the guest workers. To maintain control of the country and to help conserve national culture and cultural identity the national government ensures that all international investment is in economic partnership with an Emirati passport holder and that approximately 40% of the resultant workforce comprises Emirati nationals.

This Emiratization of the workforce is aimed at national self sufficiency and management, and its ultimate goal is to fill all available jobs with local people. Under Emiratization, there is a press to place Emiratis in as many positions as possible in as short a time as possible. Unfortunately while the country has developed at a frenetic rate many Emiratis are still not necessarily well qualified and arguably not sufficiently self-motivated, to take up some of the positions the government would have them fill.

As a consequence, many young Emiratis are reportedly placed in managerial positions where they could find themselves overseeing more experienced and qualified expatriate colleagues. Hard work and educational qualifications are not necessarily strong motivating forces. For some, success can be guaranteed along cultural or family lines, and keeping one’s contemporaries happy can seem more viable than adhering to the same corporate guidelines which bind and direct the expatriate workforce.

In such an environment decision making can run the risk of being parochial; corporate or institutional guidelines may not necessarily be followed, and decisions may at times seem contradictory to workers coming from different cultural backgrounds. Such a contradiction is apparent between the conflicting goals of modernization and Emiratization. While the UAE government does want Western
institutional process and efficiency, it does not want these innovations at the expense of national autonomy. An acceptable compromise appears to be the Emirati culture of negotiation.

Culture of Negotiation

A traditional culture of negotiation exists because of the power imbalances in UAE society. Those in positions of influence are more motivated by social or family related forces than by more democratically derived institutional processes, so when a contradiction or conflict of interest arises it can be resolved sometimes at the expense of the institution.

One example of cultural negotiation is the compromise reached between the official selection process and the process actually followed for selection of students applying for Foundation level entry to the Petroleum Institute. To be eligible to start the Foundation Program at the Petroleum Institute a student is required to be either Emirati or the son / daughter of an expatriate employee of the Abu Dhabi National Oil Company (although there are also restrictions here); they must have scored high grades in their National Secondary School Certificate (Tawjihiiyya) leaving examinations; and they must have a high level of proficiency in written and spoken English, which equates to a TOEFL score in excess of 400 points. The Petroleum Institute conducts its own testing to verify these results and to place students in classes commensurate with their English ability.

However, final selection of students for attendance at the Petroleum Institute is done by the Abu Dhabi National Oil Company Admissions Committee. Because of Emiratization eligible local students are given priority. As a consequence eligible expatriate students, including many with better qualifications, are sometimes held back until places are filled with national applicants. Expatriate students sometimes interpret this delay as a refusal or an inconvenience and therefore go elsewhere to study. Sometimes they wait up to a month after term has started to enter the Foundation Program. In addition to a reduction in the quality of the standard intake to the Petroleum Institute, by denying eligible expatriate students immediate, or indeed any access, a situation also can arise where students with unacceptable
TOEFL scores and/or leaving grades are deemed eligible to due to ‘other circumstances’. The local term for this is ‘wasta’, which means the student was allowed entry due to political influence being successfully wielded by a family member or friend.

**Class and Industrial Relations within the UAE**

Of significance also is the structural and political nature of industrial relations within the education system. Both the highly competitive private education system and the government education system seek substantial government assistance, and the private system seeks also to make a profit.

To compete satisfactorily schools produce high assessment grades. Thus the education system is strongly grade-driven. While there is little research done on UAE schools, anecdotal evidence indicates that within schools there is little scope for pedagogical innovation or teacher training to be other than examination focused. As in the West, student grades serve as currency and individual institutional entry tests indicate that some grades may be inflated or inauthentic.

In government (non-private) schools, teacher salaries are low – but as the majority of teachers come from impoverished and often politically troubled parts of the Middle East there appears to be a reluctance to ask for better wages and conditions, and the expectation exists for teachers to deliver whatever is asked of them. Anecdotal evidence from students and parents indicates that some teachers pass failing students or inflate their grades to unrealistic levels rather than be seen as ‘wanting’, thereby avoiding the prospect of non renewal of contracts and a possible journey home.

To overcome these perceived inequities and to ensure credibility and accuracy of student grades, UAE education authorities have recently introduced national exams with stricter supervisory controls. In particular, the learning of English and more recently the learning of core subjects in English have been targeted for greater quality control. An example is the introduction of the Common English Proficiency Assessment (CEPA) examination to give a consistent and accurate assessment of English proficiency, in place of the older TOEFL scores.
Another recent initiative has been the attempt to import native English speakers to serve as teachers of content in areas such as Mathematics and Science. However, a national unwillingness to pay wages that are competitive with salaries in the local private sector has seen this initiative founder with resulting low recruitment and high resignation levels. In the case of the Petroleum Institute, which started out paying attractive salaries, there has been an erosion/compression of wages due to inflation and unfavorable exchange rates. Exacerbated by the reluctance of the parent company, Abu Dhabi National Oil Company (ADNOC), to adjust salaries – including cost of living adjustments – the situation has become a major concern as many established and highly qualified teachers move to other ventures, such as consultancy positions within the oil industry which pay more attractive wages.

Implications for this Research

Thus, a wide variety of sociocultural factors may affect the way in which this research is implemented, analyzed and interpreted. Unique cultural constraints such as the political and social structure of the United Arab Emirates, social and ethical norms such as the local and institutional interpretation and enactment of class and industrial relations, ethical considerations such as fairness and equity as embodied in the processes and protocols of negotiation in such diverse areas as the determination of workplace agreements, student selection/university placements, and student study practices all bear heavily down upon the quality of the research. Student and teacher attitudes towards fitness, fairness and obligation could influence responses to some of the research questions and affect the outcomes of the research as significantly as each individual stakeholder’s desire to perform in a fully professional and optimally productive and constructive manner.

The research is set in an environment of change, as personally and academically/professionally the stakeholders – me the researcher, my students and teaching colleagues - undergo socio-political forces (and their subsequent distortions) which are rapid, significant and, for those of us born and or raised in the West, sometimes foreign, unexpected and counter to our inherent values and beliefs. In this mix of perceptions and interpretations there will most likely arise contradictions that are not easily understood by those unfamiliar with the politics and the culture of the
Middle-East, and not easily resolved by those who are (familiar). For example, a major influence on the choice of research question, analysis and strategy for consideration / solution that would appear less significant in a Western teaching environment is the issue of placement of ineligible and under-prepared students into the Foundation Program of the Petroleum Institute. A contradiction quite evident here at the Petroleum Institute as entry requirements are circumvented within and by an educational institution openly seeking recognition as a ‘world-class’ university, while academic administration courts international engineering (ABET) and educational (SACS) accreditation, while largely leaving unresolved the issue at hand.

It is not my role, nor my right, to pass judgment upon what I see to be contradictions or inconsistencies other than to identify them as possible influences upon the way in which I conduct this research and my day to day teaching activities. It is also beyond the scope of this research and indeed the capabilities of this researcher to investigate deeply the religious and social culture of the Emirati people. This I believe should be left for an Emirati with a close and personal understanding of his or her own culture.

*This is not about ignoring or rejecting modern knowledge and behavior, but rather perfecting them, incorporating values of humanity, synthesized into an ethic of respect, solidarity and cooperation. .... Knowing and assimilating the culture of the dominator can become positive as long as the roots of the dominated are strong.* (D'Ambrosio, 2001)

My perspective based on 10 years experience is that Emirati culture appears far from being dominated by the West, although what remains in question to me is which traditional beliefs and values have been supplanted in what appears to be a ‘headlong rush’ to modernize.

One thing that appears certain is that the quality of living of the majority of Emiratis has risen significantly. This could possibly be ‘written off’ against the questionable standards of living of the thousands of unskilled workers imported from Third World countries, themselves victims of centuries of colonization, cultural devaluation and oppression. That also lies beyond the scope of this research, but would present itself as a significant question for another researcher.
In my view, the culture enacted within the UAE reflects the traditional Arabic merchant culture, described in the history books as the culture that brought algebra (Al Jabr) and Hindu-Arabic numerals, in addition to numerous other commodities and adaptations, from East to West, and vice versa. The Arabs have quite figuratively been one of histories’ great ‘border crossers’, and have bridged countless cultures of significance. In this spirit the Emiratis have pragmatically imported, incorporated, modified and are now in the process of exporting many concepts and commodities that originated elsewhere. It is in this spirit that they have embraced the concept of globalization and set about the adoption of best business and educational practices from other cultures, including the West.

It is in this ‘melting pot’ of intercultural ideas and values that I find myself as author of this research as my place-of-practice changes rapidly from an institution designed following Western principles into one run along the less democratic lines of traditional Middle Eastern/Iranian culture.

Almost impossible to separate from the Emirati national identity is of course their (religious) culture of Islam. While the state allows the presence, and at varying times varying levels of practice, of the other recognized religion, Christianity, its nationals and the vast majority of guest workers worship under Islam. The predominant version of Islam in the UAE is Sunni, although Shia Muslims are present. It is a credit to the expanding tolerance of the UAE government that Christianity is permitted to function and that Shi’ite Muslims have attained positions of significance in private and public practice. This is not necessarily the case in neighboring countries where Christians are allowed but not permitted to practice openly and where members of Islamic minorities are denied the opportunities offered to their fellow countrymen.

At the time of writing these pages the student population of the Petroleum Institute is 100 percent Moslem. The Petroleum Institute offers free tuition for the children of all teaching faculty, including Christians, but most expatriate Christians in the UAE are from the West and prefer to send their children back to their home country for university studies.
Because of the difficulty of investigating my students’ religious beliefs within a culture which has a strongly established ‘beliefs system’, and because the questioning of conventional religious values can lead to strong penalties including deportation and imprisonment, as I mentioned earlier, I will also leave such areas of enquiry to Moslem scholars and focus my enquiry on the sociocultural aspects of my stakeholders’ academic and personal values and beliefs.

This leads me to consider the culture(s) of engineering as the dominant influence affecting the stakeholders – students, teachers and administrators – within this research.
Chapter 3

The Cultures of Engineering

Introduction

In this chapter I take a detailed look at what I see as the two dominant and interacting cultures that act upon and guide almost all that is done academically at the Petroleum Institute, including this research. These are the cultures of academic and professional engineering which are both complementary and conflicting in their relationship. Here I will look at how they influence the faculty and the students at the Petroleum Institute and how they have become highly transformative in nature as they attempt (through their embedded professional associations) to redefine the nature and the image of professional engineering.

The cultural matrix that embeds this research then is primarily influenced, if not dominated by, these cultures of Engineering. Regardless of their backgrounds students come to the Petroleum Institute to study Engineering and become professional engineers. These students traverse and transcend numerous interdependent sub-cultures such as their gender, ethnicity, generation, and always the dynamic (complementary and conflicting) cultures of professional engineering practice and academic engineering.

Culture – A Definition

It is important that a clear definition of culture is provided at this point so that there are no misunderstandings as to what influences the research and under what conditions it applies.

Culture (from the Latin cultura stemming from colere, meaning "to cultivate,") generally refers to patterns of human activity and the symbolic structures that give such activity significant importance. Different definitions
Of "culture" reflect different theoretical bases for understanding, or criteria for evaluating, human activity – Wikipedia

For the purposes of this research I will describe and define culture as a shared system of (learned) beliefs, values and attitudes which directly affect and influence the perception, understanding and actions of those (stakeholders/members) embedded in its predefined environment (cultural matrix).

Thus culture is embodied by the following characteristics:

1. Culture is learned (enculturation).
2. Culture is shared.
3. Culture is a systematic process involving the sharing and enactment of commonly negotiated protocols or patterns.
4. Culture is socially constructed by means of social interaction, mediation, and validation.
5. Culture is symbolic. Communication and analysis of concepts - beliefs, values, attitudes - are symbolic (linguistic/metaphoric) in nature.
6. Culture is communal. Cultural norms are accepted/taken for granted as a ‘social reality’ and often erroneously as universal truth.

Culture means the total body of tradition borne by a society and transmitted from generation to generation. It thus refers to the norms, values and standards by which people act, and it includes the ways distinctive in each society of ordering the world and rendering it intelligible. Culture is...a set of mechanisms for survival, but it provides us also with a definition of reality. It is the matrix into which we are born. It is the anvil upon which our persons and destinies are forged. (Murphy, 1986)
The Culture of Professional Engineering

There is compelling scholarly and anecdotal evidence that an all-pervasive culture of engineering exists within the minds, hearts and eyes of engineers themselves and of the general public and/or those that exist outside of the engineering field.

As numerous scholars have argued, engineers are distinctly aware that they belong to a specific culture that has very clear guidelines about what it means to be an engineer. Research on engineers by social scientists and engineers themselves acknowledges that engineers do believe in a uniform engineering culture. (Leonardi, 2003)

This culture has been identified by many as being driven by engineers’ possession of a strong belief in self, technology and power (McIlwee, 1992; Whinnery, 1965). As Leonardi (2003) states, while “the ultimate goal of the engineer is to use his or her skills to better life for humanity”, engineering is more than a set of skills. In addition it is an embedded set of shared beliefs, norms and values that identify and distinguish engineers from other members of society. As such it is clearly a culture.

However, engineering as a culture can be viewed from two perspectives. There is the internal or intrinsic viewpoint in which the incumbent culture of engineering is assumed. In this situation the culture is seen as fixed – an almost invariant background – compared to other interdependent variables such as work practice, methods of analysis and design technique which are manipulated within this contextual cultural framework (Johnston, 1996). Traditional literature/viewpoints on engineering practice written largely by engineers adhere to this practice and report from this perspective. I found this to be the case as I searched the literature on articles referring to the culture of engineering. Articles written by practicing engineers regularly presumed the cultural matrix into / inside of which the study and or research question was embedded was fixed, inviolate and sometimes, it could be argued, as almost beyond question (Whinnery, 1965).

Viewed from this perspective, “the practices of engineering culture uphold the importance of the individual and of autonomy” (Leonardi, 2003). Many revere the
engineer as a hard working individual who puts in long hours working alone at the office or at home possibly on his/her computer. The computer is considered an essential add-on here as the engineer is further recognized internally as somewhat of a technophile, possessing and demonstrating understanding of and mastery over a wide range of technological devices and applications. Indeed engineers can be chosen for specific tasks by demonstrating competence in some related technological application rather than by demonstrating understanding of the intricacies and consequences of the original task.

In addition to identifying as hard-working technophiles many engineers view themselves as scientific experts. As we shall discuss shortly, engineering work is strongly grounded in the basics/fundamentals of classical science. It is not uncommon for engineers to substantiate and justify routine/hands on procedures with rigorous and arguably over-zealous scientific explanations. A behavior reportedly to have cost engineers significant credibility in the eyes of outside observers who see such argumentation as unnecessary and overly rigorous for the processes the engineer is describing.

Such argumentation/argumentativeness is also considered a desirable part of the (traditional) engineer’s self image, with engineers describing themselves and being described by others using such terms as “masculine, dominant, aggressive, possessive, demanding, and demanding attention and respect” (Leonardi, 2003).

*Competence as an engineer is a function of how well one presents an image of an aggressive, competitive, technically oriented person.* (McIlwee, 1992)

Many engineers see themselves as aggressive hard working technical experts whose goal it is to seek out the right answers. Their orientation and their goals are to make things work, where these ‘things’ are often metaphorically represented by machines and or systems.

*In engineering culture there is a certain arrogance, characteristic of machismo, that the engineer has the power to control technology, and in turn society.* (Leonardi, 2003)
Perhaps it is this attitude which has been partly responsible for the description / criticism of engineers as non-reflective action men by those looking in from the periphery or outside of the profession (Godfrey, 2003); although others from inside engineering have supported this observation (Beder, 1999; Florman, 1968).

Beyond the engineers’ own personal perspective or cultural viewpoint there exists another significant perspective which holds to the tenets used in the anthropological/sociological definition of culture. This perspective identifies culture as another, albeit important, variable to be reflected on, analyzed and more importantly changed in response to the resultant interplay of other factors.

In my own experience as a teacher-educator of engineers, the emergence of such (self) reflection in engineers is heartening as there are numerous observable traits or characteristics of engineers and the prevailing culture of engineering I encounter every day, which in my humanistic view are in need of modification. On a wider scale, this is a view I share with others within my institution and beyond (Prados, 1998), including bodies such as the National Science Foundation (1978) of the United States of America. Indeed one of the purposes of this research is to identify and verify such areas and develop agendas / strategies for changing them from within the limited context / confines of my mathematics classroom and faculty.

What I find more heartening is that in the short period of time since Godfrey (quoting Solomon, 1996) identified ‘a lack of reflective thinking within the profession’ and suggested that ‘only a handful of engineers had set about contemplation of the nature of the discipline and its products’; there has been an increase in the number of articles by engineers (as well as others) viewing engineering culture as changeable. What they are suggesting is an agenda for change in an effort to bring engineering practice and education into step with significant changes in professional and educational practices in other areas of significance. It is worth noting, however, that in many cases these ‘practicing engineers’ are working in universities as full-time or part-time academics. This last is an important observation because, as Godfrey (2003) points out, there is an ‘inevitable tension in existence between professional and academic engineers’. This is something that I experience firsthand at the Petroleum Institute where academic management has been replaced with leadership
from an engineering research / technical background and priorities have shifted from teaching to research. With this shift has come a noticeable change in management styles as issues previously resolved through consensus are now being resolved or justified through the application of impersonal, and in my view (and shared by many colleagues), incomprehensible and short-sighted rubrics.

As already mentioned, in searching for articles/references pertaining to the culture of professional engineering I was pleased to find scholarly articles (Beder, 1999; Florman, 1976; Hauser-Kastenberg, 2001) that reflect upon and question the cultural aspects of engineering from within an anthropological/sociological framework. Having first read Godfrey’s PhD thesis and an article by Beder (1999) I thought I’d find (far) fewer than I did. Clearly at the time of their researching and writing there was evidence of how implicit the concept of culture was then for many engineers. This appears to be changing, albeit slowly.

Despite this, there still appears to be many criticisms leveled at the narrowness and self acceptance of engineering (as a) culture. Engineers are still viewed by many as exhibiting few verbal skills, and as appearing inarticulate, prejudiced, conservative and non-involved (Florman, 1968). Florman further argued that engineers should be ‘liberally educated’ in order to enrich their own lives, their profession and society in general, an observation which seems to have been taken seriously and consequently acted upon by a wide sample of engineering institutions and professional bodies at the dawn of the 21st century. This could be due largely to responses to surveys taken by national engineering bodies in Australia and the United States on the personal attributes of engineers which have generally described professional engineers as:

- Predominantly male
- Showing (as learners) a preference for order and precision
- Strongly favoring analytical / numerical / technical methods over all others
- Showing aversion for situations which incur ambiguity, uncertainty and controversy
- Introverts who avoid people oriented situations
• Being inept at verbal communication, lacking assertiveness and unskilled in conflict management
• Pragmatic and showing very low tolerance towards non-quantifiable topics and situations

In general, many observers see engineers as anti-social types who make poor leaders and managers as they are unable and unwilling in many cases to extrapolate engineering ideas into the necessary functional social, interpersonal and consensual action required as part of, and inherent in, effective contemporary leadership and decision making. Nor are they able, it seems, to think outside of/beyond narrow scientific constraints and thus they are unable to adopt or support strategies needed to empower and motivate others (outside of like-minded colleagues).

In a paper titled “The reflective judgment model: Transforming assumptions about knowing”, in the book “Fostering Critical Reflection in Adulthood”, authors King and Kitchener (Kitchener, 1990) classify knowing into seven (relatively) hierarchical levels. According to their (hierarchy) model ‘technical knowing’ as displayed by engineers sits at levels three and four. This appears to be because socially effective skills such as negotiation and consensus building, wherein multiple inputs are iteratively processed, are more favorably viewed and more highly valued by today’s complex society than the precise technical skills prized by engineers.

As a result of this hegemony and what is perceived as social limitations, engineers so often described as isolating themselves from unfamiliar situations and people, and regularly considered tightly bound within their profession, are not considered to be as aware and open to negotiation as is required from modern era leaders. Consequently representation of engineers on government panels, policy making bodies, think tanks and corporate boards has been diminishing.

By the nature of the profession, engineering is regarded by those on the inside as a culture of problem solving and design. Engineers are recognized as being able to collect specific data relevant to a particular problem and, through modeling, design a workable solution. Thus they are often seen to be ‘workers in isolation’, who pursue a narrow trajectory or limited pathway to reach a workable solution for the problem
in hand, often ignoring wider and far-reaching consequences inherent in their activities. Such an attitude and/or public perception of this attitude has led to a devaluation of the profession in the eyes of the general public and bodies employed to serve the public, where engineers are regularly seen to be to blame for any negative consequences that arise years later due to technical shortcomings and institutional myopia.

As a result of the past emphasis on technical skills and the consequent neglect by engineers of social and environmental dimensions of their work, the image and the status of the engineering profession is declining as the public identifies engineers with controversial and environmentally damaging technologies. Engineers are too often characterized as being male, socially inept, politically naïve and aligned with self serving developers and are finding themselves at the centre of controversies they don’t fully understand. (Beder, 1999)

This perception is reflected in the decline in candidature and the consequent lowering of entry scores into engineering programs at many universities and, of course, of the perceived (academic) ability levels of those students entering these courses. This is a problem many tertiary engineering programs are attempting to address.

The Academic Culture of Engineering

In my own institution a common metaphor guiding many engineering academics appears to be that of (tour) guide. Many professors while openly admitting that true reality is unattainable do appear to believe in the existence of a reality or real truth which can be identified or metaphorically discovered and displayed by means of mathematical modeling and analysis. While their preferred teaching methods range from traditional lectures to student centered research assignments, almost all approaches revolve around the concept of students receiving unquestionably valid information directly from their teacher and/or finding for themselves a predetermined and pre-established ‘right answer’. Despite being driven towards educational reform by accreditation requirements for the individual graduates and for the institution (registration with national and professional associations such as the Accreditation
Board for Engineering and Technology (ABET)), engineering education in this institution continues to be constructed around the concepts and content of engineering science and its accumulation of scientific theory and related facts. This implies two things. The first is that engineering courses at the Petroleum Institute are strongly scientific in their content and thus, in my experience, they attempt to adopt the rigorous approaches required of the classical sciences. The second implication is that as an engineering college this institution (like many other specialist institutions and professional disciplines) values professional qualifications and experience in addition to academic qualifications. Unfortunately, in my experience, working in the Middle East many of the engineering academics I currently work with, or have previously worked with, do not value teaching qualifications as highly as engineering qualifications and are often unwilling to voluntarily accept guidance directed at improving their pedagogical performances, even when that guidance is part of an official program designed to improve teaching quality. Instead many see mastery of content as being a necessary and sufficient condition (above all other alternative viewpoints), and they rely primarily upon the principle and enactment of the transmission of knowledge to relatively passive students. As such they see themselves as conduits of a pre-packaged reality (knowledge, information and skills) transmitted to students who seemingly already understand and are willing and able to accept and easily assimilate what they are being taught.

Godfrey (2003), among others (Beder, 1999; Johnston, 1996), describes engineering as an academic discipline or culture which is largely non-reflective in nature. At the Petroleum Institute, as elsewhere, this is evidenced by the observation that many traditional academic engineers appear to accept and work comfortably within the (intrinsic) culture of engineering as described above (last paragraph) without openly questioning the ethics, philosophy and practicability of their own pedagogical methods or motives. This ‘professional closure’ is regarded by some (engineering) educators as a consequence of an implied intellectual isolation of engineering programs from other university faculties and disciplines (Beder, 1999), a situation believed to have evolved from the initial response/rebuff of 19th Century academics towards engineering studies who argued that vocational and or applied sciences are inferior to the classical studies and more suited to the workplace than being placed within a university.
In response to this enactment/attitude, and in trying to improve the status of engineering as an academic discipline, many engineering educators at the turn of the 20th Century adopted a highly scientific approach in an attempt to ‘capitalize on the growing respectability of science’ (Noble, 1979). This attitude, and the responding strategy of making engineering practice highly scientific, was necessitated further by the technological demands placed on engineers by governments during the Second World War and the Cold War as ‘traditional handbook methods’ (Prados, 1998) proved inadequate and stronger mathematical and scientific foundations were required for development of new technologies. This situation largely remains today with most engineering courses placing high emphasis on the scientific principles of engineering at the expense of more socially orientated courses. While such technological depth and mastery is needed at the higher levels of engineering development and research this approach is regarded by some academics / educators – myself included - as overly rigorous and in many cases unnecessary for meeting the needs of many undergraduate students, particularly in the light of new requirements.

The scientific approach has, of course, yielded solutions to engineering problems which the old trial and error methods could not but the need to teach science in engineering schools has been grossly inflated by the needs of the engineering profession for esoteric knowledge and of engineering educators for academic respectability. (Noble, 1979)

Traditionally engineering curriculum has been overcrowded and a source of both complaint and status for many engineering undergraduates. Recent additions to syllabi have done little to alleviate overcrowding and may even exacerbate this situation. While many colleges appear to have responded to calls from researchers and national and international engineering and scientific bodies, such as ABET, IEAust, National Science Foundation (NSF) of the USA, for change in the content and pedagogy of undergraduate engineering courses, progress appears slow in removing unnecessary rigor from courses or eliminating components and courses lacking relevance.

In some institutions engineering courses remain overcrowded and recommended additions (to engineering), such as economic theory, engineering ethics, political and
environmental sciences, are offered/introduced as elective courses or add-on components to the traditional engineering science studies. Students often regard these innovations as secondary courses, as being less important than traditional offerings. This has in turn led to reduced candidacy and even cancellation of some recommended courses and maintenance of the status quo. This is an unfortunate situation because many of these courses are necessary to provide and facilitate within graduating engineers the skills now seen as necessary for this new millennium.

*If engineers are to be more than technical functionaries in the next millennium there is a need to provide young engineers with an understanding of the social context within which they will work, together with skills in critical analysis and ethical judgment, and an ability to assess the long term consequences of their work. Engineering in the modern world also involves many social skills. These include the ability to understand and realize community goals, to persuade relevant authorities of the benefits of investing money in engineering projects, to mobilize, organize and coordinate human, financial and physical resources, to communicate and motivate, and advise on many social, environmental and safety aspects of their work.* (Webster, 1996 as cited in Beder, 1999)

In the last 20 years, and in some cases earlier than this, a significant number of individual research papers and reports from engineering professional bodies have highlighted the perceived shortcomings of engineers when measured against new yardsticks of economic globalization and technological complexity; and have called for a change/paradigm shift in the way engineers view themselves and their profession; including changes in the way engineers relate to each other and the wider community.

*Beginning in the 1980’s, the emergence of global competition as the major driver for engineering employment along with the rapid growth of information technologies, have focused increasing attention on the need for new forms of engineering education that will equip graduates with stronger skills in communication, teamwork, knowledge integration, and economic understanding in addition to sound technical competence. Led by far-sighted*
educators and industry executives, engineering education is now beginning to adopt this new paradigm. However, academic culture changes but slowly, and some time will elapse before the new paradigm becomes dominant at a majority of (US) engineering schools. (Prados, 1998)

There are those who argue that the solution to this problem lies in changing the way engineering is taught in colleges and universities (Beder, 1999; Leonardi, 2003; Prados, 1998). Some go further, attributing partial accountability for the hesitancy of some institutions in implementing necessary curricula and processes to the inertia of engineering academics inexperienced in contemporary procedures and unwilling to make the required changes.

Criticism of (recent) engineering graduates when viewed in the light of criteria defining modern day engineering work readiness and effectiveness reflect earlier criticisms aimed at engineers as professionals; but these criticisms of graduates are often made by engineer employers and supervisors. Examples of such generalizations taken from Prados (1999) include:

- display technical arrogance
- don’t understand the manufacturing process
- lack design capability and creativity
- lack of appreciation for considering alternatives
- lack of appreciation for variation
- all want to be analysts
- poor perception of the overall project engineering process
- narrow view of engineering and related disciplines
- no understanding of the quality process
- weak communication skills
- limited skills or experience in teamwork

Many papers in recent times have been directed at overcoming the evident shortcomings of graduating engineers and engineering education, including some that have stressed the application of (systems) engineering principles to fully investigate and resolve this situation (Dym, 2004).
Lists of requisite skills for engineers to work effectively in the 21st century have been tabled on numerous occasions over the last decade by many engineering researchers and professional bodies. The following list adapted from the report to the Australian Institute of Engineers by its Task Force (3) (1996) is indicative of the findings of investigatory sub-committees and working parties set up world-wide. Taken from Beder (1999), expertise that an engineer would require in 2010 in addition to traditional skills will include:

- leadership skills beyond those of technology
- more innovative and creative
- better life-long learners more adaptable to new learning situations
- better managers of people and systems
- more accountable for results of decisions within context of economic, political, ethical, cultural and environmental issues
- operate within and across professions that are global
- utilize quality improvement practices in all aspects of their work.

Clearly to achieve even part of this list it is necessary to make significant changes in the structure and content of engineering courses, faculties and institutions.

There are many instances and varied opinions in this regard. Huaser-Kastenberg and colleagues at the University of California - Berkeley (Hauser-Kastenberg, 2001) envisage the implementation of these changes coming about by means of a change or expansion in the ethics of engineering. The courses they recommend/put forward to colleagues at the International Colloquium on Global Changes in Engineering Education held in Berlin in 2001 sought to identify a shift in the concept and context of technology and engineering from one of individualism, conquest and competition within our environment to one of cooperation, co-existence and sustainability.

In introducing an experiential course which aimed to ‘expose and initiate their students to the contextual underpinnings of the ethical questions at play, understand the human decision-making process and expand their ethical reasoning ability’, they saw the changes in the courses they were introducing as being shifts in thinking and application brought about by changing the context of engineering from linear to non-
linear, from individual to ‘communal’ responsibility, from case study inquiry to an awareness of perceptions and attitudes, and from public health and safety issues to issues of ecology. In doing so they were shifting the emphasis/essence of the engineer away from being the isolated and disinterested problem solver to one of engineer as a reflexive/reflective, interested and aware member of the global community.

They listed the following desired outcomes to their proposed course:

- Engineers understand that the way a technical problem is framed already contains ethical choices.
- Engineers are able to thoughtfully reflect on their own internal assumptions as well as solve external problems.
- Engineers are responsible and capable for being in an on-going dialogue with other members of the societal decision making process.
- Engineers are able to work from other contexts such as sustainability and transparency.
- Engineers are aware of the role of the law in the design process.

(Hauser-Kastenberg, 2001)

Other researchers argue that the problems inherent to engineering education could best be resolved, or at least attempted, using an engineering systems-design based approach. Further the point is not to create a brand new design for the engineering system in its own right, but to provide a structured approach to informed questioning of the current enterprise.

Some of the basic steps in a design based approach are:

- eliciting and refining properly drawn objectives
- articulating appropriate and realistic constraints
- deriving the functions that must be performed in order to realize the desired objectives within the extant constraints, and
- detailing the metrics against which the achievement of the objectives can be measured and assessed.
Regardless of approach an eclectic range of strategies has been suggested as forms of resolution. These include a refocus on learning for understanding and on the development of generic learning skills, values and attitudes to enhance learning ability and flexibility that would further encourage and develop engineers as lifelong learners and reflective practitioners.

*If re-engineering is to take place, it will require the incorporation of broader truths, bringing engineers to a reflexive consciousness of the contexts and consequences of their practice. (Johnston, 1996)*

Starting with undergraduates (or, desirably, earlier at school) engineering education should instigate a critical discourse which includes the social responsibilities of the profession and the individual viewed, analyzed and discussed from political, economic, cultural, and environmental perspectives.

*Engineers must recognize the relevance of community needs in every aspect of their work if they are to sustain their claim to be professionals. (Johnston, 1996)*

To initiate critical discourse and instigate and support development of the necessary skills for engineers of the modern era requires a ‘paradigm shift’ and movement from the traditional standards of science based content driven courses to courses situated in case studies and centered on student research activities.

Prados (1996) lists the following alternatives to traditional lecture style, information transmission and skills practice as desirable components/descriptors of the new engineering courses.

- active, project based learning
- horizontal and vertical integration of subject matter
- introduction of mathematical and scientific concepts in context
- close(r) interaction with industry
- broad(er) use of information technology
- commitment to developing emerging professionals as mentors and coaches.

It is based on these descriptors and those implied within, such as cooperative and collaborative, contextual, relevant and reflexively critical interactions, that I intend to investigate and refine a learning environment that is aimed at being effective and consequently (culturally) empowering to students learning mathematics (for engineering) in spoken and written English (as a foreign language).
Section II: The Research

Introduction

In this section I provide an overview of the research method used, including a definition of many of the terms I use to describe the stakeholders, and to explain what I see emerging as the research takes place.

In Chapter 4, I place a theoretical perspective on my research and the methodology I plan to use. As part of this I formulate (again) the questions that I believe are pertinent to this research. I then discuss the theoretical/philosophical viewpoints behind the greater ideals I possess for this research. I begin to situate my research within the scenarios I discussed in earlier chapters in that I look into the purpose behind this research.

In Chapter 5, I explain my choice of research methodology. In doing so I describe myself as a bricoleur, transformative and ethnographic researcher, and I explain how this connects with what I am trying to achieve in doing this research. It is at this stage that the duality of my research emerges as I first consider the evidence of my own professional and personal transformation (Mezirow, 1990b), the guiding principles for this transformation, and the concept of emancipation (Habermas, 1972; Young, 1990).

In Chapter 6, I look more deeply at some of the theory underlying the methods and the words I will use to investigate and report on whatever it is that I find.

*The resultant research is an emergent construction, a ‘personal (autobiographical) narrative’ and an (ethnographic) in-the-field report ‘pieced-together from a set of representations that are fitted together according to the specifics of a complex situation’.* (Denzin, 2000)
Chapter 4

Placing the Research into Context

Introduction

At this point I would like to develop the research problem by reflecting critically on the cultural context of my work as a mathematics lecturer at the Petroleum Institute. I will introduce some (possibly) contentious issues that seem to have a direct bearing on the teaching/learning process within the Foundation Mathematics Program at the Petroleum Institute.

I would like to start this section by stating clearly that it is not the intention of this research to judge the quality of Emirati culture or measure the efficacy of the teaching-learning culture of the UAE using Western science education as the ‘gold standard’. Nor is it the intention of this research to criticize the application of Western scientific learning methods within a non-Western indigenous culture.

It is the personal belief of this researcher that all cultures deserve recognition and respect. It is the imbalance in the power-relationships between contributing and/or conflicting cultures that this author may bring into question or attempt to address in the course of this research. The efficacy of neither is under question, except perhaps in regard to the context and relevance of their application in achieving predetermined personal and cultural goals of the stakeholders.

It is worth noting that as researcher I am operating within the bounds of my professional and personal experiences, beliefs and values, including ten years of living and teaching within a relatively different culture to that of my upbringing and, I conjecture, to that of the majority of my readers. Consequently, what the reader may interpret as criticism may, in fact, have been written with a far less critical intent. It is the intent of this research to avoid being judgmental and/or hypercritical, and instead to generate or synthesize a symbiosis amongst multiple cultures in order to instigate genuine communication between cultures and optimize student learning.
To achieve the goal(s) of this research I intend to investigate, identify and evaluate the cultural characteristics of my stakeholders which can contribute to the development of an empowering mathematics learning environment for English as Foreign Language students at the Petroleum Institute. In reflecting on the core nature of my professional work, across the many different levels of my experience and application, I plan to address the following research questions.

1. What am I really trying to teach in Foundation Mathematics?

2. What are the perceived benefits for my students of learning the Mathematics we teach at the Petroleum Institute?

3. What is mathematical competence in the context of my students and in the eyes of my colleagues at the Petroleum Institute?

4. How do I define and measure the mathematical competencies of my students and my colleagues?

5. Do I hold the same professional beliefs and values as my teaching colleagues and administration at the Petroleum Institute? Is my interpretation of mathematical competence the same as that held by my colleagues and/or my students?

6. Over what levels ‘of being’ does the value of mathematical competence extend?

7. What innovative pedagogical practices - teaching strategies and management protocols - employed by this Foundation Mathematics teacher are culturally empowering for both me and my students?

8. What beliefs and values are manifested through the learning of Mathematics?
9. How do cultural differences – ethnic, gender, generational, socio-economic – influence the effectiveness of teaching and learning strategies? What strategies can be adopted to produce successful cultural border crossings?

10. How can educational technologies, such as graphics calculators, computers, the world-wide web, assist the process of constructing an empowering learning environment?

My goal in seeking answers to these questions (and to others that may arise during my enquiry) is to clarify and re-define that which I experience as a teacher of Mathematics, and ultimately to improve my professional practice. In doing my research in this manner – interactively with my students and teaching colleagues – I hope to engage with them and to mutually enrich all our experiences, as well as answer my own important existential questions as a teacher.

Who am I? Why am I doing what I’m doing? How do I feel about what I and others are doing? Why do I teach? What is meaningful about what I do? What are things I need to do, should do and can do if I am to have the chance of being a truer person as well as a truer teacher? (Schmier, 1999)

At a later stage (see section III) I will use the data collected from and generated by students and teachers at the Petroleum Institute from surveys, questionnaires, and informal lessons observations and interviews to try to validate or refute the largely anecdotal observations about the culture of the UAE and its impact on teaching and learning at the Petroleum Institute.

My purpose for now is to provide an impressionistic account of key cultural forces acting upon teachers in this environment that (directly or indirectly) affect the quality of their teaching practice, especially their efforts to develop students as autonomous learners.
Theoretical Perspective

In terms of the educational theory (research papers) that I have read in an effort to understand what it is that I am doing and or seeking, I see the intent of this research to be the identification of an operable ‘third space’ (Luitel, B., 2006; Taylor, P., & Campbell-Williams, M., 1993). As such it is a conglomeration of interstices (Asher, 2005), those ‘in-between hybrid spaces that emerge at the intersections of different cultures, histories, and locations’. The space I seek, or seek to nurture and optimize, will traverse (and draw strength from) both the culture of Western science and the other learning cultures that influence and affect my students, colleagues and their environment. I consider this to be a space of confluence or convergence which connects multiple cultures some of which are complementary and others, as mentioned above, contradictory. In addition to the ethnic cultures outlined there exist numerous other sub-cultures influencing the viability of the learning experience. It is the contribution and reflexive interaction of these other cultures that dynamically populate these interstices. Contributing sub-cultures include gender, age, academic, professional (engineering), economic and religious influences among numerous other less identifiable and idiosyncratic existences.

The aim of this research is to find, or perhaps show (within the context of my teaching practice), how, where and when many of these cultures will combine to contribute to a meaningful learning experience and to construct valuable and viable (border) crossings (Aikenhead, G., & Jegede, J., 1999; Giroux, 1992; Ogawa, 1995). I believe it is (by my) operating within these spaces which will support and optimize the study of engineering and the empowerment of the learner and later the engineering professional. For me (or others) to do this effectively it is important that I as teacher and researcher understand these influences and some of how they affect the relationships within the frame(s) of reference selected for, by and of this research.

*Kumashiro (2000) suggests that in crafting anti-oppressive pedagogies “educators need to acknowledge and affirm differences and tailor their teaching to the specifics of their student population”*. (Asher, 2005, p. 29)
The importation and implementation of a dominant culture such as Western science into a largely non-Westernized and/or traditional culture can lead to situations of cultural displacement or replacement and devaluation of traditional beliefs. This process of enculturation (Aikenhead, G., 2000; Ogawa, 1995) can lead to a loss of personal and cultural identity on behalf of the indigenous population of the importing culture. This situation of conflicting beliefs and values can in turn lead to alienation from the philosophy and processes of Western science, and foster a situation in which the tenets of Western science are superficially accepted and learned (sometimes in a rote and canonical fashion), but have little perceived relevance or connection with the learner’s real-life world.

While not limited to ethnic cultures (cultural mismatch also occurs across generational, social, gender and economic cultures) the consequences can be significant, as learners develop parallel yet unrelated ‘modus operandi/webs of significance/zones of practicality’ inside of which understanding is pragmatic and self-contained. This style of learning seriously affects the epistemological and ontological development of learners, to an extent that individuals regarded as expert in a particular field may possess a naïve and immature view of ‘reality’ (Kitchener, 1990). Such a belief system in itself may impede the learners’ ability to take in and assimilate new information and may severely limit their adaptability and their flexibility to ask new and important questions, and to take appropriate action.

Such instrumental learning (Mezirow, 1990b) finds proponents, while gifted with skills of analysis, unable to operate effectively within undefined situations that require qualitative judgments, collaborative effort and the seeking of consensus (Mezirow, 1990a); skills which are characteristic of communicative learning, and prevalent in modern learning experience.

This formation of independent or parallel learning cultures or compartmentalization of learning can be observed and interpreted from the two closely connected perspectives of empowerment and emancipation. Empowerment of learners (Ernest, 2001) requires learners to have a full and critical understanding of the subject matter (Mathematics), the learning process, and implications and applications of both.
Those with a naïve ontological and epistemological viewpoint arguably do not possess such a full and critical understanding.

Emancipation in the context of this research refers to Jurgen Habermas’ critical theory (Habermas, 1972; Young, 1990) which defines the three fundamental areas of human cognitive interest as technical, practical and emancipatory. The technical addresses the ‘immediate and fundamental’ survival needs of the individual and is driven by a desire to control and exploit the environment. The practical is founded on reason and addresses social and cultural needs by way of understanding the environment for the purposes of coexistence and interaction. The emancipatory interest is concerned with the liberation of learners so they are able through reflection to make critical decisions and take action directed at individual autonomy and communal betterment (Grundy, 1987).

To create an environment in which learners are emancipated – freed, valued and empowered - it is necessary to cross cultural borders (Aikenhead, G., & Jegede, J., 1999; Giroux, 1992) - so that the host culture is valued rather than discredited by the imported culture (i.e., acculturation) in a way that enables both sets of knowledge and beliefs to coexist in a mutually respectful although possibly dialectical relationship (Willison & Taylor, 2005).

This research is an attempt to identify and implement pedagogical processes that empower students’ to develop their acculturative abilities by means of facilitating their two-way border crossings between a diverse array of learner and teacher cultures (Aikenhead, G., & Jegede, J., 1999).

My ideal is to develop an enlightened and appropriate curriculum that will liberate me, my colleagues and students by empowering us as critical thinkers capable of understanding and performing mathematical actions, while being aware of the consequences. I will actualize this by accepting that my students and my colleagues have different belief systems from my own and that if we are going to mutually benefit from this research then I must respect and include their expectations – beliefs, values and aspirations - within my own schema. To do so I must be pragmatic and equitable; and recognize all three fundamental human cognitive interests as pertinent
and relevant to my stakeholders. Only through observation and application of the
technical will I encourage my students (Engineers), my colleagues and myself to
develop an understanding and appreciation of our (contextual) environment that will
foster instances of personal reflection and critical understanding in critique of our
own position, place and of our performance and our significance within the
environment. To do so I will be creating what Luitel and Taylor (Luitel, 2007)
describe metaphorically as the ‘third space’ existing at the intersection of the two
dialectically competing spaces of alternative and contemporary mathematics.

*The growth of mathematical understanding is perhaps not to be conceived in
terms of a linear progression but as a loosely determined path through a
multidimensional lattice of concepts which are mastered as existing
knowledge is viewed from a new and more enlightened perspective.
*(Rowland, 1984)*

My approach in conducting this research will be eclectic. I will draw no straight lines
and I will make few, if any, bold predictions. I will, however, make connections
where ‘in the eye of my experience’ I see them, or when they are brought to my
attention by the other stakeholders pertinent to this research – and I will reflect upon
these and attempt to position them within the mosaic of my learning experience.

In Chapters 5 and 6, I will examine the philosophical underpinnings of learning, such
as epistemological and ontological beliefs, critical theory (technical, practical,
emancipatory interests), and related issues of instrumental and communicative
learning; open and critical discourse; and learner empowerment. In addition I will
examine pedagogical issues, including the interconnected subsets of curriculum
(relevance, development, negotiation) (Boomer, 1992; Duit, R., & Confrey, J., 1996),
teaching and learning methodologies and strategies; assessment and evaluation and
classroom and institutional management.

**Conclusion**

The purpose of this research is multi-faceted. As I stated earlier, in addition to my
initial goal of professional developmental assistance for myself and my teaching
colleagues I also view it as my own transformative learning experience; where through critical reflection (Mezirow, 1990b) I can re-evaluate my personal (ontological, epistemological, pedagogical) metaphors (Deshler, 1990; Johnson, 1987; Lakoff, G., & Johnson, M., 1980b) and through open and critical discourse (Taylor, P., & Campbell-Williams, M., 1993; Taylor, P., & Cobern, W., 1998) with my students and teaching colleagues, I can redefine and re-evaluate my teaching beliefs, values, understandings, expectations and practice as a teacher of mathematics. Then, positioned so, within the self-regulating cycles of my own personal and professional evolution I can further develop even more effective and empowering pedagogical resources.

To achieve this I intend to focus the lens of my enquiry upon the practical aspects of my teaching. That is, I intend to investigate my own (contemporary) mathematics teaching and learning practices within the context of an English-as-a-Foreign-Language (EFL) environment within the cultural context of the Middle Eastern Gulf States. I aim to use my own underlying personal and professional philosophies of pragmatism and constructivism as referents (Tobin, K., & Tippins, D., 1993) to investigate and test the efficacy and viability of my own (and others) administrative and pedagogical practices within the environs of the Foundation Mathematics Program of the Petroleum Institute.

*Being a teacher is not possessing a body of knowledge that is passed authoritatively to others; being a teacher is being a learner and helping others to learn effectively.* (Chen, A., & James, J., 1999)

The intent of this transformative research as professional learning is to provide me the opportunity for personal – intellectual, spiritual and cultural - growth. It gives me the opportunity to evaluate and refine my teaching methods so that I can provide my students with a more culturally relevant learning experience. As well, the study enables me to identify common student misconceptions (Sewell, 2002), student perceptions and life-world beliefs, and to develop teaching strategies (Fosnot, 1989) that connect, in a more coherent manner, students’ other cultures to their academic learning cultures.
The teachers themselves have to be researchers ... he or she alone, has full access to what happens in the classroom. (Pring, 1999)

It is envisaged that the ensuing research will provide a unique and timely understanding of the efficacy of innovative teaching and learning strategies on students from a ‘culture in transition’ which is being heavily influenced by traditional (objectivist) Western teaching practices and values (Universalism) (Luitel, 2006, 2007). It is intended that the results benefit my own teaching practice and my students’ learning approaches as well as providing my peers and colleagues (elsewhere in the UAE Region) with management and teaching strategies to enhance their own pedagogy.

It is further intended that other researchers use the findings herein to compare strategies and results devised within other learning communities/cultures.
Chapter 5

The Research Methodology

Introduction

In this chapter I look at how I am going to conduct my research and give reasons as to why I plan to approach it in a given way. In particular, I look at how this seemingly simple activity has grown and diversified from a simple exercise in providing some tools for best practice into what seems to me an almost all encompassing and transformative experience.

For me the ongoing process of conducting this research and writing up its findings and stakeholder observations is rapidly expanding into a much more ambitious project.

As I mentioned when opening Chapter 1, I began with the intention of developing a teacher support document designed to introduce and offer strategies for best teaching practice, effective classroom management and improved pedagogical performance. After a couple of illuminating experiences which I consider to be pivotal points within this research, I began to question my motives and to question the value and viability of what I was initially proposing. I have since learned that this questioning and any subsequent change of direction is quite common with experienced teachers (and other experienced professionals/experts) (Polkinghorne, 1992). I have since, upon reflection, recalled numerous instances of philosophical – epistemological, ontological and axiological – discussions initiated by myself or my peers as an extension of some initial practical issue that has realigned our teaching processes.

In acting upon my reflection (Chen, A., & James, J., 1999; Pring, 1999; Schon, 1991) and readjusting the objectives of my research to include my own personal and professional enlightenment, I had doubled my research load. I still wanted, and I still do want to produce a ‘good teaching practice’ document with the intention of helping many of the mathematics teachers working in the Arabian Gulf region who, in my
opinion, appear underprovided with fundamental professional support and development. However, just creating a compendium of recommended classroom activities with some side discussion and some classroom management strategies, is no longer enough. All and any of my suggested strategies and activities had to be justified as viable in the practical, philosophical and ethical sense. This was going to be difficult for one individual researcher to do.

It meant that my research became open for discussion and part of that discussion was to assist my seeking answers to such questions as – what am I really teaching when I teach mathematics? (Khait, 2005; Lakoff, G., & Nunez, R., 2000) What do my students get out of it? What is it from the teaching of mathematics that really benefits my students and what is it that entraps them? What will my students do with the mathematics they have learned in my course and classes? What is mathematics? What is mathematical competency and how do I measure it? (Niss, 2003; Thurber, 2002) These questions naturally lead to other questions or aspects of the same question.(Empson, 2002; Ernest, 2000)

I realized or recognized at this stage that I was looking at things from a personal perspective, which to me, could be best situated upon Jurgen Habermas’ three fundamental human interests – technical, practical and emancipatory (Habermas, 1972; Young, 1990). My initial interest, while people driven, I believed to be a technical solution or strategy. My ethical and philosophical response to my transformative experiences had also identified me as an emancipatory teacher, learner and researcher. My further investigation of these responses lead me to the concept of student (or individual) empowerment (Ernest, 2001), and on to cultural empowerment through mathematics (D'Ambrosio, 2001, 2007) and the democratization of learning (J. Henderson, 2001). Investigating these ideals further, including their interconnectedness with each other and pursuit of the greater ideals of human (cultural) liberation, emancipation, empowerment and democratization (Aikenhead, G., & Jegede, J., 1999; Asher, 2005; D'Ambrosio, 2007; Giroux, 1992; Luitel, 2007), provided a wider reason and motivated me to expand and extend this work.
While researching these particular ideas and ideals in the context of my own wider (institutional) teaching environment and its surrounding and inwardly permeating spheres of influence and or cultures, I suddenly came across another important objective that was highly pertinent to this research. That was the greater objective or need enunciated worldwide by engineering bodies and professional associations including, but certainly not exhausted by, ABET (Accreditation Board of Engineering and Technology in the United States and IEAust (Institute of Engineering, Australia); calling for the urgent upgrade of engineering education, as I outlined in Chapter 3.

In reporting these findings and as a result of my response in attempting to meet the criteria laid out for improvement of engineering education, my teaching and learning document expanded, or at least refocused itself to discuss my own educational philosophies and strategies in the context of improving the quality, viability and the process of engineering education (in my case within the Petroleum Institute), but with a wholly global perspective. To achieve such a broad objective I realized that I had to go beyond my own classroom and include my own teaching colleagues and the wider institution of the Petroleum Institute, in general.

As a seasoned administrator, albeit a very minor one these days, I have been long aware that I feel professionally fulfilled (and happy) when my teaching peers are themselves happy. My peers are happy, in my experience, when their voices are heard, their opinions are valued and their contributions recognized. For this reason it was necessary to include them in this research project so as to get their opinions on what I was doing, to get their input, and to learn what it was they themselves were (proud of) doing. In my experience, this is essential to develop harmonious teamwork in the form of common ideas, direction and mutually significant strategies.

In addition to increasing the size of my team, while I act as participant-observer within this research, and aim to act as natural and unobtrusively as is possible, I do have some personal theories I hope to tacitly test. To achieve this means I must watch and wait for what I hope will be the emergence of these same ideas, beliefs, values and connections from my colleagues and independent of my own
involvement, or possibly the emergence of some alternatives which lead me to discard them (my own).

So at this point, what was once a teacher support document has expanded and evolved into a self-transformative search for viable and ethically suitable teaching-learning practices and for viable management strategies and practices enacted across the whole Foundation Program (and beyond).

As I write these notes to assist me in accommodating these changes, yet another shift is taking place. Ongoing dialogue and debate between teachers within the Foundation Mathematics faculty has overlapped with discussion within other Foundation Program subject areas. Interested teachers in English and Information Technology have joined Mathematics teachers to develop cross curricular units of work which focus on the technical concepts of engineering including mathematics and its applications. Such cross curricular collaboration is also worthy of inclusion in this narrative as it is inextricably intertwined with all of the other aspects of this research within a college intent on streamlining its processes.

Fortunately, as one who describes himself as a connected learner, I am willing to include these concepts rather than exclude important data and perspectives and reduce something I see as holistic to a series of incomplete and seemingly unrelated observations.

It is my intention then, to investigate and report on all of the aspects of the research that I encounter and, all the angles at which they are perceived.

To deliver such a picture I envisage making a holistic and eclectic analysis, which entails what I have already described as a multi-faceted approach and which will include a variety of research activities including quantitative research such as empirical data collection and analysis; and qualitative research approaches such as anecdotal responses, case studies, scenarios and narrative writing, etc.
My metaphor for describing my action in piecing together such a wide and contrasting arrangement and array of data, ideas, activities and philosophies, is that of quilt maker, or bricoleur.

_The qualitative researcher may take on multiple and gendered images: scientist, naturalist, field-worker, journalist, social critic, artist, performer, jazz musician, quilt maker, essayist. ….. The researcher, in turn may be seen as a bricoleur, as a maker of quilts, or, as in filmmaking, a person who assembles images into montages._ (Denzin, 2000)

While I will describe myself in a variety of different ways in reference to my conducting and reporting of this research, the term bricoleur is a viable description.

To me this research, the research tools and the methods I employ are all consequences of action that is ‘pragmatic, strategic and self-reflexive’. The resultant research is an emergent construction, a ‘personal (autobiographical) narrative’ and an (ethnographic) in-the-field report ‘pieced-together from a set of representations that are fitted together according to the specifics of a complex situation’ (Denzin, 2000).

As this research is situated in a socio-personal matrix it encompasses a wide variety of stakeholders, including me, my students and colleagues, within the referential framework(s) of our institution, our profession(s); our personal and ethnic cultures. Social concepts such as empowerment, critical discourse, emancipation, acculturation, enculturation are as important as concepts such as cognition, metacognition, equilibrium, accommodation and assimilation (Kelly, 1963; Piaget, 1955) which are related to personal (radical constructivist) paradigms (von Glasersfeld, 1990a).

As teacher-researcher another metaphor that I use to describe myself for this transformative research (Johnson, 1987) is _explorer on an inward journey (meditative quest) seeking greater self realization_. This is because in addition to observing (and analyzing) responses to my various teaching methodologies, I am observing my own personal and professional development as I reflect and respond to stakeholder adaptations and responses. To assist me with this task I try to keep a
personal (teacher’s) journal (Lukinsky, 1990) in which I loosely record my observations, feelings – developing understanding, beliefs and values – and log my professional and personally transformative journey.

I describe the reporting styles for this research dissertation as (auto)ethnographic and critically autobiographical. I describe this work as auto-ethnographical because in addition to much of its content being auto-biographical in nature, I record my feelings as a participant-observer, who lives and works with (and like) those subjects who are being studied for a specified period of time (in this case 1-4 years.) within a given cultural network. (Van Maanen, 1999)

In operating in such a manner I am closely adhering to the definition of ‘ethnography’ as the painting of word pictures, using a variety of techniques – vignettes, short stories, commentaries, reports, and narratives – of the given culture embracing the teaching and learning of mathematics using English as a Foreign Language and, embedded in an engineering studies culture within a Middle Eastern University (The Petroleum Institute, Abu Dhabi).

In examining (critically observing, analyzing and evaluating) the ‘goings – on’ within the classrooms (mine and others) , faculty offices and administrative centers of the Petroleum Institute, I carry out social scientific research that befits the description of ethnographic and ‘relies upon up-close, personal experience and participation, not just observation’ (Genzuk, 2003). To support and broaden such participatory observation and to avoid the pitfalls of losing sight of the ‘wood for the trees’ I am involving and utilizing my own ‘multidisciplinary research teams comprising students, mathematics teachers and teachers from other faculties who are involving themselves mathematically by teaching mathematical ideas and content as part of teaching (other disciplines) of English language, Information Technology and to a lesser extent Physics, Chemistry and Geology. In including and employing these co-participant stakeholders I am attempting to eliminate associated hazards and reduce the chances of being too subjective, or possibly idiosyncratic, with my findings, opinions and even my choices of analysis and methodology. In addition to their invaluable support with this research, the very existence of these teachers – in possession of a different mind-set and pedagogical procedures – enhances the
teaching and learning of mathematics and the mathematization of all subject areas within the Foundation Program of the Petroleum Institute. This is something of such import that it will be further investigated and deeply reported upon (and evaluated) in later chapters of this research thesis.

To investigate the key concept of empowerment of learners of mathematics at the Petroleum Institute, I am collecting data from a wide range of teachers and students over a wide range of teaching situations. This data is taken in the form of interviews (of students and colleagues); scenario (classroom and faculty office) observations; and documentary artifacts such as institutional and faculty policy documents and working papers; curriculum and assessment guidelines; and work units and individual lessons.

To effectively tell this (my) story, as seen through my own eyes, filtered through my own lenses/schema of personal beliefs, attitudes and values, although somewhat influenced - mediated and refined – by the beliefs, values and attitudes of these other stakeholders, I am producing a narrative description of my experiences and my interpretations. Such a narrative includes relevant quotations, descriptions and excerpts, diagrams, charts and other artifacts as needed to tell the story of this research to other stakeholders and to uninvolved/outside observers in a clear and relatively unbiased manner. My intention being that all participants (can) draw their own conclusions and make their own interpretations.

*The challenge is to combine participation and observation so as to become capable of understanding the experience as an insider while describing the experience for outsiders.* (Genzuk, 2003)

Part of my challenge is in conveying a clear picture of my research environment and an accurate description of my experiences to other observers both inside and outside of this environment, i.e. my frames of reference. This is because such a description includes evidence of the changes or transformations that I (and my stakeholders) undergo as an ongoing consequence of the cycles of reflection, introspection and which are generated by the research activities and their (iterative and continuously evolving) outcomes (Chen, A., 1999; Schon, 1991).
Principle(s) of Ethnographic Research

The acknowledgement of continuity above obliges me to make (or at least identify) an apparent paradox, which if left unaddressed could be considered a contradiction within my reasoning and my approach to this research. This is because in following an auto-ethnographic approach I am using as rationale what Genzuk (1999) describes as the three fundamental (methodological) principles of the ethnographic method – naturalism, understanding and discovery.

Naturalism is the view that ‘the aim of social research is to capture the character of naturally occurring behaviour’. This perspective argues that it is both sensible and desirable that ethnographers ‘carry out their research in natural settings that exist independently of the research processes’. In following this reasoning (it is further argued that) the researcher will minimize the influences he or she has over the subjects being studied, and in turn allow for greater generalizability of the research findings and their applicability and or transferability to other cases and or research studies.

While I do not dispute this line of reasoning, in the case of my own research there appears need of greater description or distinction. This is because my own intended process by its own iterative, cyclic or autopoietic design (Capra, 1997) entertains the concept of self supporting and self stabilizing feedback loops. By its very nature and intent my research activities will have a direct and ongoing influence on my stakeholders and, of course, itself. In conducting my research in this cyclic manner I am remaining true to all of the principles of ethnographic research, including naturalism, because I am introducing and ‘explaining those social events and processes within the self regulating context in which they occur’. Namely, within a dynamic and empowering learning environment driven by the principles of continuous improvement (Morgan, 1994); critical constructivism and critical discourse (Taylor, P., & Settlemaier, E., 2003) and professional reflection and action (Schon, 1991).

I believe that any attempt to remove myself as a co-participant within the research process would be counter-productive and nullify the initial and overarching purpose...
of this research. Arguably, it would lead to reification of my own unsubstantiated beliefs as I lose what I consider my desirable (and contextually natural) spontaneity of response; and restrict myself to the analysis of my own isolated ideas and theories rather than report in and upon what should (to me) be an holistic process.

In maintaining my position as co-participant in this research, I am rejecting the concept of generalizability (Tobin, K., 2007) and replacing it with such criteria as credibility, trustworthiness and viability in that I am appealing to the individual experiences and subsequent responses of my readers. I believe that each reader is an individual learner with their own personal constructions - beliefs, attitudes, values, processes and protocols – and I leave them to take whatever they value and want from this research, including some areas of commonality and others of possible conflict.

Rather than seek generalizability, I seek to present a credible story about my interaction with the students and faculty of the Petroleum Institute which is truthful, fair and unbiased in the eyes of these other stakeholders, who shall act formally and informally, as auditors for this research, as well as protagonist, antagonist and conscience for its author.

In this way I address the second principle of ethnographic research, which is defined as understanding, because I am recognizing and acting upon the principle that human actions are more than simple responses to isolated stimuli. Instead they are more complex and ongoing constructions designed to interpret and test the stimuli and the actions themselves for future personal, social and cultural reference, response and assimilation into the individual’s schema. In the case of the teaching and learning of Mathematics within the Foundation Program of the Petroleum Institute, I am initiating and reintroducing strategies that act as stimuli to the learning and other responses of my students in an attempt to observe how they influence their beliefs, attitudes, values and practice. In addition, I am attempting through ongoing observation, interview, analysis and discussion; to gauge whether or not the effect is (considered to be ) individually and culturally empowering (Aikenhead, G., 2000; Ernest, 2001).
While I confess – indeed I have already confessed in the opening lines of this thesis – that I have and hold my own beliefs, theorems and hypotheses as to what comprises effective and empowering mathematics teaching and learning, I am placing these ideas to the back of my consciousness, in a genuine attempt at discovery (third principle of ethnography).

Having ten years experience of working within a very different culture I am aware of the different perspectives or world views held by my students and many of my teaching colleagues. As a professional educator and a life-long-learner I have already experienced many surprises which have been both enlightening and humbling, and I am aware that if I approach any (case) study with a set of preconceived ideas (hypotheses) I am going to miss other important observations as I attempt to prove my own value laden theories.

Thus this research seeks to discover new ideas, attitudes and processes that will transform this teacher as well as enlighten and empower his colleagues and students. This objective by its eclectic nature, I believe, is not as ambitious as it may at first appear.

As the format of this research is significantly autobiographical, I will tell much of my story as it is related to, and enacted through my own experience and by my personal interpretation of other people’s experiences within a research environment largely constructed and mediated by and through my own personal schema and cultural interactions. In essence, I present my own insights as my own story, as experiences delivered as direct commentary, as observations translated and transferred from my own journal entries, or as my own commentary on other stories presented in the form of vignettes and which I have taken from sources such as student-teacher interviews, questionnaires or other data.

**Autobiographical Data**

I am aware that data generation and its subsequent analysis can be problematic in an autobiographical situation. Traditional techniques useful for analyzing empirical data and even methods used to analyze other people’s data are less useful and more
questionable when it comes to reporting on one’s own data. To address what could be perceived as a crisis in credibility it is necessary that I (the autobiographer) ‘focus on self and practice, as researcher and practitioner, and reveal, in all its complexity and as authentically as I can, what I do, how and why I do it, and what it means about me and the context in which I operate (as modified by me from (Tenni, 2003)) as Mathematics Lecturer within the Petroleum Institute.

In presenting my story in this way I take a great personal risk. I am aware that to fully engage with my own data depends on me being aware of, and understanding my own ‘defense and sources of resistance to difficult, unexpected and confronting information or my reactions to such material’ (Tenni, 2003). In short, I bare my professional and personal soul to many, including many of those with whom I work closely every day. If I do not take this unnerving step then I place myself at further risk of discarding or ignoring pertinent observations and subsequently depreciating the value of my research or I possibly over-rationalize and intellectualize my information to render it impractical or, at worst, completely trivial.

Outcomes

As I have already stated there are many intended outcomes to this research, and one of these is my own personal and professional transformation as teacher and researcher. So while I am personally anxious about putting myself – my feelings, beliefs, attitudes, values and personal practice – on show, I will myself to overcome any feelings of self doubt and inadequacy and I set myself a course for the seeking of greater professional (theoretical and practical) and self (philosophical and spiritual) awareness.

*The willingness to see, confront and discover oneself in one’s practice and to learn from this is at the core of this work and central to the creation of good data.* (Tenni, 2003)

One consequence of the process of creating such ‘good data’ is the expectation, generated from experience gathered in collecting data and writing this thesis, that I write from my heart and soul as well as my intellect, to convey the passion I feel for
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my professional practice, its subject matter and even its politics. In doing so I present a ‘rich full account’ that conveys my weaknesses as well as my strengths. Such an account may at times, appear disjointed and disconnected, irrational or illogical, and will naturally include my fears, self doubts, mistakes and perhaps convey my delusions, all of which are data for analysis and interpretation by my readers.

In the sense I use here, critical-autobiographical-ethnography ‘signifies the textual representation of my personal experiences within my own cultural context’ (Luitel, 2003). These writings are critically autobiographical because I am ‘critiquing my own situatedness with others’– my stakeholders – within the multilayered context of my learning experiences. By reporting in this manner I place, and expose to others, and through, my own lenses – my beliefs, values, experiences - so as to justify my interpretations and personal responses (reflexivity) to those issues which confront me as a researcher and as a learner seeking transformation (Pereira, 2005; Taylor, P., & Settlemaier, E., 2003).

As an ethnographer I use a wide range of qualitative and quantitative methods as I cautiously move from learning about my stakeholders and their culture to testing my own related theories (interpretations and conclusions) (Genzuk, 2003), and I employ diverse methods of data collection – interviews, observation and documents (among others) to support the generation of a narrative description rich in quotations, descriptions, excerpts and artifacts such as diagrams and charts.

I am also writing as a means to reflect upon my own pedagogy and research method, which means I am writing for inquiry (Richardson, 2000). In documenting my observations of stakeholder’s responses and subsequently evaluating their attitudes towards a variety of teaching and classroom management techniques (differentiated learning techniques) (Bar-Yam, 2002; Gregory, 2002; Tytler, 2002) and innovations, I am applying the instructional paradigm of constructivism as my referent (Driver, 1994; Tobin, K., & Tippins, D., 1993).
Documentation

In addition, the documentation of this research targets the multiple perspectives of the emic – how the stakeholders (my students and teaching colleagues) perceive their own life-worlds/learning cultures; the etic - how each of these communities perceives the other, and the personal / autobiographical, as through my journals I attempt the sometimes painful task of providing evidence of my own reflexivity in the unearthing of my own deeply embedded cultural biases and beliefs (i.e. tacit knowledge). This being the case because I am aware I am more than just a passive observer/recorder in the course of events instigated by and through my research. I have committed myself, to a large extent to be a co-participant.

*The extent of participation is a continuum which varies from complete immersion in the program as full participant to complete separation from the activities observed, taking on a role as spectator; there is a great deal of variation along the continuum between these two extremes.* (Genzuk, 2003)

Data Generation and Collection

In general, this research will be ongoing and mainly conducted within the Foundation Mathematics program of an international (Islamic) university in Abu Dhabi, UAE, over a period of one year. The study will focus on pre-calculus classes consisting of 15-20 students each. Teaching colleagues including some non-mathematics teachers and students of varying academic ability will be observed, interviewed and their responses critically examined and discussed.

The data collected will be generated predominantly through naturalistic inquiry aimed at imposing minimum constraints upon the learning environment and the stakeholders; and will be presented predominantly as my ‘narrative of experience’ (Milne, 1993). This data will be both qualitative and quantitative, taken from student interviews, anecdotes, questionnaires, survey results and analytical derivatives such as student pretest and post-test results.
My research journal will record my interpretation of events as they arise and will act as a source of reflection and action, (Chen, A., & James, J., 1999; Schon, 1991), from which I will share my observations and interpretations on a regular basis. The effects of my sharing my journal entries with other stakeholders means I am initiating open and critical discourse at three levels – 1) within my own classroom with my students – 2) with teaching colleagues, giving my ideas a wider, institutional perspective; and 3) as reflective and personal discourse with reference to my own beliefs and research practices.

By researching and reporting in this manner, I am embracing the seven domains of curriculum inquiry – techne, poesis, praxis, dialogos, phronesis, polis and theoria (Henderson, J., 2001; Henderson, J., & Kesson, K., 2004). In particular, I draw upon my own experience and the critique (interpretation and subsequent endorsement) of my stakeholders to give credibility to my observations. The legitimacy of my arguments are founded within the domains of praxis, phronesis and dialogos (Pereira, 2005). As a living and cognizing being I demonstrate/enact self-regulation or autopoietic behaviour as I put my theoretical knowledge into practice to develop further practical wisdom, which I then apply and test to further extend and enhance my personal and socially validated theories (Capra, 1997).

Due to the interpretive nature of this research I adopt the quality criteria of Guba, Lincoln and others (Bryman, 2001; Denzin, 2000; Guba, 1989) as justification for and legitimization of my research methods and findings. In particular, I apply Guba and Lincoln’s (1989) dual criteria for legitimizing qualitative research, based on trustworthiness and authenticity, to provide a structural and ethical framework for the implementation, interpretation and ongoing development of this research.

In modernist terms my attempt to validate my data and observations could be considered triangulation methods (Denzin, 1978 as cited in Janesick, 2000). In this sense I attempt to employ data triangulation through use of varied sources of data; investigator triangulation by employment of multiple participants within and evaluators of this research; theory triangulation in canvassing multiple perspectives on single sets of data such as student surveys and other artifacts; and methodological
triangulation as evidenced in using multiple methods of study to examine an individual situation or problem.

However, as an emergent post-modernist researcher/educator with a strong belief in the multi-dimensionality of learning and in the many facets or iterations of the self regulation that defines life, a more appropriate description of my method of validation is crystallization (Richardson, 2000). Such an approach, to me, fits well with my adherence to multiple perspectives and multiple methods of observation and analysis that do not necessarily seek a single shared truth.

*Crystallization, without losing structure, deconstructs the traditional idea of ‘validity’ (we feel how there is no single truth…crystallization provides us with a deepened, complex, thoroughly partial, understanding…. Paradoxically, we know more and doubt what we know…we know there is always more to know.”* (Richardson, 2000; p. 934)

In the case of legitimacy, or how accurately the research represents the reality of events as perceived by stakeholders, I interactively audit all responses and provide regular feedback (via my journals and other methods) to stakeholders, and encourage open and critical discussion with them as means of confirmation of my interpretation of generated data. Regarding my own credibility, I have already argued that all knowledge, including research findings, are interpretive and as such represent different ideas, beliefs, values and feelings to different stakeholders. In order to confirm the dependability of my interpretations I make my observations over a prolonged period and open them for re-interpretation by all stakeholders. The transferability, or degree to which the findings of this research are transferable to other situations, is optimized by broad description of the context and culture of the inquiry. However, because different experiences give rise to different interpretations stakeholders are not expected to reach full agreement; and consequently data and contextual transfer, as educative authenticity, is optimized through mutual or complementary learning rather than complete agreement. Confirmability of the research is further optimized by openly recorded (and reported) data, whose sources, methods of analysis and interpretations are easily tracked and audited by stakeholders.
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To ensure credibility of my qualitative data I adhere to the principles of: (i) prolonged engagement (research takes place over a prolonged period of time); (ii) progressive subjectivity (my reflective journal maps the evolution of my ideas during the course of the research); (iii) negative case analysis (students targeted for analysis are taken from all levels of success, including those who appear to be in conflict with the aims of the research); (iv) member and peer checks (in which all stakeholders are encouraged to check and critique the research data and interpretations and add their own interpretations.

In opening this research to all stakeholders I establish an environment which encourages open and critical discourse, in line with the theory of ‘communicative action’ (Habermas, 1972), and which establishes an ethic of emancipation aimed at the liberation and empowerment of all; rather than simply serving my own technical interests.

Ethical Considerations

As previously stated, to avoid disrupting the established learning (processes) of my students I conducted this action research as part of my normal teaching practice. To establish mutual ownership of this project, the purpose of the research, the process and stakeholder involvement in data collection, generation and analysis were explained and stakeholder permission was confirmed.

For reasons of privacy, confidentiality and professional and personal integrity, individual stakeholders are anonymous and in the case of individual references, pseudonyms have been applied. All participants were aware (see Appendix 5.1) that they had the right to select those questions they wanted to answer and those they preferred to waive; and that they had the right to withdraw from the research activity at any stage.
Conclusion

According to the criteria laid out by Denzin and Lincoln as editors of the Handbook of Qualitative Research (2000), this research is situated in the seventh moment. By its nature qualitative research means different things to different people, but from my perspective and awareness of my intent as author there are several sub-definitions I apply to what I am doing. Its positioning as a product of the seventh moment is evidenced in the concern of this research with the moral dimensions of emancipation and empowerment and its inclusion of critical analysis and discourse. In positioning itself so, this research seeks to initiate and ‘engender critical conversations about democracy, race, gender, class, nation-states, globalization, freedom and community’ (Denzin, 2000). In addition it looks at other important interconnected and interrelated concepts such as intra- and intercultural relationships, human technological progress and the environment. The cultural matrix that embeds this research is the mathematics classrooms of the Foundation Program of the Petroleum Institute, Abu Dhabi, and the means of initiation and promulgation of the intended debate or dialogue is through the application of mathematics as employed by undergraduate engineers. In this case it is expedited by means of observation and discussion regarding the relevance or context of the content matter, the fallibility of the methods applied and the overall use and abuse of mathematics in a technical society including of course, the consequences. For me as a mathematics teacher this works as a ‘double-edged sword’ in that the added relevance this critical approach gives to mathematics content and learning is highly motivational and in itself empowering.

As the author of the research I view it primarily as postmodernist research in that it attempts to present its findings in narrative form as I attempt to tell my own story, or at least express my own observations, interpretations and opinions from the vantage of the first person. The fact that I am using a variety of approaches and that my already accorded avenues of argument are clearly non-realist and/or post-positivist also categorizes this research as a blurred genre, and metaphorically justifies my description as bricoleur. The fact that I am using such an eclectic array of methods without privileging any particular one also confirms the postmodern position I am taking.
Having positioned my research methodology as primarily qualitative approach and one based upon a postmodernist and non-positivist perspective, I will next look at the epistemological, ontological and axiological stance or stances I need to justify and or present to represent the direction and findings of the ensuing research.
Chapter 6

Theoretical Referents

*Social inquiry is a distinctive praxis, a kind of activity (like teaching) that in the doing transforms the very theory and aims that guide it. In other words, as one engages in the practical activities of generating and interpreting data to answer questions about the meaning of what others are doing and saying and then transforming that understanding into practical knowledge, one inevitably takes up concerns about what constitutes knowledge and how it is to be justified, about the nature and aim of social theorizing, and so forth. In sum, acting and thinking, practice and theory, are linked in a continual process of critical reflection and transformation.* (Schwandt, 2000, p. 204)

Introduction

In this chapter I outline the underlying educational and sociological theory that defines and drives much of this enquiry. In particular, I explain what I mean when claiming to be a (critical) constructivist and a pragmatist. I also look at what motivates these claims in the first place. As a practicing teacher I believe that I fit no one specific category or definition precisely. I see myself and my practice as ever-changing and evolving. As a teacher I am always adapting my resources and my approach, but never fitting what I see as one specific classification or category at any one time. However, some categories, paradigms or perspectives do describe me (and my professional activity) better than others and it seems to me that some specific paradigms do have significant influence upon who it is I am and on how and why I teach and conduct my research in the ways I do. From my perspective, as teacher and researcher (in action) I recognize dominant paradigm influencing my work, but rather three co-existent or competing paradigms held in a dialectic tension – constructivism, pragmatism and criticalism – which allow me to rationalize within later chapters, examples of what I call complementary opposites such as male and female, theoretical and practical.
Constructivism

My combination of epistemological, ontological and axiological beliefs leads me to describe myself as a constructivist.

Constructivists believe that the mind is the primary source of knowledge and that reality is constructed rather than discovered. Whereas the traditional (positivist) paradigm of teaching and learning holds that there is a single external reality which can be accessed and understood by an objective observer, the constructivist paradigm holds that multiple socially constructed realities exist, which observers can only subjectively access. Thus it follows that research or inquiry using constructivism as its referent (Tobin, K., & Tippins, D., 1993) is value-bound and focuses on the interpretation of observations of phenomena rather than with objectively proving or refuting an hypothesized view of the one true reality.

As a constructivist I believe that knowledge construction is idiosyncratic and is a consequence of personal resolution of situations engendering cognitive conflict. I also believe that often (or, arguably, always) these situations of resolve are influenced by other individuals and are carried out in a social medium. As such my interpretation of constructivism embraces both the radical and social aspect in that I see individual understandings and interpretations as theories – (single) iterations of a process – which are mediated (rejected, accepted refined) in response to and in relation with other stakeholders. So while knowledge or understanding, to me, is an individual construct (radical constructivism), the process of construction is mediated and legitimated in a social context (social constructivism).

The above interpretation provides a rationale for my teacher-research practice within the Foundation Mathematics Program of the Petroleum Institute. The pedagogic strategies I apply to improve the learning experiences and outcomes of my students are designed to individualize their learning experiences and are validated from within a social / cultural medium. Believing that each individual will learn differently – in a different manner, making different connections, nurturing and constructing different values and understandings in collaboration with their peers - I use constructivism as an underlying epistemic referent for my lesson development and my personal
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transformative inquiry, especially the criterion of viability, to gauge and evaluate the levels of my success.

Pedagogical Implications of Constructivism

_Ultimately the import of an educational paradigm concerns its implications for practice, notably in pedagogy._ (Ernest, 1995)

Using viability as the major criterion for curriculum development and implementation permits a great deal of freedom in what I as teacher and developer choose to do within the mathematics classroom. Such eclecticism implies a wide and varied approach to teaching and learning, but it does not mean complete freedom. In particular, certain learning protocols and values must be adhered to in order to optimize learning opportunities. Constructivist learning protocols preferred by this teacher researcher and like-minded colleagues at the Petroleum Institute can be summarized as follows.

1. Sensitivity toward and attentiveness to the learner’s previous constructions (knowledge, understanding, appreciation, methods).
2. Diagnostic teaching that aims to remedy learner errors and misconceptions; with perturbation and cognitive conflict techniques being part of this.
3. Attention to meta-cognition and strategic self-regulation by learners.
4. Use of multiple representations of mathematical concepts.
5. Awareness of the importance of goals for the learner, and the dichotomy between teacher and learner goals.
6. Awareness of the importance of social contexts, such as the difference between folk or street mathematics (and an attempt to exploit the former for the latter).

In taking such an eclectic approach as teacher and researcher I believe myself to be pragmatic although, as I will argue next, not in the complete sense of the definition.
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Pragmatism

In addition to being a pragmatic teacher who develops and implements curriculum eclectically, I also consider myself a pragmatic researcher.

As a pragmatist I believe that knowledge is acquired through experience, interpreted through reason, and is temporary and tentative. I consider ‘expert knowledge’ such as mathematics to be negotiated understanding based upon the agreement of experts. As a pragmatic researcher I consider my research question(s) and their ensuing solutions to be more important than the methods employed to reach these solutions and the underlying paradigms involved in justifying them. As I said before, I choose my methods according to the criterion of usefulness, namely, whatever seems to work best in the given conditions. Consequently within this research I apply both quantitative and qualitative approaches and, wherever possible, I ignore distractions thrown up by theoretical issues.

As a pragmatic researcher, one of my intentions is to concentrate on developing a ‘toolkit’ of methods and techniques for fellow (pragmatic) teachers to use should they so desire. I have collected and offer an eclectic range of such from various and differing areas of professional practice including pedagogical and management/business. Total Quality Management, which I have designated for discussion in Chapter 8, is one such example of a resource that I value and apply. I use these tools as the need arises, regardless of their epistemological and/or ontological bona fides. As a matter of fact, I sometimes use these applications to test and verify my own theoretical questions.

As a pragmatist my ontological position can be considered to be both realist and relativist. While admitting the possible existence of an external reality, I do not have to accept that one single and/or irrevocable truth exists which can be determined, and I am permitted to question whether one description/explanation of reality is more accurate than another. Unable to determine which theory or paradigm relates best to reality, I unashamedly choose and apply those best suited to achieve desired outcomes or those which adhere best to my own beliefs and values.
As a pragmatist my epistemological position is dynamic and translates itself along the continuum between the objective and subjective positions, according to the requirements of the context of the research I am carrying out. In this research, for example, there will be times or situations arising when I will choose to interact with other stakeholders; and there will be times that I choose to be more objective as I attempt to observe other stakeholders detached from my personal beliefs and values. In most cases I will position myself somewhere in between. This is because the axiological position of the pragmatist is that research is value-laden (somewhere between value-free and value-bound). Pragmatically I hold that my beliefs and values as a researcher are critical in the selection of my research questions, methods and protocols; and in the interpretation and presentation of data, findings, results and conclusions.

In this regard, I have no problem with the interaction between my own value system and the generated data and process of my research. This is because while other contemporary belief systems, such as post-positivism (Lyddon, 2000), constantly search for better explanations of reality, pragmatists believe this is not achievable and instead select those explanations that best fit their own values.

The pragmatic view of science as primarily a practical activity directed at constructing useful knowledge, as opposed to seeking a better or truer understanding of a real world, is one such viewpoint guiding this research.

In terms of describing myself as a pragmatist I consider my belief system and my practice most inspired by the ideas and works of John Dewey rather than the more recent and, in my view, controversial viewpoints of Richard Rorty (Rorty, 1991; Rockwell, 2003). Rorty’s interpretation of pragmatism excludes the existence of an external reality, which is something I personally cannot exclude. This is because I believe there is a reality beyond my experiences or sensorial system, but as I can neither access nor confirm its existence, like Dewey I exclude it from all except my deliberations, and focus instead on those practices within my spheres of influence.

Another highly significant paradigm relevant to this research is criticalism or critical constructivism (Taylor, P., & Cobern, W., 1998), as derived from critical theory. I
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have come to recognize this paradigm (emergent within the course of this research) as the dominant driving force for what I do as researcher and as classroom teacher/critical constructivist.

**Ethical Research and Critical Theory**

Critical theory was initially developed from the numerous philosophical and applied theories that emerged from Karl Marx's critique of capitalism. As a result, the lenses of critical theory focus largely upon the emancipation of society through a genuine democratization of individual and collective cultures (humankind) seen as those seemingly oppressed by traditional regimes such as, but not only, capitalism.

Consequently, a major characteristic of critical research is its aspiration to expose and challenge what is inequitable in society and to change the status quo.

This is an important issue for me as teacher/reformer/critical researcher. It is not enough for me to identify and interpret inequities and inconsistencies in society in my own way; I must also genuinely attempt to challenge them. Critical research aims to bring about social change and ‘challenges the status quo in a more radical way’ (Mingers, 1992, p. 105 as cited in McLean, 2007), so as to eliminate social inequities and help the disadvantaged. Clearly, this intention to change society or social reality for the better is a fundamentally ethical stance, the realization of which is enacted through the emancipation of humankind.

*Emancipation describes the process through which individuals and groups become freed from repressive social and ideological conditions, in particular those that place socially unnecessary restrictions upon the development and articulation of human consciousness.* (Alvesson & Willmott, 1992 p. 432 as cited in McLean, 2007)

The act of emancipation is directed at eliminating injustice, prejudice, political and cultural imbalance, and attempts to help people (individually and collectively) achieve their true potential. The definition and description of perceived injustices and imbalances remains subjective and varies from culture to culture, but in general
emancipation is an attempt to enlighten and (through that enlightenment to) empower individuals.

Critical theory and the concept of emancipation probably originated in the social commentaries and theories of Karl Marx. It was further developed by a group of researchers – Max Horkheimer, Theodor Adorno, Herbert Marcuse and Jurgen Habermas – collectively referred to as the Frankfurt School. Other philosophies/viewpoints/paradigms such as feminism and post-colonialism have emerged either directly or in consequence of this work, and sharing similar practical aims are now also considered as critical theory.

In educational research it is the critical theory of Jurgen Habermas which has been most influential.

The Critical Theory of Jurgen Habermas (An Aside)

A philosopher and sociologist Habermas articulated an extraordinarily wide range of ideas relevant to the social sciences, social theory and the critical theory of knowledge and human interests. Habermas identified three main areas in which human interest generates knowledge. These relate to how we classify or define knowledge. Described as being 'knowledge constitutive', they determine the mode of knowledge and mediate the warranting of knowledge claims. As such these areas define the basic human cognitive interests (learning domains), and are grounded in the different aspects of social existence – work, interaction and power.

From the perspective of research in education these three domains may be renamed the technical, practical and emancipatory domains of knowledge/interest/action. It is worth noting that at this stage I am referring to the warranting of knowledge claims of (this) educational research as opposed to the closely connected and interrelated actions/areas of educational practice such as curriculum and pedagogy which will be discussed later within this chapter.
Technical Knowledge

Also known as instrumental knowledge, the technical interest lies in how we can manipulate and control our environment. The technical cognitive interest arises from the fundamental need of the human species to survive and to reproduce itself, and is manifested in attempts to control and manage the environment (Taylor, P., & Campbell-Williams, M., 1992).

Technical knowledge then refers to ways we can carry out this manipulation leading to eventual perceived control of our environment. In terms of research this type of knowledge is based upon empirical investigation and is governed by technical rules. Arguably, all areas of scientific research such as applied mathematics, physics, chemistry and those areas which contribute to engineering constitute examples of technical (or work) knowledge.

Practical Knowledge

Practical interest (interactive knowledge) refers to human social interaction by way of what is called communicative action. Such knowledge and ensuing action is governed by binding consensual norms between individual members of society. These can be related to empirical or analytical propositions, but their legitimacy is verified through mutual understanding. Many of the historical-hermeneutic disciplines such as social science, history and law constitute examples of practical (or interactive) knowledge.

Emancipatory Knowledge

The emancipatory interest/emancipatory knowledge manifests as self awareness or self-knowledge generated via personal analysis as enacted in critical self-reflection. Contributing factors include an individual’s (researchers) personal history and/or biography written as how these persons see themselves individually and culturally. Emancipation, by way of personal awareness, is sought as liberation from oppressive social/cultural (institutional) and environmental influences which restrict (one’s) potential by limiting individuals’ options and reducing/restricting autonomy –
personal control of their lives. Examples of emancipatory or critical sciences include feminist theory and psychoanalysis.

The Transformative-Emancipatory-Critical Paradigm

Transformative-emancipatory-critical researchers do not base their choices on 'what works' as pragmatists do, but on an explicit value choice to advance justice, democracy and help the oppressed or less advantaged. (McGriff, 2001)

The above description of a transformative researcher exposes a contradiction to my claims of being a constructivist pragmatist teacher – learner – researcher seeking or engineering his own transformative experience. It seems particularly contradictory because the stated goal of my research is to develop/construct (and implement) an empowering mathematics learning environment for foreign language students. I justify my position or self definition as follows. As a pragmatist I seek to identify and apply viable processes that will enhance my functioning as a teacher and assist me to achieve my desired outcomes. One major outcome of my teaching is the empowerment – mathematical, social and epistemological – of my students (Ernest, 2001). In achieving this goal, or more accurately in attempting to achieve it, is to make my students aware of the greater world, and as part of this awakening see how the (mis)application of mathematics – as a gatekeeper (Stinson, 2007), as propaganda and or the highly contentious belief that mathematics is an infallible science – distorts their view of the world and is used to deny them and others access to justice, democracy and freedom.

In a more positive sense, one of my aims is to help them see how mathematical thinking and application can be used to free them, and empower them to realize and achieve their own ideals and goals.

Conclusion

In education it is the teaching-learning activity/ process which provide data to test the educational theories. It is these classroom or institutional practices which test the
efficacy of all theoretical postulations regarding institutional learning. Regardless of their scientific authenticity – accuracy and reliability – underlying theories or objectively derived concepts in education arguably are meaningless until they are shown to serve (practical) educational purposes.

In providing an ethical/emancipatory justification for educational reform and personal transformation critical theory provides a theoretical scaffold/background to those approaches and methodologies used by action research advocates such as myself. It is this theoretical background, rather than any epistemological or ontological underpinnings which supports and justifies the research in action evident in the following pages of this thesis.
Section III: Constructing a Culturally Empowering Mathematics Learning Environment

Introduction

In this section I use my teaching/learning environment at the Petroleum Institute and surrounding, interacting zones of influence to model – develop and describe holistically – what I perceive to be a culturally empowering mathematics learning environment in progress for EFL engineering students at the Petroleum Institute.

In Chapter 7, I discuss the existence of what I believe to be the culturally empowering mathematics learning environment that exists within my classroom at the Petroleum Institute. As part of this I describe the strategies and practical examples that I and other colleagues use to set up and sustain what we perceive as emancipatory learning.

In Chapter 8, I look at how a culturally empowering classroom environment can be supported ‘in the field’ by means of faculty policy, procedure and management protocols. In particular, I consider the idea of enacting or role-modeling empowerment by working within a collegial unit where the teachers themselves are empowered. I refer here to my own positive experiences with the philosophy and practice of TQM (Total Quality Management) and explain how I use this as an administrator and team leader at the Petroleum Institute.

In Chapter 9, I expand my enquiry beyond the borders of the Foundation Mathematics Program. I look at the interaction between this program and others, particularly at how we (in mathematics) have collaborated with colleagues from the English faculty and the Engineering programs. I consider how these colleagues have contextualized and or mathematized their regular curriculum, such as the STEPS program, to provide wider access and experience for our students to work and think mathematically. In addition to explaining what is happening within the Petroleum Institute I describe how the teachers have reached out to the wider educational community of the Gulf region and the world engineering education community by way of the METSMaC conferences. In support I discuss examples of student work activities for further discussion and analysis.
Chapter 7

Constructing a Culturally Empowering Mathematics Classroom

Education is one human activity that is profoundly affected by attention to environment and inner experience. (Slattery, 1995)

Introduction

This section is aimed at exploring innovative teaching and learning management strategies designed to engender critical thinking, self-direction and collaboration within, and between students and teachers. My intent being to offer an investigation which is being carried out within the context of realistic and achievable educational reform and which is situated within an emergent postmodern framework.

Due to the holistic nature of teaching and the oneness that is teaching and learning, I have in some places integrated faculty management and policy.

Journal Entry – February 2008

The further this enquiry goes the larger it seems to get. I have difficulty selecting direction or points to make and I am questioning much of what I am doing in my professional practice. If teaching and learning is, as I perceive, a whole and irreducible experience of the individual teacher (as learner); and ‘teaching cannot be reduced to technique’ [Parker 2007] then why am I continuing with my original goal of developing a useful ‘manual of strategies and procedures’ to assist others?

My reply to myself seems to have many parts – or justifications to keep going. I still recall and indeed still meet and interact with those individuals new to teaching or in some cases just new to teaching mathematics, who were so in need of any kind of assistance. Some still ask for help directly, or indirectly, for clarification in using me as a ‘sounding board’ for some idea they have come up with or some realization they have come to.
This in itself is enough to keep me going. Not just for passing on my experiences and looking like the venerable old master – far from it – but for maintaining the dialectic, continuing the discussion and the debate that I find so refreshing, so stimulating and life-giving to my own teaching practice.

Following on from this is my own style of self development and development of ideas. I am not one for starting with nothing and collaboratively brainstorming and forming ideas. I always start with something concrete – not as a fait accompli – but as clay for reshaping.

The ideas, samples and examples I provide in this chapter are suggestions. I have found them useful and in many ways successful, but not entirely so. They have allowed me to ‘streamline’ my practice and have helped my classes run more smoothly. I believe most of my students enjoy being challenged by what we do, while at the same time feeling informed and secure in what we do. My colleagues have adopted some of these strategies with success and have in turn been the source of many of the strategies I use. The fact that they are willing to try some of the things I suggest and are willing to offer their criticisms and refinements to many others indicates (to me) that my teaching is alive and breathing. Their critique of these and their reflection upon their own practice provides me with much valuable input and food for thought during this chapter.

Democracy is an ideal that is filled with possibilities but also an ideal that is part of the ongoing struggle for equality, freedom and human dignity.
(Slattery, 1995)

Encompassing the desire to assist colleagues and to make the learning of mathematics more enjoyable for my students (and theirs) is a greater ideal: to democratize education. To liberate, emancipate and empower myself, my colleagues and my students as mathematicians, as learners, as human beings on a local if not a global scale.

But how does one achieve emancipation and empowerment when teaching mathematics at an engineering college in a wealthy country such as the United Arab
Emirates? I find this a rather difficult task in as much as I am teaching to and with those who believe they are in many ways very privileged. In such an environment it is difficult, even irrelevant, to discuss injustices perpetrated by the Western system of education to those who have successfully passed through its numerous gates and checkpoints (Stinson, 2007). Many of the lecturers have passed through the gates/checkpoints of the modernist era and still believe strongly in an objective reality and function very much in a modernist and ‘structuralist’ mode.

*The chief aim of all investigations of the external world should be to discover the rational order and harmony which has been imposed on it by God and which He revealed to us in the language of mathematics.*

(Johannes Kepler, as cited in Doll, 1993, p. 134)

While I do not personally agree with the substance or the sentiments of Kepler, I have still been greatly influenced by those who do and it is easy for me to slip towards their point(s) of view. It is, however, not easy convincing those whose great passion is mathematics that mathematics is a human construction (Lakoff, G., & Nunez, R., 2000) and not the language of the cosmos, tuned to eventually reveal the truth about (in their eyes) a very real universe. It is also very challenging work to convince people with very strong religious beliefs and rituals that all men are created, and should be treated, as equals irrespective of culture or religion.

The best way I know to achieve this is through acceptance and dialogue, and by challenging and perplexing my learners with problematic scenarios and by modeling other (not necessarily perfect) possible solutions via solution scenarios, which I believe, live close to my learners’ everyday life-world experiences. Through my own experiences I perceive that when people are working together, rather than competing against each other, attempting to solve complex problems or sharing ideas related to a particular perplexing scenario, that mutual respect often develops, if not due to admiration of the other’s ability then through the sharing of ‘hardships’, challenges, possibly even with the infrequent acceptance of failure.

I attempt to do this by initially gauging and meeting learner expectations, establishing an environment of supported risk-taking where prompt and regular
Constructing a Culturally Empowering Mathematics Classroom

feedback allows my learners to orientate themselves and assess their progress. In this inquiry into my teaching practice I attempt to initiate and sustain this cyclical mechanism – assess, evaluate, modify and moderate – by means of my emergent research questions.

Such a modeling process involves providing students with contextual or relevant examples, in this case engineering problems, which also connect to global issues such as environmental and cultural degradation. In addition to being contextual these models attempt to challenge the students’ own academic and life-world assumptions including their tacit acceptance of the infallibility of mathematics.

It is the evaluation of these models and their application and management that I seek through answers to my research questions. I seek these answers in many ways, such as drawing my own answers through observation of my colleagues and students, including observing my own interactions and thinking; and by directly asking them these questions as part of a general questionnaire or in individual interviews.

The results/responses to these questions are interspersed as vignettes at relevant parts of this report or in the appendices.

Curriculum for an Effective Classroom

There seems to me to be a wide and eclectic range of ideas about curriculum, how it should be interpreted, executed, deconstructed, reconstructed and just exactly what it is? Because of such a variety of opinion it is difficult if not downright adventurous to come up with a personal description or definition. But then, in my opinion, a personalized interpretation of this is probably what is most needed to provide an adequate description. Provided that the person doing the describing includes both their philosophical/theoretical and a practical interpretation, I believe an accurate and valid perspective of curriculum can be offered which may be interpreted and employed as a referent by prospective readers. This is what I am attempting to provide here.
Constructing a Culturally Empowering Mathematics Classroom

Curriculum in the modernist sense of my own experience – schooling, teacher training and later professional development – has largely been explained (almost literally) as a course to be run. In many ways it has appeared (as) a prescribed course (or trail) which could have, perhaps in the eyes of many, should have, been followed step by step and in almost precise detail. I believe this is what influential (modernist) curriculum theorists such as Ralph Tyler, Franklin Bobbit or Elwood Cubberly believed when they developed their practical perspectives which closely followed the scientific and industrially derived principles laid down by Frederick Taylor and others in keeping with the realist scientific philosophies of Robert Locke (Doll, Jnr. W., 2002). Such a viewpoint of curriculum has been the dominant operational paradigm for a significant period of time and as such has been around long enough to be analyzed and re-exposed from a variety of angles and for a variety of reasons – philosophical and practical. Some criticisms of this perspective have been presented on epistemological and ontological grounds such as the pragmatists’ argument that ‘if there is no definite truth then there exist no one single and privileged belief or belief system’. Taking this line of reasoning it follows then that all systems of belief should be judged on their viability or applicability to specific situations rather than one overall dominant and correct system of belief. This has in turn led to criticism leveled at curriculum (the course) and curriculum studies (the thought) as being irrelevant, even moribund (Schwab, 1960), and having a hidden agenda; or at least holding more than one kind of agenda. Curriculum for example has been described by Eliot Eisner as comprising the ‘explicit, the implicit and the null (Cherryholmes, 2002). In this scenario Eisner argues that curriculum can reinforce or support certain values and practices through what is excluded and what is hidden but implied, as much as by what is included in the curriculum. Meaning that certain established prejudices and practices such as unethical control and denial of (certain) freedoms to stakeholders may be supported overtly or tacitly by what is included or excluded from a curriculum. In many cases these criticisms can be linked to arguments of power, of cold reason and hard control (Taylor, P., 1996) and maintenance of a sometimes undesirable and inequitable status quo (D'Ambrosio, 2007; Stinson, 2007).

Recently a number of theorists generally categorized as post-modern ‘(post-structural, post-colonial, post-patriarchal and post-industrial’ (Cherryholmes, 2002),
have more closely aligned their ideas to the ways of thinking of influential practical philosophers such as John Dewey and Frederick North Whitehead (Doll, 1993; Mack, 2006; Vanderstraeten, 1998) who have advocated a more personally relevant or situated curriculum. One which could be better described metaphorically as currere, (Doll, 2002, p. 43), or the running of the race, rather than the racetrack.

*We need to reconceptualize the nature of curriculum, to see it not in terms of plans preset or ideologies advocated, but as an image hovering over the process of education, giving direction and meaning to that process.* (Doll, 2002)

Such a viewpoint focuses upon flexible negotiation of curriculum activity based upon the development of (self organizing or reflective-responsive) educational experiences rather than the subsuming of content knowledge and attendant (behaviorally) derived response skills.

This viewpoint is more in line with the constructivist argument that knowledge is constructed rather than just being ‘out there’ as part of some external inaccessible objectivist reality. It implies that learning, and therefore its ‘mapping’ in the form of curriculum, is very much dependent upon those unique circumstances which influence and interact with and within it. These circumstances/influences are all naturally occurring parts of the learning environment and very much include the learner.

As a practicing teacher I ascribe partially to this belief, although I further believe that curriculum must be viewed and activated from both perspectives, as a course to be ‘run’ and the running of the course. I believe in the requirement of curriculum as a course to be run so as to provide an optimization of process and/or guidelines, boundaries, restrictions that are formulated and (sometimes) enforced to provide the common needs of the community of stakeholders. In my own situation I must provide a curriculum/course designed to cater for the general needs of students wishing to become Engineers. In doing so I have to be aware of the general requirements placed on us (me, my peers and students) for providing a learning environment/situation that develops skills in problem solving, analysis, applications
of technology; and more recently (refer to Chapter 5), skills in collaboration, communication and an awareness of cosmology, ecology and sustainability. So for me, a course must be laid out to direct me, my colleagues and my students, as a signpost to give some indication of where we are going and through which ever changing areas/terrain we must pass to get there.

It is this second consideration of an ever changing terrain that makes me ascribe as well to curriculum as a verb, as the running of the course, as each individual stakeholder applies different abilities, values, beliefs, experiences to negotiate, interact with and change the original terrain.

In doing so I believe I reject the modernistic dualistic distinction of curriculum vs. currere. I favor neither the student nor the content, instead preferring to recognize the intimate and interdependent relationship, the ever changing oneness shared by and within the integrated perspectives which, in my experience, fosters a shared relevance or ‘aliveness’ (Whitehead as cited in Kesson, 2002) within the ‘throb’ of interaction, interpretation and transformation.

Seeing myself as pragmatic in my application I adopt the approach that Jacques Derrida describes as reading curriculum and/or currere ‘sous rature’ (under erasure) (Cherryholmes, 2002). In this posture I ‘see’ curriculum as ‘dispersed and deferred, as are my efforts to negotiate it’, and requiring ‘continuous interpretation, criticism and rewriting’ (p. 120). Similarly, my attempts to read currere ‘under erasure’ can be interpreted as being my locating of the study of Engineering within the broad context of its use, both contextualizing the engineering and the study as sources of interest and motivation.

Functioning in such a manner I see myself as an emergent post modernist, in that I am still grounded in modernist technique and frames of reference. Subsequently, I try to navigate a passage through my own ‘questionable’ (in the eyes of post-modernism) beliefs and techniques, using these same beliefs and values, but at the same time regularly questioning, refining and redefining my professional and personal self.
As a man enmeshed in his own ‘webs of significance’ I identify with Cherryholme’s description/critique of Lee Shulman’s 1985 address to the American Educational Research Association (Cherryholmes, 2002, p. 121) and Shulman’s apparent reading of Pedagogical Content Knowledge (PCK) (p. 121) under erasure, in that much of what I attempt is framed in modernistic terms but aimed at facilitating my transformation professionally and personally towards a postmodern perspective of practice. By this remark I believe that much of what I am soon to intimately describe my teaching and its facilitation are described and rationalized by Schulman’s words,

*A second kind of content knowledge is pedagogical knowledge which goes beyond knowledge of subject matter to knowledge for teaching …, I speak of content knowledge here … of the particular form of content knowledge that embodies the aspects of content most germane to its teachability. I include, for the most regularly taught topics in one’s subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, – explanations and demonstrations — in a word, the ways of representing and formulating the subject to make it comprehensible to others.* (Cherryholmes, 2002, p. 122)

This certainly described my feelings when I began this (re)search, but as I formulated and asked my questions I found that there were deeper and (to me) more important issues and questions to be asked and answered. Issues that influenced what and how I taught in Mathematics classes, that both influenced my teaching and learning from the outside as well as issues emanating from my ‘classroom’.

I decided that to ignore these issues would be foolish even dishonest to myself and my stakeholders. At the same time to fully give way and surrender my whole focus to these influences would be missing the whole point of my research. In the end – or at least in the process – I decided to continue with my initial objectives but as the importance of what I had been doing had shifted focus I decided to ‘map’ my progress or emergence as I reflected and responded to what I was doing.
I have read many inspiring words and have experienced interactively as well as, as an onlooker, many inspiring moments since I started this study. I have learned and unlearned, then reappraised and realigned many things, and all the time I felt that I was circling, spiraling back around again through my cycles of reflection-on-action, reflection-in-action, action-on-reflection (Lee, 1999; Pring, 1999; Schon, 1983, 1990, 1991), always re-evaluating what I was thinking and doing, asking ever deepening questions and seeking what I felt were sometimes inaccessible answers to seemingly indefinable questions.

Throughout all this searching and questioning myself and others there seemed to be a recurring theme – empowerment. Whatever I was doing and whatever evidence I was looking for my ultimate goal seemed to be to liberate and empower my students, myself, my environment, my peers – are we not all one anyway?

As I have discovered and keep discovering in a variety of ways this goal/objective/ideal manifests itself at various levels.

One of these levels is the way I live my personal life, as an imperfect environmentalist and humanitarian. Another is in the words and the ways I write these pages as part of my personal and not quite practical philosophy; and yet another is the enactment of my beliefs and ideals through my life’s work of teaching. One of the dances within this, my act of teaching, occurs through the iterations or interactions of writing-implementing-evaluation-refining/writing curriculum. While performing this dance it is the earlier manifestations that act as my quality control, checking what I am doing and (re)questioning much of what I do.

If this sounds confusing it is because one of us, probably both, is still trying to conceptualize in a linear manner, something which is highly iterative self-regulating and I believe autopoietic (Prigogene, 1996).

To provide the necessary simplicity required to convey parts of something high in complexity I (once again) retreat to use another’s words;
As both a teacher and administrator, I have endeavored to make a difference in the lives of children and teachers. (Wickersham, 2002)

In her commentary/critique of Cherryholme’s chapter in Curriculum Visions (Doll, W., & Gough, N., 2002), Ellen Wickersham goes on to say of her role as a teacher..

‘This was a package deal; my goal, or, in John Dewey’s terms, my ends-in-view, quickly became to help my students achieve both knowledge and skills and the means to achieve satisfying and fulfilling lives’ (p. 127).

My own package-deal is very similar. The teachers under my supervision may believe themselves to be a little more qualified, and my aspiring engineers may appear more worldly than Wickersham’s fifth graders, but all in all when the technologies and techniques become redundant and/or obsolete, I believe it is the passion and the ability/willingness to take risks and face the unknown that will sustain them as people and as professionals/practitioners of their particular ‘craft’.

So I try to teach more than just ‘mathematics’, I attempt to use my passion for mathematics to enthuse and engage my students, and also as a lens through which to focus their attention and awareness upon a wider world which includes their own abilities, esteem and aspirations.

In attempting so I recognize that within my environment I cannot completely or even substantially relinquish control. For a start my students would be extremely uncomfortable and I predict that they would quickly complain to administration that I am not doing my job and probably that I am jeopardizing their learning. Such is their basic expectations of learning inculcated through a schooling system that is far more authoritarian than my education was back in the 1970s. Instead I attempt to meet student’s initial expectations and deliver a mathematics course or curriculum that is well mapped out. The difference for me, and my students, is that I exercise or at least encourage that which is referred to as ‘emergent control’ (Doll, Jnr., W., 2002), wherein much of the direction the course takes and its facilitation largely ‘arises from the situation at hand’ and guides the activity, based upon student needs and negotiation towards a consensual conclusion.
In terms of control, complex systems have relations built into them. These systems need no deus ex machina, for they are not mechanistic and have no outside force governing them. In Dewey’s terms, they have no preset, external ends; yet, as Whitehead says, it is in their nature to be unified. (Doll, 2002)

In my hybrid emergent situation then things are far from ideologically or theoretically sound, particularly in terms of shedding the bonds of modernist and structural control. However, within a traditional curriculum structure, governed by numerous prerequisite rules, semi-prescribed course content issues and rigid assessment protocols, exists an emerging frame of mind or attitude which encourages and fosters critical thought and dialogue, negotiation, reflection – in and on action; and genuine communication in the form of conversation (Moore, 2002).

Such are my small but significant beginnings as I attempt to empower through encouraging my stakeholders to question the outcomes of their decisions as applied to mathematics, and to take risks as they theorize and comment on their ideas and observations.

Students arrive in the Foundation Program of the Petroleum Institute expecting to be stimulated and challenged with what they consider to be high-powered mathematics. They are often disappointed. Coming from the Science stream within the local high school system they have studied calculus and its applications and are ready for more of the same. Instead they enter a pre-calculus course fully taught in the English language. For them this can be very frustrating because they don’t always see the need to relearn in English what they have already learned in Arabic. For the teachers there is a different frustration, students don’t have the language proficiency nor the work habits and ethic to become successful engineering undergraduates, but they think they do.

The curriculum for the Foundation Mathematics program was initially designed by teams of teaching engineers from Colorado School of Mines. It was half way between the required pre-calculus courses of US high schools and the freshman bridging courses of the US colleges. It relied heavily on (what I consider) a fairly good textbook chosen for its wide range of applications questions including those
which used graphics calculators as tools for modeling. The incoming teachers relied heavily upon this text but with time made their own adaptations to make the course more relevant for the students. For their own convenience they also made several working assumptions that perpetuated as the course progressed. While teachers realized/recognized that some of these assumptions were being questioned in almost every lesson, they held onto them for the sake of orientation and foundation.

One of these assumptions was about the relational level of English language (proficiency) of the textbook, the teaching materials, the teachers themselves and the students. What was assumed was that the levels of the text and materials were suitable for students whose high school grades including TOEFL results were quite high.

This first assumption was challenged and re-aligned through the introduction and analysis of what I called a basic skills or baseline test.

**The Baseline Test**

The Mathematics Baseline (basic skills) test was first trialed in 2004 on students entering the Pre-Calculus 1 course through classes presented by this teacher. Primarily a vocabulary test, it tested the assumed entry level of Mathematics in English vocabulary of students as found in the course textbook, teacher lesson plans and early sections of (completing) student notebooks. The findings of this test were so dramatic that they instigated an immediate and ongoing reappraisal of the course materials presented and their presentation strategies. As a result, in 2008 all students entering the Pre-Calculus 1 course sat the baseline test, and all responses were viewed and analyzed by teachers with statistical and qualitative results widely shared across the faculty and the Foundation Program. Students diagnosed as at-risk (STARs) are identified and supported within the faculty and across-the-other-curriculum areas of English, Information Technology/Computing and Science. Students who performed strongly in the baseline test were also identified and were often used as mentors/support students for the STARs within the classroom and for homework and project support.
Ongoing fine-tuning of the baseline test has led to the inclusion of a problem solving section to gauge the presence (or absence) in students of standard problem-solving strategies and the addition of questions to identify common student misconceptions carried on from high school mathematics classes.

**The Structure of the Baseline Test**

The baseline test (Appendix 7.1) consists of six sections. Four of these are mathematical/technical vocabulary sections and are designed for students to connect a particular (technical) word with a graphic – picture of a geometric shape; or a formula/algorithm, a subset of a given number set and or mathematics symbol. The fifth section is a simple algebra test which is designed to identify any simple misconceptions carried through from high school and the final section is a series of problems that require direct strategies for solution (or alternatives). Solving these problems requires mastery of simple technical vocabulary, awareness of simple strategies and some spatial cognizance – which is something many learners in this region do not possess through lack of exposure in high school mathematics.

On the back of the basic skills test there is a simple contract that both students and teachers sign, as a symbol of their mutual commitment to learn mathematics in a mutually supportive and stimulating environment. It is to this contract that students are referred when they initially breach a collaboratively negotiated classroom operating procedures (Appendix 7.2).

There appears a wide and eclectic range of supporting evidence for the use of a baseline test, beginning with the practitioner’s own professional experience (Gray, 1997).

Numerous educational scholars and or practicing constructivists state clearly that if learners construct their knowledge, understanding and learning strategies from previous knowledge and experience then it is necessary for teachers to have an awareness of at least some of this previous knowledge, beliefs, values and processes (Confrey, J., 1990; Driver, 1994; Duit, R., Treagust, D., & Mansfield, H., 1996; Ernest, 1991; Fosnot, 1989; Tobin, K., & Tippins, D., 1993).
Professor Norman Reid of Glasgow University takes what I view as a more traditional and an empirical approach to his work on memory and memory overload, including recommending the use of pre-learning experiences in the learning of Science.

*The aim of pre-learning was to bring to the surface previous ideas so that these ideas enabled the selection filter to work more efficiently. The new material was more easily understood as the working memory was less likely to overload.* (Reid, 2007)

Paul Cobb, Erna Yackel and Terry Wood arrive at this conclusion from a more cognitive approach.

*We have suggested that initial instructional activities that constitute starting points for students’ mathematical constructions should satisfy two constraints. On the one hand they should make it possible for the teacher to draw on students’ prior experiences when guiding the negotiation of initial conventions of interpretation.* (Cobb, P., Wood, T., Yackel, E., & McNeal, B., 1992)

Feminist emancipationist educator, Nell Noddings, comes from another.

*Pedagogical constructivism suggests more sophisticated diagnostic tools – tools that will uncover patterns of thinking, systematic errors, persistent misconceptions.* (Noddings, 1990)

The baseline test is more than just random questions on a sheet of paper. It is a non-threatening procedure in which students are told the truth about their prior mathematical knowledge or at least about ‘where they are at’ in relation to our courses. There are no assessment marks given for this test. It is solely to determine what students do and do not know. Students are advised to treat this test honestly and openly so that teachers can identify and later remedy student lack of knowledge, blind-spots and misconceptions. In addition it is a formative tool because students are also notified that the content is requisite student knowledge for the course. This
motivates them to go home and research and remedy any deficit knowledge, understanding or skills. That, in turn, provides them with a suitable vocabulary for the ensuing pre-calculus course.

For the teachers the results of the baseline test often are a revelation. For many, their initial expectation is that students will score close to 100% in most categories. As the following data shows that was and still is, far from being the case.

**Baseline Test 2004 - Data and Observations**

In order to avoid unrealistic assumptions it is necessary to pretest students (entering the course) for competency in English. In the case of a math class we are looking at students’ English-Mathematics Vocabulary. Students entering the Precalculus 1 Course were tested in 4 areas of Math Vocabulary.

- **Physical Vocabulary** for describing a physical object, item or concept, such as prism, integers, etc.
- **Algorithmic Vocabulary** refers to standard formulae, such as the midpoint formula.
- **Logical Vocabulary** is for more tenuous concepts such as positional and logical operators such as direction, and, initial, between, etc.
- **Symbolic Vocabulary** which refers to correct syntax, symbolic manipulation, etc.

In Physical Vocabulary students are asked to match 10 objects with their ‘English” names (provided).

In Algorithmic Vocabulary students are asked to match 10 formulas with their ‘English” names (provided).

In Logical Vocabulary students are given a set of numbers and asked to write 10 subsets based on ‘positional/logical’ descriptors. In Symbolic Vocabulary – students have to simplify 10 math expressions applying symbolic manipulation, notation etc.
For each area students score a (raw) decile. This decile is used to compare individuals and class groups by means of class averages, standard deviations, etc. Data is also checked for bias and corruption.

It is worth noting that the **content in the baseline test is considered to be necessary criteria**. Meaning that, students are expected to possess this knowledge already.

This ‘content’ is chosen from a review of the student texts, teacher expectations and notes, past exercises and exams and student high school syllabi and texts. In essence it was not unreasonable to expect students score a decile of ten in all of the areas.

This in fact was not the case (see Table 1.1 and Figure A below)

Table 1.1 below gives the baseline test results as class averages (in deciles) for the 7 classes tested in 2004. Each class (listed A to G) contained a variable number of students ranging from 10 to 18 in number. All students sat the baseline test within their first 3 days of arriving at the Foundation Program.

**Table 1.1- Baseline Test Results – 2004**

<table>
<thead>
<tr>
<th>Class (decile)</th>
<th>Physical (decile)</th>
<th>Algorithmic (decile)</th>
<th>Logical (decile)</th>
<th>Symbolic (decile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
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<tr>
<td>C</td>
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<td>6</td>
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<tr>
<td>D</td>
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<tr>
<td>F</td>
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<td>8</td>
</tr>
<tr>
<td>G</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>
In some areas, actual student vocabulary was less than 50% of that expected. Some classes performed better than others, but no class achieved anywhere near the desired result. In short, our students knew far less than we expected and certainly had far less than the vocabulary we required them to know to comfortably understand our questions and or explanation (Figure B).

![Average Knowledge Deficit](image_url)

**Figure B**

![Average Student Vocabulary](image_url)

**Figure A**
The issue is to address and reduce this deficit.

*Addressing the Knowledge Deficit*

Three methods are applied. These we title … Band Aid, Preventative and Formative. **Band Aid** is the standard method of addressing shortfalls in knowledge (in this case vocabulary) used by most teachers. That is to list ‘new’ vocabulary as part of each lesson to explain/describe within the problem context and then move on. This method has a few weaknesses in that teachers do not always anticipate vocabulary blind-spots and so may need to use up valuable instruction time answering unforeseen questions, or worse teachers may not be aware that their students have little idea of what they are talking about. Often ESL students (and others) memorize an algorithm without understanding anything about the process or its application. This can be reduced if the vocabulary is clear at the outset. Band Aid is a useful and necessary process.

I will leave the other 2 methods for later discussion because, as their names imply, they are general too much of the work done throughout this research and so equally applicable elsewhere.

**In addition** students were tested for preference and competence in choosing a particular problem solving strategy. This was done in two ways;

Problems were given to students which entailed them using specified method. Their success was mapped by using an index of 1-3 depending on how successfully they applied this method, and

Open-ended problems were given to students in which a variety of approaches could be used. Each student’s problem-solving approach was noted and once again a success indicator (index 1-3) was applied.
These strategies were categorized as:

- **Physical Strategy** – use drawings, maps, plans etc to assist.
- **Algorithmic Strategy** – write/apply standard formulae etc to assist.
- **Logical Strategy** - use/apply (some) logical process, explanation or interpretation.
- **Symbolic Strategy** – convert words to symbols other than standard formulae, manipulate symbols.

> My experience is that when students are entrusted and empowered in a holistic environment, the quality and quantity of their scholarly work improves exponentially.... Learning and discovery replace grades and course credits as the focus of the curriculum. (Slattery, 1995)

In 2008, student responses seemed a little better. To the analytical mind they may not appear significantly improved, but what happened was the development of an interesting culture. Verified by their older peers, students are more believing of the classroom teacher’s comments that this is necessary vocabulary and are spending time learning the many simple words and definitions we require as course prerequisites. A small number of students with brothers and cousins already studying at the Petroleum Institute do research the required definitions before arriving here.

The fact that the purpose of this non competitive non-gradable test is/was to identify and remedy weaknesses and obstructions to learning mathematics means that, although we do change questions each year, we are only interested in preparing our students for learning. The fact that they are doing it themselves is a delightful and beneficial outcome for all involved.

**Student Centered Worksheets (Algebra Review - Diagnostic)**

Born out of the baseline test results for the algebra section has been the introduction of a series of student centered collaborative worksheets to commence the Pre-Calculus 1 (opening) course for Foundation Mathematics. A significant and
frequently recurring number of student misconceptions and misapplications of basic algebraic approaches have been identified in the baseline tests and teacher attempts at remedying these as a standard classroom process have been spectacularly unsuccessful as those same errors occur again and again in later student class-work and assessment tasks. Part of this we believe is because initial attempts at remediation were done during the opening weeks of the courses during which students were coming to terms with a large number and variety of distractions such as navigating a new physical environment, new systems of protocols and procedures and even coming to terms with new and strange teacher accents.

To remove a few of these distractions and provide students with a smoother, less stressful arrival into the Foundation Program, Foundation Mathematics has developed a series of worksheets (Appendix 7.3) which use a minimum of written English. These sheets employ a small number of technical terms in getting students to work on relatively standard high-school algebra questions (which are) often of the type used to expose student errors and misunderstandings.

In addition students are given at the same time a collaborative assignment that they must work on with one or two partners in class and at home (Appendix 7.4).

This combination of tasks has led to what appears to be a very comfortable and enjoyable entry for students into our courses. While the long term data has yet to be collected, at first appearance teachers are reporting that students seem more engaged, are assisting each other, including discussing each other’s apparent misconceptions and beliefs. In the case of disputes teachers are being called upon to mediate and asked to provide verification in the form of more detailed explanations to seemingly more interested students who hold a higher stake in the outcome than was previously the case.

Different teachers have used different approaches. Some of the more traditional staff members have at times tried to introduce certain concepts before students attempted the sheets. They have reported mixed results, from greater student attention in anticipation of getting an insight into the upcoming worksheets to teachers who have started but given up due to students being inattentive due to a debate/discussion
raging over a previous question. Other teachers have issued students with all of the sheets and the assignment together with a deadline and then allowed them free rein. Other teachers, such as I, myself, have issued sheets on a daily basis or every 2-3 days and have included milestones or checkpoints to ensure students are keeping to a loose but necessary time frame.

As curriculum developer and coordinator of this section of our course I am happy to accommodate all approaches as teachers appear comfortable with what they are doing, are more communicative of their successes and failures and are happier to share their ideas, anecdotes and critiques with their colleagues (including me as designer and researcher).

**Collaborative Research Projects**

The Foundation Mathematics Course is a Pre-Calculus Course which relies heavily on mathematical modeling. Using recent technology, such as computer animations and graphics calculators, students collect data and model solutions in an attempt to arrive at a relevant and explainable answer. An important and necessary part of teaching this course has been to familiarize students with the graphics calculators they will use constantly for the next year (or more). Until recently this has been done through demonstration and providing students with samples of procedures and examples to help them learn the use of the calculator. The calculator research project is an attempt to move away from teacher driven demonstrations and to pass responsibility for learning how to use the calculator and how to discover the calculator over to the students.

In addition to developing technical and mathematical skills, students are also developing research, collaborative and communication skills. This is something which has not gone unnoticed by our colleagues in other faculties. For example, for the past three semesters mathematics and English teachers have collaborated to make this a joint project. Students now begin the semester issued with a collaborative project (for 2-3 students) which contains a list of calculator keys, menus and procedures and a couple of recommended websites. Students must go to these sites (and others), read their calculator manuals (and others) so they can research these
phenomena, and teach their uses to their peers three weeks later. This means that the students now spend the first three weeks of semester researching their calculator in their spare time in mathematics classes and then refining their written and spoken explanations, demonstrations and descriptions in their English class. At the end of two weeks students hand a written copy to both teachers so that the Mathematics teacher can gauge (and grade their) technical knowledge and understanding and their English teacher their writing skills. The annotated sheets are then returned to the students for refinement and use at the end of the third week when the students present their findings orally (using handouts and other media) to their peers and teachers. The supervising teachers then amend any grades according to how well the students (showing understanding) explain to their peers, and more importantly provide prompt and relevant feedback to the presenting students.

Yet again there have been ‘spin-offs’ or by-products as the high standard of presentation media developed by students has encouraged the Foundation Information Technology teachers to join in, assist students with the development process, and consider adopting the project as an assessment task in the future. A second by-product has been that student materials put on display have become resources for the next semester’s students looking for explanations and answers, and English teachers looking for samples of presentations to assist students develop their speaking skills have filmed the presentations and made short video clips useful for both themselves and the mathematics teachers.

One consequence seems to be greater commitment to the courses by students. They seem happier to manage their own time in class and they appear to take greater pride in their creations and presentations. They also, I believe, see greater relevance to engineering studies in what they are doing than when they worked separately in Mathematics, English and Information Technology.

‘Problem-posing education, responding to the essence of consciousness, rejects communiqués and embodies communication’ (Friere). Liberating education consists in acts of cognition, not transfers of information. When the illiterate peasants of [Freire’s] Third World classrooms, as well as uncritical students of First World schools, begin to participate in a problem-
posing and problem solving educational experience they begin to develop a new awareness of self, a new sense of dignity and ultimately an experience of hope. (Slattery, 1995)

As a mathematics teacher my students seem more knowledgeable about their calculators and more willing to discuss them and other issues with their peers and their teacher. With this, I believe comes a greater sense of achievement and the raising of their dignity as learners and people.

Journal Entry – March 2008

How do I begin? I have/share so many noble ideas that are seemingly useless unless somehow I can put them to real practice. I feel inspired – so many readings and from them so many ideas I once thought were my own unique beliefs, yet now I find them already covered, already discussed and printed and ‘out there already’. The concept of order within chaos contained in the works of Ilya Prigogene, Umberto Maturana et al. has been comprehensively linked to curriculum and pedagogy as a postmodernist enactment. I have been motivated and inspired in my readings of Slattery and now move on to other postmodernist writings and viewpoints such as those of William Doll, Jr., through which I find as many connections between my own questioning and struggles with scientific thought, its abuse or deism in the form of scientism and my own pedagogy. But how can I, now influenced by such philosophical empathy, make this happen? How can I make this a meaningful reality or at least an outcome of my teaching? To this end I am further inspired by the words of Alfred North Whitehead.

The harmony of the whole is bound up with the preservation of the individual significance of detail. (Whitehead as cited in Slattery, 1995, p. 252)

I use these words and take my own advice from my own personal philosophy, developed from experience and passed on as parental advice to my own clever and idealistic children. “To change the world you must start from within” or “You can only change the world from the inside.”
In the case of this research work I interpret Whitehead as meaning that if I am going to influence the ‘world’ and change it in the way I see as appropriate then I must work within my own boundaries and perhaps in time I can extend them to include a (if not the) wider world (that is my own webs(s)) of significance.

Then to emancipate, liberate and empower all of those within my spheres of influence so that they may go out within their own and influence others as they see fit or interpret such fitness, I will continue to work within those bounds placed upon me, such as student, institutional and cultural expectations. I believe that only by initially meeting these expectations and changing them slowly from within will I have any success.

My teaching then is as expected. It is at one with this research. All that is attempted here is a searching, even a yearning. It is a transformational journey, a bridge or border crossing between two imaginary classifications or cultures. But by simply yearning, searching and trying to do things that work within the boundaries of my professional existence I sense that I am leaving the restrictions of modernist thought and venturing towards the ideals of postmodernism (Doll, 1993; Slattery, 1995)

In the postmodern curriculum it does not make sense to evaluate lessons, students and classrooms based on predetermined plans, outcomes, or standards, for like the elusive electron, relationships and potentialities explain their existence – and not predetermined structure. (Slattery, 1995)

The curriculum or work units unfolding in this chapter as examples of my own ‘personally preferred practice’ (under given conditions) are bound by the overt, implicit and tacit conditions and restrictions placed upon them by Petroleum Institute vision, mission, goals and expectations; and by my own professional limitations, beliefs and values.

Their spirit and their position on the imaginary continua of curriculum and philosophical evolution are largely postmodern (Doll, 1993; Slattery, 1995) but their history and the forces that created, and to some extent still shape them, are modernist, objectivist and Tylerian (Tyler, 1950).
Constructing a Culturally Empowering Mathematics Classroom

While lesson goals and objectives conform to (some) predetermined principles and a course outline/syllabus exists to ensure that students are trained in and about the required and desired aspects and content of engineering mathematics, there exist broader, more flexible curriculum outcomes that are spontaneously arrived at and ‘teased out’ of what could otherwise be a very intense and technically orientated curriculum. Whereas such structure and content belies modernism, an objectivist epistemology (discover the truth) and a realist ontology, the spontaneity of process although imperfect, and the intent, however, is post-modern and attempts to stimulate greater awareness, autonomy and critical thought within its learners. These are outcomes something the Tylerian model of predetermined purposes, experiences, organization and determination would consider adjuncts at best and, by the nature of its being, try to suppress.

Like my own ongoing transformation that occurs as I spontaneously and simultaneously write and reflect upon my practice through these pages, in and on these pages, my teaching practice is intended to be self transformative. In this I mean that although I do start with predetermined objectives other than the content and skill specific goals so inherent in the teaching of mathematics to engineers, I also have broader cultural or philosophical intentions. For example, when I present students with a problem either in written form or through a scenario, I usually aim at their development of important or higher-order skills in addition to the development of mathematical skills, knowledge and understanding. My lessons are aimed at stimulating cognitive conflict within individuals and often intra-cultural conflict within groups as preconceived ideas and values are challenged. For me, as I will soon show through detailed description and analysis, my problem posing creates situations where negotiation, communication, innovation and consensus building are often required. By challenging some basic assumptions my students often hold about mathematics I strive develop in them the need to question carefully and to recognize that mathematics is value laden and interpretive.

In doing so, as someone trained in the modernist, objectivist tradition, I realise that I should also question my own intentions and influences. For example, in writing these few lines I must consider how I argue my own imperfect position and stake my own questionable claims.
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_Cause and effect has taken [such a] powerful hold on our minds that we have the greatest difficulty in freeing ourselves from its compulsion...unconsciously we fall back on it at every turn. It has become our natural way of looking at all problems. But in spite of allegiance, the principle itself is mistaken: nature is not strictly a succession of causes and effects. Embodied within nature, defining its very essence is the powerful force of creation, of spontaneous action, of self regulation._ (Doll, 1993, p. 5)

But if I am to successfully transform my teaching and the learning of both myself and my students I must begin with what I know and through personal awareness of my own influences (as difficult as this is to see) slowly and iteratively regulate my transformation(s). So my (shared) transformation will be a gradual one, and certainly iterative and non-linear in its course. While at times my trajectory will seem predictable I expect the overall mapping to appear random, although confined to certain bounds by practical and philosophical restraints. At one extreme I see those bounds imposed upon me by my institution and my professional limitations and at the other my personal and philosophical boundaries as enunciated in my ideal of the democratization of teaching and learning, which is to emancipate and to empower.

The following examples then, like their creator(s), are ‘caught between paradigms (Doll, 1993, p. 62) and so, are part of the pragmatically derived process of translation and or transformation towards a newer more idealistic paradigm. They are offered heuristically on a ‘local scale’ as samples and examples that can be considered and possibly adapted for others to use, and importantly on a wider, more global scale as stimuli, as thought provokers, as fuel to generate discussion and debate as to how, where and why they do or don’t fit, and as my contribution to the ‘dialectic tension that suspends belief’ and maintains, in my opinion, a healthy interplay between an eclectic array of belief and practice.

Curriculum that Challenges

The Foundation Mathematics Curriculum has developed from a straight textbook driven course into one that aims to be contextual, multi-representational, challenging and discursive. In attempting this it has spread from a faculty based course to one
which is now remarkably cross curricular. Ideas and concepts traditionally developed in mathematics classes now find their way into other faculty areas as part of developing student language and research skills and as part of social and ecological debate. Part of this debate often stems from the inconclusiveness or ambiguity of some of the mathematics results that come about as part of the modeling process, which is in turn exacerbated by the realization/recognition that the technology used, like the mathematics employed, is in fact fallible, questionable and open to corruption and, of course, debate.

**Contextual**

The unique nature of the Petroleum Institute Foundation Program whose role it is to develop learning skills and mathematical competencies (in English) within Arabic speakers (and thinkers) (who are) fated to become professional engineers, means that it is necessary to convert Western styled examples and questions to suit local conditions and sensitivities. This conversion and/or the development of original problems allows curriculum developers to include cognitively and culturally challenging questions embedded in questions that connect students professional and personal aspirations to the daily routine of learning/doing mathematics.

**Example 1**

Salt corrosion/salinity is a major problem for off-shore oil wells.

In the Khaleej *[Arabian Gulf]* gulf salinity is determined by the function;

\[ f(x) = 51.2 - 1.5 \log (x + 1) \]

where;

- \(x\) is the water depth in metres
- \(f(x)\) is the salinity of the water in g salt/kg sea water

a) Calculate the salinity on the surface of the gulf.
b) Calculate the salinity at a depth of 9 m.
c) Does the salinity of the water increase or decrease with the depth of the water? Explain why this could happen.
d) If salinity greater than 50 g/kg is ‘damaging’ to drilling equipment (pipes), calculate what length of pipe must be protected by a plastic cover.

e) Would you expect the same situation to occur in drilling operations in off-shore wells in the North Atlantic Ocean (Scotland)?

f) Write a simple logarithmic function that might model the water salinity in the North Sea.

Analysis

Example 1 is taken from the second half of the course – the Pre-Calculus 2 section. The mathematics is fairly simple and covered in most high school curricula. This problem has, however, many agendas.

In a contextual frame that is relevant and therefore interesting to students,

- it revisits and reviews high school mathematics such as logarithm properties and uses
- it revises or introduces some non-specific and some technical vocabulary not necessarily familiar to students – such as surface, salinity, depth;
- it encourages students to visualize. In particular students are required to visualize the drill pipe, measured from the surface down to the sea bed. [Spatial reasoning is an area in which these students do not show great promise, often preferring a complex analytical/algebraic solution strategy over using a simple graph];
- it challenges students to connect the world of mathematics to their professional world using their common sense. [Common sense argues that due to the inversion of the pipe it should all be covered.];
- it reflects local conditions in that students are aware of the gulf and its salinity and they easily determine why it is saltier at the surface. It then moves from local conditions to different conditions and stimulates in students an awareness of the ‘other’;
- in many parts it is open, creative, interpretive and negotiable, and it stimulates much discussion and debate about a wide range of conditions,
situations and mathematics pertinent to students local and global realizations; and

- it connects and carries over into other subject areas such as Chemistry, Computing (internet research) and English (as discussion and debate).

**Multi-Representational**

The previous example (Example 1) closely related to the students’ professional life-world of engineering has been, from experience, motivating and engaging for many students provided they managed to work through some difficult language issues associated with the use of some reasonably uncommon technical and general terms. Set late in the semester for the advanced students it tends to provoke much discussion about differences between problems encountered in different geographic and cultural locations.

Students with a poorer level of English reading ability are drawn into the problem in two ways. While discussion is held in English it is permissible for students to assist and elucidate in Arabic. This enables weaker students to remain informed and contribute verbally (in English) to the discussion. In the case of the mathematics, the inclusion of a logarithmic function gives a second form of information representation which students can access and use to enter the problem scenario.

What also happens during the discussion and solving of parts c) and d) is that students make their own diagrams to come to terms with the problem or to explain/argue their point(s) of view with their teacher and each other.

Sometimes it is necessary for teachers to present problem scenarios in a multitude of forms, including diagrammatic, to assist students with and in developing visualization skills.
Example 2
The diagram shows a support ‘bridge’ carrying oil pipes at Das Island gas refinery.

![Diagram of bridge with dimensions]

The height [AX] of the bridge is given as 20 metres and all triangles in the bridge are similar.

a) Calculate the width [BC] of the bridge.
b) Calculate the gradient (slope) of ‘arm’ AC
c) Calculate the **exact** length of ‘arm’ AB.

Analysis

Example 2 is taken from the first half of the course – the Pre-Calculus 1 section. Once again the mathematics is relatively simple and can be done using a variety of possible approaches covered in standard high school curricula.

It is also contextual and therefore potentially motivating for engineering undergraduates,

- it revisits and reviews in English a wide variety of high school mathematics [including similarity, ratio and proportion, Pythagoras’ rule, trigonometry, Euclidean geometry and coordinate geometry].
- it revises or introduces some non-specific and some technical vocabulary not necessarily familiar to students – such as width, slope, arm;
- it assists students in visualizing and encourages them to make and annotate diagrams and graphs; and
it challenges students to connect the world of mathematics to their professional world using their intuitive senses. [Students can see and therefore often utilize the symmetry inherent in this diagram].

In general a question such as this opens to students’ eyes the realization that a problem can and will be done differently by different people. As touched upon above, there is a variety of solution paths. Some students use methods not anticipated by those who wrote this problem. While some of these methods are quite inaccurate and inefficient, they are still viable solution paths. Such a variety of ‘viable’ responses set off alarm bells for students who (mostly) had been passive observers to teacher demonstrations of perfect solutions. In the case of this problem students tend to be reluctant to copy down so many different answers and appear to be more than happy to discuss and debate what they view as highly questionable and (in their eyes) un-mathematical.

Students often are perplexed as to how their peers could question those solutions they themselves believe to be right, and yet many begin to see some sense in the others’ alternative solutions.

This problem, if nothing else, tends to make students aware of the multifaceted nature of mathematics and the existence of ‘multiple perspectives’.

*Perhaps the greatest of all pedagogical fallacies is the notion that a person learns only the particular thing he is studying at the time.*

(John Dewey as cited in Doll, 1993, p. 76)

Problems such as Example 2 are mathematically and culturally rich. In addition to unearthing and subsequently validating a large variety (and quality) of sometimes ingenious approaches, they immerse learners in a culturally and philosophically significant learning experience. Each learner may take from it his own unique perspective which includes (I believe) that he or she is indeed unique and that what he or she believes is respected but is always under review in the eyes and minds of equally alert and respected ‘experts’.
In my own case, as teacher-learner I find the enactment through interaction of these problem solving and discussion lessons both invigorating and daunting as I try to navigate a course that is informative and stimulating to both myself and my students but which allows us to incorporate the required content of this mathematics course.

While I agree with those who believe that learners need sufficient time to respond to questioning (Tobin, K., 2007) and for deliberation so that they can ‘feel comfortable with new material’ to accommodate the development of new emergent insights (Bruner, 1973), I am aware also of the time constraints placed upon me by a conventional, traditional objectivist syllabus model.

So, whereas I recognize that ‘pressure, over-direction, and narrowly defined goals are counterproductive to my ‘cause’, I cannot eliminate all such influences from my everyday teaching life.

This, I believe, justifies my search for a ‘third space’ which allows me passage through a set of contradictory thoughts and practices. A space in which I realistically incorporate both sets of ideas and practices in dialectical tension at various levels (teacher-student, teacher-teacher, teacher-administrator). In effect, I ‘play judo’ as I use numerous examples to fortify, reinforce and at times, destabilize my various arguments. In doing so I attempt to provide stimuli that challenge and destabilize, yet at the same time support all who participate as they attempt to re-equilibrate, accommodate new idea(l)s and reshape themselves. In Piaget’s terms, I am (pedagogically) focusing on the interactive dialogic relationship between the learner and the learning environment.

*The teacher’s art, along with helping disequilibrium occur, is that of constraining this disequilibrium – of not letting it turn into unbridled disruption. For the teacher and curricularist this is a greater problem both theoretically as well as practically than for Piaget.* (Doll, 1993)

Such an art goes beyond the content and practices of the curriculum, it envelopes all manner of classroom management and faculty policy. In a traditional and
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conservative establishment such as The Petroleum Institute it borders on the diplomatic.

*Challenging and Discursive*

**Example 3**

Pollution table – heavy metal contamination at distance x km downstream from industrial site

<table>
<thead>
<tr>
<th>x (km)</th>
<th>0</th>
<th>100</th>
<th>200</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>y (ppm)</td>
<td>18.0</td>
<td>11.2</td>
<td>5.2</td>
<td>4.5</td>
</tr>
</tbody>
</table>

a) Plot the data from this table and determine if it is best modeled by a logarithmic function OR an exponential function. What are the consequences of your choice of function over the alternative?
b) Use your answer to part (a) to find a function by *regression* that best models the data. *Give values to the nearest ppb.*
c) Calculate the interval over which contamination exceeds 10 ppm.
d) Given that 10 ppm or less is considered safe for fish and other aquatic life forms, explain the outcomes of your answer to part c).

**Analysis**

Example 3 is taken from the final stages of the Pre-Calculus 2 course. It was developed in 2005 following a call by students to form a Petroleum Institute Environmental Protection Club. The formation of this club was a response to survey data (unsighted as yet by this author and anecdotal) which placed the UAE in 187th place out of 187 countries surveyed about environmental awareness.
Highly contextual and therefore motivating for engineering undergraduates,

- it revisits and reviews in English a wide variety of high school mathematics concepts and terms [such as interval, exceeds, and logarithmic and exponential functions];
- it revises or introduces some non-specific, some technical and some specific scientific terminology not necessarily familiar to students – such as ppm, ppb, contamination];
- it includes the concept of modeling and the idea of a ‘best’ answer as opposed to ‘the correct’ answer;
- it encourages the use of calculator technology to develop systems of alternative/multiple representation which (incidentally) must still be interpreted by the user;
- it challenges students to connect the problems of their world (pollution) to the problems of mathematics, and suggests mathematic(al) modeling as a possible method of identification and solution; and
- it is highly contextual and provokes discussion on a wider and more practical, professional and personal level.

In terms of mathematics a problem such as this involves the generation and analysis of multiple representations of data and information. Students convert numeric data into graphical and symbolic forms. They then interpret their findings in technical and real-life (consequences) terms. It makes very valuable connections between mathematics and other areas of science (chemistry) relevant to engineering and the problems faced by engineers. It implies the existence of imperfections or side effects to the engineering process. It also gives students a feel for the usefulness and the limitations of (graphics) technology.

*Curriculum in a post modern frame is not a package it is a process – dialogic and transformative, based on the ‘inter – or’ transactions peculiar to local situations.* (Doll, 1993)
In general this problem is very topical and leads students to discuss solutions and interpretations. In a second language environment it is highly dynamic as students not largely involved in political issues tend to open up and discuss and admit to problems they are not always conversant with. From my own experience and those conveyed to me by colleagues in other faculties, the discussion generated by this problem carries over into the Chemistry and Engineering Science areas. It is a current social issue that most students are aware of and feel quite strongly about, and it offers a variety of options for future reference.

Making it Happen – Classroom Management Protocols

*The first important change taking place in the postmodern curriculum is the relationships that exist in the classrooms. These changing relationships in turn foster ecological and global sensibilities.* (Slattery, 1995)

If learners are to be empowered the first major step is for them to participate freely and openly in what may appear to them a very foreign, possibly even threatening environment. Indeed an emerging postmodern classroom, one which bridges the world of new ideas and activities with the old student world of traditional classrooms, passive learning and student spectators can appear frightening and counter-productive to many students. In such an environment students must develop trust in their teachers, peers and themselves, and desirably develop an interest in the subject or learning situation that enfolds them as it unfolds before and within them.

The eventual goal is to have learners who, in William Doll’s words, ‘know the material studied well enough and have enough personal confidence to be able to both solve, interpret, analyze, and perform the material presented and to play with the material in imaginative and quirky manners’ (p. 164). To create such a multi-perspectival environment ‘requires a curriculum rich in diversity, problematics and heuristics, as well as a classroom atmosphere that fosters exploration’. To establish such an environment requires students (and teachers) to take risks, and risks are only taken if there is an underlying atmosphere of trust and the understanding that support is available.
To develop such trust I believe requires starting work within the bounds of student expectations and then slowly moves out as unfolding problems, conundrums or situations of cognitive conflict indicate to and through the learners that a change in strategy/approach is desirable. This gradual transformation, I believe, should be expedited with full student support as it starts within the learners comfort zone and expands into what Vygotsky describes as the learner’s zone of proximal development (Liu, 2005).

To draw further on the diverse ideas of Piaget and Prigogene as encapsulated in the words of Doll, ‘perturbation will trigger self-organization only when the learning environment is rich enough and open enough for multiple uses, interpretations and perspectives to come into play’ (p 164).

My own experience with my students at the Petroleum Institute is not all that different from working with students at other local institutions, for example the University of UAE; or Western institutions, such as NSW high schools. That is, most students enter our courses as spectators or passive learners, and unless teachers (in particular) and administrators/curriculum developers arrange things otherwise they can depart as graduate students who still do not know (in my opinion) how to learn and who do not really understand the areas they have studied except perhaps for a narrow band of exam related materials and behaviors they have rote learned and which, by means of reinforced behavior, are ingrained in their being.

If, however, the teachers involve students in decision making and are willing to negotiate a suitably mutual curriculum (Boomer, 1992) in which students are kept aware of their progress and the pertinence of what they are learning to their academic progress and to the wider world within which they (indeed all of us) live, then in my experience students tend to take an active interest in what they are learning and do go beyond the standard limits set by their teachers.

I employ a variety of methods to partially transfer power and some decision making to students. One such example is via the Pre-Calculus 2 Trigonometry Unit which is accessible to students via Moodle on the Petroleum Institute’s Intranet (www.moodle.pi.ac.ae). This unit of work comprises several folders which contain
lesson notes, examples and worksheets; and inside the worksheets several websites leading to further work samples, examples, practice questions and some excellent animations or simulations. Included in the course is an introduction which explains to students that they have full and free access to all materials to use as they complete the worksheets within a given time frame. Students are free to do the work in any order and are welcome to use their own and other sites/sources of information, including their traditional mathematics lesson. Owing to the traditional nature of much teaching and learning at the Petroleum Institute and the cultural propensity of the students to over-share information, it has been necessary to include an assessment vehicle for this unit of work comprising grades for completed worksheets submitted within the given time, inclusion of trigonometry based problems within final examinations, and bonus marks for finding suitable alternative sites.

I consider the returns from this project/experiment to be mixed. Some students seem to relish the opportunity to manage their own learning, including use of time management skills. They log on to the course (Moodle) regularly, complete all worksheets ahead of time and attend and primarily direct the mathematics lessons and tutorial sessions when they seek help with problems that have arisen, and they participate enthusiastically in the practical or conversational scenarios that emerge around some of the problems. In many cases classroom sessions become highly student-centered as advanced students bypass an already busy teacher to help each other with problems and often to argue the outcomes of results and methods they consider contentious. It was during these sessions that students started coming up with ‘better’ alternative sites which led to the inclusion of bonus marks in the assessment program.

Other students, however, are less self-directed and use the Web-based learning exercise as an excuse to skip classes and, in many cases copy voluminous amounts of work from more dedicated peers (towards the end of the session).

So while this unit of work potentially empowers students to choose how and when they complete the work it is not necessarily as motivating as I had hoped.
Something that I found to be more motivating is to offer greater flexibility and student choice in classroom quizzes. Coming from a traditional behaviorist teaching background I was inculcated with the idea of reinforcement and the drilling of skills. Although such a process made some sense to me early in my career it lost its appeal as I developed my own teaching philosophy. It didn’t, however, depart from my repertoire. One reason for it staying was that I always believe that the value in mathematics lies in the doing (for one’s self). Consequently, I always begin my lessons by doing, or more precisely by making my students do. Given the right activities, whether they be a few simple questions or perhaps a provoker such as some of the examples I gave earlier, students tend to enjoy doing mathematics and are usually willing participants if the person posing the questions/problem starts out with something they can do and then by means of the activity leads on to something new, relevant and perplexing. Owing to the nature of our students at the Petroleum Institute, it is faculty policy to quiz homework as a way of getting students to make genuine attempts at the set work (rather than have them quickly copy the work of others).

As these quizzes are graded and their marks contribute to final grades I utilize them as a method of offering ‘guided choice’ to my students. In doing so I employ a variety of ‘fun’ methods to devolve responsibility and offer greater choice and freedom to my students. Firstly, I quiz regularly. So regularly that I generate more quizzes than there are spaces in the official faculty mark-book. As a result I offer students the option of having low quiz scores replaced by higher scores from later surplus quizzes. This ameliorates the need for students to get excuses from student counselors for quizzes missed due to sickness or other reasons. It also allows students to accept that a bad day can happen but that, provided they are working as they expected, a bad day is not an irredeemable situation. It also allows me to include some parts, sections, questions that are tricky, challenging or related to upcoming work. Students seem to be less afraid to take on more difficult work when they are given choices in how their responses will be processed in the long term. In addition, students have the choice of declaring a quiz an ungraded question. In such a situation, if students decide a quiz is too difficult, or for other reasons, they may vote for it to be changed to a question which becomes open for group discussion and group marking. In a mark/grade driven culture such as the Petroleum Institute marks
are still awarded for the question, but only for student information purposes. They are never recorded by the teacher.

I also believe that this flexible use of assessment activities and grades as currency depressurizes the effect and importance of assessment activities and (happily) devalues the currency of grades. With this pressure reduced and the price lowered in my opinion, students seem less focused on grades and more interested in the intrinsic worth of many of the questions posed. Although I have to admit there have been occasions when a stimulus question I considered too difficult to warrant quizzing has been challenged by students and proposed by them as a quiz question.

Another fruitful procedure I use within these quizzes/stimulus activities is running on student-time rather than clock-time. I give no set time for doing a quiz or question. My initial countdown begins when the first student is finished, when I declare ‘darqueeqa’ (one minute), when the next student finishes irrespective of true time, I call thirty seconds, then ten, and finally a quick countdown – sometimes in English, sometimes Arabic, sometimes Japanese, German or Spanish - keeps students amused until we collect responses and work through/discuss/debate solutions ‘on the board’.

Conclusion

Constructing an effective and empowering classroom involves a large number of influences and has varied requirements.

First and foremost it requires a clear definition of just what is meant by the term effective. Such a definition needs to come from consensus between the stakeholders – the learners, the teacher and others who contribute directly to the learning experience. In my experience most learners consider a learning environment to be effective when it meets their own expectations and leads towards what they see as their own extrinsic goals. In an environment such as the Petroleum Institute these extrinsic goals usually conform to the goals of the institution in that students are working towards the attainment of an engineering degree and are thus willing to cooperate and work within the guidelines laid down by the university. To the teacher
constrained by these guidelines there is sometimes another different or additional definition, that is, the concept of effective learning or learning for true understanding.

In my own case I have used this chapter to explain how I perceive effective learning and how I navigate a course that meets student and institutional expectations while still offering my students the opportunity to share in the decision making at a classroom (and later faculty) level.

I have explained and demonstrated by means of collected data, and work samples and examples how I attempt this, and I have framed my sometimes detailed explanations in terms of what I consider to be appropriate curriculum theory.

So my definition of an effective leaning environment is one which meets learner and institutional expectations AND in addition meets my own expectations as a teacher trying to ‘make a difference in the lives of his students’. As such mine seeks to be an environment that empowers my stakeholders by encouraging choice and negotiation within the constraints laid down by the institution, the local cultures, teacher limitations and student needs and expectations. It is an environment which aims to be stimulating and challenging in that it relates closely to the world as known by the learners and is desired by them. It possesses a level of complexity in which learners can make important connections and encounter situations in which they are called upon to go outside of their comfort zones and to seek the help and support of each other as well as their teacher. It aims also to be a relatively secure environment in that, although not all answers are provided and some things are left open for the learner to make his or her own conclusions, the learner is valued and supported and respected enough to take risks and participate.

In the theoretical terms of curriculum development and reform, such an environment is the product of a collaborative effort between interpretations of curriculum in the traditional sense as a planned course to be run and as currere, the actual running of the course.
A constructive curriculum is one that emerges through the action and interaction of the participants; it is not one set in advance (except in broad and general terms). (Doll, 2002, p. 162)

Justified by the ideas enunciated by Ilya Prigogene, Umberto Maturana, Felix Mandelbrot, Jean Piaget and many, many others, I agree that ours is a complex interactive reality which is constantly in change. Following on, I conceive all of those things which we view/interpret as systems, especially living systems are constantly going through stages of destabilization and re-equilibriation.

Self organization is essential for biological concepts of adaptation and evolution, for Piaget’s theory of equilibration, and for Prigogene’s concept of order arising from fluctuations or chaos. (Doll, W., & Gough, N., 2002, p. 117)

Influenced by the works and ideas of practicing philosophers/curriculum theorists such as John Dewey, Alfred North Whitehead, Jerome Brunel and more recently Peter Slattery, William Doll Jnr. and Cleo Cherryholmes, I see my enactment of the teaching and learning process as a critical and integral part of any form of curriculum development.

Coda

The Lorenz curve for this chapter could be viewed as the intertwining of two main themes. The first theme being gradual and painstaking conversion of a learning environment from a traditional and arguably limited scenario into one considered more effective in the minds and hearts of its participant stakeholders. The second is the cautious transformation or emergence of this researcher through reflection, interpretation and action from my primarily modernist influences towards a belief system that could be best explained in terms of the still evolving postmodern viewpoint. In the oneness that is teaching, learning and being, both of course are the same thing.
Facilitating an Empowering Mathematics Learning Environment

*The maintenance of organization in nature is not - and cannot be – achieved by central management; order can only be maintained by self organization. Self-organizing systems allow adaptation to the prevailing environment, i.e. they react to changes within the environment with a thermodynamic response which makes the systems extraordinarily flexible and robust against perturbations from outside conditions. We want to point out the superiority of self-organizing systems over conventional human technology which carefully avoids complexity and hierarchically manages nearly all technical processes. .... An entirely new technology will have to be developed to tap the high guidance and regulation potential of self-organizing systems for technical processes. The superiority of self-organizing systems is illustrated by biological systems where complex products can be formed with unsurpassed accuracy, efficiency and speed. (Biebacher, Nicolis & Schuster as cited in Prigogene, 1996, p. 71)*

Introduction

This rather lengthy quotation is taken from a report to the European Communities by Christof Karl Biebacher, Gregoire Nicolis and Peter Schuster. While the report was discussing progress and process within the physical sciences, and follows closely from the work done on dissipative structures and self-regulatory systems by Ilya Prigogene (Prigogene, 1996) and the autopoietic systems of Umberto Maturana and Francesco Varela (Capra, 1997), its focus I believe also relates closely to the social sciences and in particular William Doll’s four c’s of curriculum – complexity, cosmology, community and conversation (Doll, Jnr. W, 2002) briefly met in Chapter 7.
Chapter 8 bases itself upon an extension of this (above) premise, namely that self-organization is more viable and a more successful approach in managing social systems. This I believe to be particularly so in terms of its greater usefulness and effect as compared to other forms of traditional hierarchical control systems when facilitating the enactment of curriculum (as currere) within most learning communities. I use (in this chapter) as my example the scenario of my ongoing activities – historical, long term, recent and projected experiences – with faculty management and leadership within traditional and emerging learning communities – such as the Petroleum Institute, and to a lesser extent UAE University and NSW DET schools. This I do within the context of the teaching and learning of mathematics within its own dedicated subject areas, and also extended here and in Chapter 6 across the institution (Petroleum Institute) as part of mathematizing and unifying a wider curriculum.

In describing these activities it is my intent to connect them together in principle and identify within their expedition, successful processes evident of (emerging) self-organizing systems.

To begin, I draw an analogy between the mathematics of ensembles used by Ilya Prigogene within his research on dissipative structures and observable behavior within human social systems. Prigogene used probabilistic analysis to justify and explain his assumptions towards dissipative structures and self organization. In particular, to move beyond the limitations of Newtonian mechanics and deterministic processes, Prigogene used probabilistic analysis of ensembles of elements to show that although the behavior of individual elements (or their trajectories) could not be accurately determined, the behavior of the ensemble or population of elements could be predicted (Prigogene, 1996).

It is this recognition and acceptance of order within (what appears) to be an otherwise chaotic system that theoretically grounds, scientifically justifies and practicably permits mathematicians and scientists such as Biebacher, Nicolis and Schuster to recommend a shift from rigid hierarchical control of processes to methods of self regulation (within given bounds).
I believe that this has long been evident in the social sciences, particularly education and even more particularly (its subsection of) curriculum studies which has become a focus area for those investigating the perceived (ongoing) failure of traditional education systems. This is a perception that has led (I believe) to widespread disenchantment with curriculum (content and application) and contributed to an ongoing search for viable alternatives. Critics of traditional, modernist, structural, reduction(ist) systems of learning, such as John Dewey, Frederick North Whitehead, Jerome Bruner and numerous others have long suggested and tested alternatives leading, they believe, to a more relevant and empowering curriculum. A system which they envisaged would desirably evolve or emerge through the input, interaction and consensus (reached) of all stakeholders, and one which will continue to evolve on local scale in response to perturbations provided at this (almost) personalized level (Asher, 2005; Boomer, 1992; Cherryholmes, 2002; D'Ambrosio, 2007).

Drawing parallels to Prigogene’s mathematically derived observations of particle behavior/trajectories I contend that while it seems impossible to determine the complete behavioral trajectory of any individual learner over even a short space of time, it is possible through probabilistic means such as reflective analysis of personal experience or interaction, to determine the likely behavioral responses of groups of individuals. On a more personal note – through personal experience – developed through reflection in and on my practical actions I believe I have developed sufficient praxis and phronesis to consider myself an expert practitioner. In this capacity I believe I can reliably predict general behavioral outcomes of those learning communities – students and or teachers – with whom I interact. Provided that is that those communities of individuals are empowered and motivated enough to sufficiently negotiate and execute the mutual goals of that community. As a consequence of this analysis embedded in my personal reflection or as reflective moments throughout my career, as teacher and teacher leader-manager, I have developed the following ethos, strategies and approach.
Faculty Management and Leadership

As coordinator of the Foundation Mathematics faculty I attempt to engender an atmosphere of collegiality and cooperative ownership. A passionate advocate of Total Quality Management (TQM) I have a long history of working in collegially based productivity loops, and I believe strongly in the concepts and processes of continuous improvement and reducing variation within negotiable processes.

*Total Quality Management (TQM), a form of management that emphasizes continuous quality improvement processes in institutional operations, represents a major shift in academic administrative circles from hierarchical to collegial management.* (Andews, 1997)

TQM was conceived by American economist, W. Edwards Deming, shortly after the conclusion of World War II as a means of improving the overall quality of goods and services. The idea was generally ignored by businesses in the United States, who at the time were satisfied with their position at the top of the global markets. The idea was, however, taken up by Japan, which was about to embark on the difficult path of reconstructing a shattered national infrastructure and economy. By 1980 the Japanese experiment with TQM had proven remarkably successful with its products highly respected and sought over products and services from the United States and other industrial nations. By this stage, as a result of smarter business practices based on the concept of TQM, the Japanese economy was booming and many Japanese companies were in the process of buying into or taking over many foundering US and international corporations.

As an educator – teacher and administrator – I am one of the ‘many educators (who) believe that Deming's concept of TQM provides guiding principles for needed educational reform’.

I base my belief on many positive and ongoing experiences applying this style of management, starting with my roles of Mathematics and Computing Teacher; Computer Coordinator, Student Year Adviser; Mathematics Head teacher and TQM

As a young teacher I was involved in the introduction of TQM into the school as a means of teacher training, management and leadership. The Lisarow High School TQM team aspired to make the school the first TQM driven school in Australia and the first to achieve ISO-9000 accreditation. Driven by this goal the team used TQM principles of investigation, analysis and application as they involved all staff in almost all areas of investigation and decision making.

I experienced first-hand the personal and professional satisfaction of feeling valued, of having my ideas listened to and acted upon by my colleagues within the school environment. Buoyed by such personal success and what was a fulfilling experience I applied the same concepts to my classroom and my areas of responsibility – Coordinator of the Computing Studies and Technology area and later as Head of Mathematics. During this time I developed personally and professionally within an ever strengthening professional team and I believe I developed significantly as a classroom teacher and further, I believe, as a leader. In addition, Lisarow’s success as an educational institution, which was signified in many diverse ways including its outstanding academic, sporting and cultural results (locally and internationally), led to TQM team members being employed as TQM trainers to our own staff members and interested teams from other schools.

Such strong positive experiences have nurtured others and instilled in me a strong belief in TQM principles and practices, which I intend to describe and explain in the samples and examples introduced later in this chapter.

Deming explained his concept of TQM that underlies these (my) examples in the form of 14 guiding principles or points, a summary of which I have taken from the Cambridge University – Institute for Manufacturing website (Appendix 8.1) (Richards, 2007).
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It is within the framework of these 14 guiding principles that I translate and operate, if loosely, inside my educational environment as an administrator and as a classroom teacher.

While Deming’s points are aimed mainly at manufacturing and provision of goods and services, I can and do, closely relate and translate these to my own educational purposes in an attempt to provide smoother and more effective management of my faculty and my classroom and to address one of my main purposes (if not) my core educational purpose – to develop an effective mathematics learning environment for EFL learners. Specifically, I aim to model and demonstrate a collegial, interactive and empowering method of learning that will eventually produce engineers who are informed, articulate and globally aware of the sustainability and implications of their actions.

In this vein I enact and model many of Deming’s principles such as: a constancy of purpose (see preceding paragraph), a new professional and personal philosophy of emergence from a modernist to post-modern theory and practice (see Chapter 4); an application of statistical analysis to investigate and facilitate an awareness of the need to reflect and analyze the quality of one’s own individual and collaborative practice (see Chapter 3 and upcoming examples); and maintain ongoing response to this analysis as a commitment to continuous improvement.

In the following examples I believe you will see also clear examples of Deming’s other areas of applicability such as: ongoing staff (self, collaborative and imported expert) training; devolution of responsibility and empowerment of all stakeholders; attempts to reduce the barriers between faculty tasks, disciplines and levels; and an attempt to foster pride of workmanship and self within all of those willing to take a risk at professional and institutional (self) transformation.

As a professional practicing Total Quality Management I have often reflected on what I am doing and on how these practices have influenced me as a teacher and a human being. This includes leading me to my choice of research which focuses upon and feeds from my search for true personal meaning and value (for all involved) in what I do professionally, namely, the emancipation and empowerment of a specific
group of learners, but which I believe extends to all learners, including my students past, present and future, myself and my teaching and administrative colleagues. In this regard, most of my search by means of reflection in, on and upon action (Kitchener, 1990; Mezirow, 1990a, 1990b; Schon, 1983, 1990, 1991) has been holistically enacted in terms of the practical and or the philosophical. I do, however, transcend or bridge my beliefs to the theoretical as well.

I explain my transcendence as a leader across the philosophical-theoretical-practical in regard to the management of people in terms of the model described by John Jay Boningstl (Boningstl, 1992). In articles on TQM in education Boningstl refers to ‘four pillars of Total Quality Management’ that he sees as’ relevant to educational ‘reform’. These pillars are the principles of synergy (synergistic relationships), continuous improvement (self evaluation), a systemic perspective and responsible leadership.

Synergy refers to the dynamic created in a working relationship whereby the output of the group far exceeds the input (and output) of the individual parts (members). Transposed and transported to a team’s environment, such as a mathematics faculty, this could be further explained in the way power, responsibility and recognition are shared equitably among the members, and how what I see and experience as enhanced contribution of all members leads to synergistic outcomes as the multiple intelligences of several different minds and sets of experiences and beliefs come together to create something far more intricate and valuable than the product of several individually competing minds.

Synergy means creative cooperation. (Covey, 1990)

Continuous improvement, I believe, is a natural consequence of synergistic relationships. In my experience from the time of the Lisarow experiment to the present, members of ‘synergistic teams’ are constantly looking for and suggesting ways to improve their own teaching / learning and that of their collaborators. Like Prigogene’s dissipative structures and Maturana’s autopoietic systems, these ensembles of beings become self regulating and, through the interaction of their
members, are continually finding ways to adapt to stimuli arising within their environment in a collaborative manner.

A systems perspective, I believe, is a direct consequence and a progenitor of the other two pillars – synergy and continuous improvement – because only when individuals become a team do they achieve synergy and the only way I know for individuals to develop sufficient trust to become team members is by negotiating individual goals as components of team goals and making them shared goals - part of a (mutual) system.

Once this process begins members are more willing to trust and rely on each other. Individual strengths become inputs to the system and individual weaknesses become weaknesses of the system, often to be ‘ironed out’ on systems lines in the form of tacit support or guidance as the process of continuous improvement occurs.

Synergistic team members learn to understand and appreciate alternate and sometimes opposing points of view for the purpose of expanding perspectives and reaching higher levels of knowledge. Team members learn to recognize and tap the vast resources made available by a diverse group of people working together toward the same goals. They learn to value differences by putting together the best everyone has to offer. The synergy generated in content area instruction emphasizes ownership of problems by all team members and genuine involvement of all members in the problem solving process. [(Covey, 1990) as cited in (Administrator, 2006)]

Leadership as the fourth pillar, I believe, is shared by members, but if a hierarchical management system requires a spokesperson accountable for the team then that person should naturally embody and enact the other principles of TQM.

In accordance with these principles I have, with the agreement and collaboration of my faculty/teaching colleagues, implemented a team’s approach to faculty management. As such I have attempted to devolve much of the responsibility and decision making to team leaders responsible for significant tasks. I see my own role
as facilitator rather than as overseer within the continual expedition, analysis and refinement of faculty tasks.

Most of these faculty teams consist of 2 or 3 members who interact with each other in fulfilling a particular role while also being active members of other teams consisting of different combinations of faculty.

In this structure it is a regular occurrence for faculty members to seek to improve operations by discussing their ideas with their team mates and the wider faculty. As members participate in other teams it is common for them to come up with protocols that are well considered and which integrate well with other faculty functions. In addition team leaders feel empowered. They are listened to by their peers and their ideas are regularly implemented, critiqued and refined with a minimum of angst.

For a relatively small body of 7-9 teachers the Foundation Mathematics faculty makes a lot of noise, is renowned for its animated discussions and the relative tightness of the unit in the closeness of its team members.

It also has a considerable number of productivity loops for its size, with leadership roles being delegated for members to oversee teams looking at and managing the following areas.

- Curriculum and Assessment
- Course Coordination
- Educational Technology
- Professional Development
- Logistics – Male Campus and Female Campus
- Gifted and Talented Programs [Mathematics Club – Laboratory – Challenge]
- Remedial Support Programs [Tutorials – Laboratory – Mentors]
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Clearly, each team leader is also a member of 2 or 3 other groups. Some groups such as the Curriculum group act as an umbrella group, overarching the Course teams, while other teams interact and recombine on a regular basis.

As coordinator, my role is that of a participatory member of my own group and involves listening in on or co-critiquing ideas developed by other teams. Possibly my only special role as coordinator is to formalize a lot of the procedures – as negotiated protocols – developed by faculty members and to get put these forward to my fellow coordinators for integration in the wider vision, mission and management statements of the Petroleum Institute.

In what we consider a very dynamic and interactive environment most faculty members see themselves as one of many interchangeable parts, with no one really seeing his or her self as irreplaceable, knowing full well that colleagues in each working group are aware of the group’s purpose and function.

Most leadership roles are negotiated at a faculty meeting/level with members often nominating themselves for reasons of personal or professional interest. Occasionally they are put forward by colleagues. In each case group leaders are asked to write a job description for the role as they see it and based upon their own goals and aspirations. These roles/descriptions are then meshed so that each integrates the vision and goals for other related tasks.

For example, roles for the upcoming semester have been negotiated with Dr Gary Miller nominating for leadership of the team investigating and upgrading curriculum for the course. As a very competent and gifted mathematician, Dr Miller is concerned with what he sees as falling standards within the Petroleum Institute. His personal goal is to maintain the integrity of the Mathematics courses by introducing more challenging yet understandable (to EFL students) work. Dr Miller includes in his team, Ms Jane Neilson who is leader of the Precalculus 1 course organizing team. Ms Neilson was nominated by Dr Miller as an important member of his team. She also self-nominated for her role as coordinator of the Precalculus 1 course.
Part of each leader’s role is to submit a job description for faculty perusal and approval. Ms Neilson’s job description for this leadership role (and other related committee work) was as follows.

_Jane's "Job Descriptions"

**PEC**
*Produce, review, and revise evaluation matrices for the PC1 and PC2 courses.*
*Produce Foundation Program Evaluation summaries for other faculties (Core Mathematics), and include recommendations.*

**AI**
*Highlight the importance of the Academic integrity policy at PI, and assist in its application across the Foundation program.*

**PC1 coordinator**
*Develop and document the PC1 course curriculum. Review it against the course description and PEC educational objectives and student outcomes. Evaluate math web site for independent learning. Develop on-line math courses on Moodle. Liaise with PC2 coordinator to ensure students leaving PC1 have the necessary background for the following course. Liaise with math faculty teaching PC1 to ensure everyone is on target and on schedule. Correlate projects and applications. Maintain an on-going student homework/study regime, and offer support.*

Ms Neilson includes in her team Mr. Neville Martin who is leader of the scheduling team which maps out all assessment times, timelines and special events such as projects, excursions and cross curriculum work. As such scheduling affects both campuses Mr. Martin includes in his team Dr Tung Tran who is leader of the logistics group for the men’s campus. Also included in his group is Mr. Turlough O’Brien as the co-leader assessment team which oversees exam writing, implementation and marking, as well as coordinating with the curriculum team and
the Educational Technology teams lead by Mr. Dominic Munster, which assists in the preparation of specialized questions and tasks such as presentation of the student calculator projects using a variety of media and IT techniques. Once again, Mr. Munster plays an important role on the Professional Development team which is lead by me (Graeme Ward).

In most cases these roles reach out into the wider Foundation Program, with Dr Miller acting as faculty representative on the Petroleum Institute Curriculum Committee. Mr. Munster is Mathematics representative on the Foundation Information Technology Committee. Mr. O’Brien is faculty representative for the ABET accreditation committee using his informed position on assessment and results to keep us informed of what is required. I am chair of the Foundation Program Professional Development committee using my experience to integrate our mathematics into a wider field of learning and also bringing alternative viewpoints and approaches to my colleagues in mathematics. In addition, many of these leaders have taken to negotiating, recording and refining the required procedures and protocols as carried out in and by their respective teams. To encourage and facilitate this, the faculty leadership is developing a Procedures Manual in which teams document their operations in a common format that is easy to follow and understand. Examples are given in Appendix 8.2 of two overlapping/interrelated procedures developed by the Examinations/Logistics teams.

*Administrators, as facilitators of TQM, can bring it into the classroom by recognizing, rewarding and reinforcing the performance of faculty in teaching.* (Andrews, 1997)

I believe, from experience, that TQM practices modeled within the faculty progress into the classroom. As teachers appreciate the benefits of working within a genuine team, as they experience being valued and being listened to, as they experience greater responsibility and recognition within the day to day operation and ongoing development of the faculty area, they become more willing and able to pass on these benefits and responsibilities to their students.
I see evidence of this in the willingness of teachers to implement a team’s approach to their classrooms and assessment tasks. Students who have previously worked alone are being encouraged by some teachers (confident in their own teams environment) to work in groups to solve problems and do homework assignments. Assessment projects have evolved from being individual assignments to teams based activities, and mentoring systems whereby high achieving students (GaTs) have been coupled with students at risk (StARs) have sprung up in many classes in addition to Jane Neilson’s support tutorials.

Problems with regard to ‘academic integrity’, which have long plagued Western trained teachers working in an Arabic style culture of fully committed collaboration and community support, are being viewed from new perspectives as teachers realize the value of a collaborative approach. Instead of being viewed with suspicion, helpful students are being trained as trainers, including advice on the necessity of providing full and meaningful discussion, analysis and explanation rather than providing answers to peers for copying and memorization. While this description speaks of progress and hope it must not be misconstrued. In a foreign language based education system found in many Emirati high schools a lot of teachers – not native English speakers themselves – pass on numerous shortcuts to learning which favor a mnemonic system and propagate a culture of misconceptions and pragmatic, teleological learning. Overcoming such previous training is like the implementation of TQM practices themselves – slow and purposeful. It does not happen overnight.

Part of the reason for such slow progress is because of what the students call a ‘culture of negotiation or consultation’ where it is easier to work as a team and to copy a colleague’s work and answers. Students justify this (entrenched) behavior because of what they see as a heavy workload in a language many have not yet mastered. Indeed there are many good reasons put forward, including lack of proper language preparation at high schools, a complete change in the language and numeric structures from Arabic to English (Arabic vs English), and the desire of the university to deliver an accredited ‘comprehensive, if somewhat traditional ‘Western’ Engineering education to students who are not always prepared for it.

In many cases students struggling to learn and understand the nuances of general and technical English take the shortcuts provided them by older relatives and better performing peers. University policy does not necessarily address this situation and,
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compounded by the Emiratization policy of the country, takes the contradictory step of basing the great majority of assessment tasks on traditional testing, which again motivates students to focus on the test rather than develop a wider and clearer understanding of what they should be learning.

To assist students realize genuine learning for understanding in such an environment requires teachers to ‘play judo’ with students and to use student focus on testing and grades to motivate students towards other areas of assessment. Consequently, as mentioned in Chapter 4, some areas of student assessment have a component of negotiation wherein students can opt for certain conditions or re-sits. In addition, other areas of assessment have been opened up to students with the provision that there exists a rubric that is fair and equitable (psychometrically tight).

As a consequence of meeting such a provision two new assessment tasks have been recently introduced in which students are evaluated/assessed upon written and verbal presentations; and teachers have negotiated a further 5% grading mark for student performance based on the teacher’s own professional judgment. While this may seem far from Doll’s (Doll, 1993) or Boomer’s (Boomer, 1992) ideal of a post-modern negotiable curriculum it is still a far cry from the ‘tests only’ regime of 4 years ago.

But in this environment there is clear evidence that students will attempt to ‘collaborate’ in individualized assessment tasks and that student communities will conceal/protect their fellows ill-suited to studying Engineering, so it is necessary to have some checks and balances in place such as a testing component. To ensure the integrity and fairness of the non-testing components, such as teams based assignments and teacher based performance marks, it is also necessary to have our own checks and balances in place.

Our interpretation of Deming’s third guiding principle, ‘cease dependence on mass inspection; require, instead, statistical evidence that quality is built in’, (Appendix 8.1), all assessment data is analyzed statistically by the team with the view of seeking out and reducing any ‘unacceptable patterns of variation’. Such analysis often provides food for thought (or reflection) by individuals within the context of the team and any reduction of variation is seldom mandated. Teachers are permitted to stand
by their own professional decisions or, in light of some findings, they may choose to modify their decisions and related work practices.

An example of using statistical evidence to uncover trends/patterns of variation and the subsequent process of reflection and remediation involves a relatively simple analysis of final student grades and the breakdown of components. The main reason for this analysis was to compare each teacher’s individual grading of coursework so as to determine the variability within grading of coursework within the faculty.

*Example/Scenario*

Final grades for Pre-calculus 2 students comprise 25% Course-work, 10% Team’s Project, 20% Common Tests, 15% Mid Semester Examination and 30% Final Examination. While there is some overlap of definition here (in that Quizzes contribute to the coursework) it is generally considered that our assessment / grading scheme comprises one-third coursework or teacher based assessment, and two thirds common / test driven assessment.

While the test driven component is highly questionable in that, in my view, it discourages true learning and deters students from taking risks as problem solvers, it is desirable to many teachers and administrators here, in that they see it is the only accurate method of gauging individual student abilities (even if it is in my view an artificial analysis of a few contrived learning artifacts.). Their argument appears sound because there is clear anecdotal and recent statistical evidence to show that large numbers of students do in fact copy homework sheets and projects from others without trying to understand what is written.

With this as their justification many teachers and administrators have reluctantly conceded that it is also necessary to reward students for numerous other skills and abilities – such as communication, collaboration, mathematical reasoning, organization, sequencing, creativity – which cannot be evaluated let alone revealed in traditional testing.
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An Analytical Experience

In an Engineering college dominated by quantitative methods it is not unusual to come across mathematical methods of analysis. Furthermore, in an Arabic culture of negotiation it is not unusual to have teacher decisions and grades challenged at every step as students attempt to negotiate a better mark, grade or outcome. Such norms of behavior put teachers and administrators under significant pressure, and inconsistencies in response can expose them to further manipulation, complaint or possibly punitive action by administration. I believe that in an environment such as this it is necessary to be open and fair in all dealings with students, teachers and administrators. Furthermore, I feel it is important that operating procedures are consistent and open to scrutiny, and that the TQM principle of ‘reducing variation’ is closely followed. I feel that this is particularly important in balancing the issues of teacher/learner accountability against teacher/learner autonomy.

For example, I recently established a common electronic-mark-book system to be run in our faculty. While this was much against the principles and wishes of some teachers some relatively simple analysis had shown us/me that inconsistencies existed in our system and that these inconsistencies were discriminating unfairly against some, (if not all) students and teachers.

In a nutshell, my problem was that some mathematics teachers from the women’s campus passed in student grades that I felt were unjustifiably high. As an administrator and educational leader I divide my teaching time between both campuses which allows me to be (partially) aware of issues, problems and performance related to faculty and students from both campuses. My ‘gut feeling’ in this situation was that the difference in performance between male students and female students was not as significant as the grades I had been given indicated.

Further comparison between these female students grades those of my own female students indicated that these students were outperforming my own (in my opinion – good) female students who were in turn, on a par with my (good) male students, who in turn, were on a par with the other male classes.
The related data to this problem is available in Appendix 8.3, but the overall analysis and solution is as follows.

The data showed clearly that two teachers had innocently misinterpreted the faculty policy on coursework grading. As such they had clearly advantaged their students over some better performing students from other classes. By creating a Professional Judgment Index (Coursework/Test work) I was able to communicate this clearly but non-accusingly to all faculty members, who then negotiated (and enforced) a mutually agreeable and functional rubric and process of checking and review.

As team leader I did not mandate any changes, nor did I insist that teachers review and change their grades. As an individual team member I did try to influence the group, by suggesting that I planned to upgrade (this time only) the course-work estimates of the few students of mine who had been ‘disadvantaged’ by what I stated as variation within the system (but what I personally considered as overgenerous grading by one teacher in particular). I know other colleagues followed this lead and upgraded their borderline students as well.

For the long term several suggestions by team members were acted upon by the group.

1. This process of analysis was seen as an ‘eye-opener’ to most faculty members and it was decided it would always be a component of assessment performance analysis.

2. The faculty assessment rubric was adjusted (and mandated by the team) so that teachers could still enter 100% performance grades BUT only as a smaller component of the overall calculation of the course-work, meaning that the only way a student could get 100% for coursework was to do everything perfectly and not just in the eyes of their classroom teacher.

3. To further address/eliminate variation in this area of assessment, while at the same time maintaining individual teacher integrity and autonomy, a
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‘post’ Final-Examination Applications Course was introduced for eligible students.

This third suggestion requires further explanation in that it is a viable and desirable practice for any readers who are practicing teachers and who might want to try a similar approach.

In what is largely a traditional, objectivist and modernist (in perspective) institution, we do have to act as gatekeepers. While we use various criteria to assess our student’s eligibility for progressing from Foundation Mathematics to the Calculus Courses of the freshman year, many of the ‘stated outcomes/criteria’ are an adjunct to a number based assessment scheme. As well as being gatekeepers it necessary for us to determine student weaknesses and shortcomings and remedy these (in a system that can in my view and my colleagues), be open to distortion and corruption.

This hybrid system works as follows. Students must score 70% or better to pass the course AND they must also score at least 60% in the final written exam. Such a double check we believe is necessary because (due to the ‘wasta’ system of family or socio-economic privilege evident in this culture – see Chapter 1) some students are ‘carried’ by their peers through the courses without doing much work or understanding much mathematics (in written English).

In addition, many students are skilled at memorizing mathematical algorithms and formulas without really being able to understand them and apply them to engineering problem solving. To identify these students and to develop problem solving abilities in them as soon as possible we have, in accordance with ABET requirements, an applications section to every assessment activity, and it is usually here that our students do poorly. In accordance with suggestion 3 (above) it can be shown (using ABET subcommittee data) that those students considered borderline in that they meet only one of our assessment criteria (not both) usually fail the applications / problem solving sections of their examination and or assessment tasks.
Facilitating an Empowering Mathematics Learning Environment

By means of suggestion 3, these students are invited to attend a 2-3 week Applications Course and if they pass the final assessment task for this course they will be eligible to progress to the freshman calculus course.

I believe there are numerous aspects from which this activity can be viewed. From my perspective as a classroom teacher and faculty member I learned a lot from and about my colleagues. In listening to their descriptions of how they evaluated and assessed their student’s performances I learned about their classroom practices. In listening to them discuss the nature, the implications and the relative importance of the variation in their assessment procedures I also learned a little more about their personal values and from that the emergent ‘shared values’ of the mathematics faculty. From my perspective as a curriculum developer (and innovator/catalyst for reform) I believe I had a win, in that my colleagues were able to connect the familiar (to mathematicians) process of statistical analysis to a qualitative procedure that many felt unsure of. In addition we were able to demonstrate to Petroleum Institute ‘management’ that such a qualitative procedure could be checked and mediated by a quantitative process without seriously detracting from the process. All of these practices provided valuable tools that we as teachers could use to improve our teaching and benefit a better running and more effective/efficient faculty.

However, greatest value I took from this experience was from the perspective of an emancipator. This was because, in my view, the whole experience was a shared experience in which we all got to reflect upon ourselves and each other. This act of looking included openly looking at each others’ beliefs and values as components of a larger system guided by the concept of TQM and, in particular, driven by the (cyclic) principles of democratic learning – collaboration, empowerment and emancipation.

*Principles are not practices. Practices are specific activities or actions that work in one circumstance but not necessarily in another. If you manage by practices and lead by policies, your people don’t have to be the experts; they don’t have to exercise judgment, because all of the judgment and wisdom is provided for them in the form of rules and regulations.*
[However:] If you focus on principles, you empower everyone who understands those principles to act without constant monitoring, evaluating, correcting or controlling. Principles have universal application. And when these are internalized into habits, they empower people to create a wide variety of practices to deal with different situations. (Covey, 2002, p.98)

As I mentioned in concluding Chapter 7, the Lorenz curve for that chapter, indeed the whole of this research, could be viewed as the intertwining of two main themes. The first is the gradual and painstaking conversion of what I know as a wider learning environment from a traditional and limited scenario into one intended to be more effective. The second theme is the personal and professional transformation of this researcher through the cycles of reflection on action, reflection in action and action upon reflection.(Schon, 1983, 1990, 1991)

**Journal Entry – May 2008**

As I reflect along this second thread I return to the beginnings of what I see as my leadership roles and experiences.

I consider my professional beginnings as being shortly after I commenced teaching in 1977 at the age of 25. I came to teaching after spending just over a year as Chemist-Manager of a Geochemical Laboratory and as a result of this experience I was no stranger to leading and organizing small teams of people.

Interestingly enough, as a fledgling Mathematics teacher my first major leadership role had very little to do with mathematics or even the classroom. It was in fact related to school sports. As a local surfer living in the vicinity of Sydney’s Manly beach I had surprisingly been transferred to start my career at Balgowlah Boys High school, just up the hill from the beach. I say surprisingly because most of my graduating class for our teaching Diploma (Dip Ed.) had been sent hundreds of miles from their homes. Part of my duties as a classroom teacher for the NSW Department of Education was to manage and train a school/house sporting team and one day when a large percentage of my house basketball team seemed to disappear from the school early –instead of coming to sports lessons – I was asked by the
school’s Sports Organizer to join him on a trip to the beach to identify sporting truants which, many of whom, were escapees from my own aforementioned basketball team, along with many, many, many other students from our own and nearby schools.

I’m not sure if he (Sports Organizer) was trying to make a point – perhaps about the perceived irresponsibility of (us) surfers, but what I saw was that we were punishing students for skipping sports-day even though they were in fact doing sport – just not one of those sports we chose for them.

Shortly afterwards with the encouragement and presence of a colleague very much enmeshed in the local surfing culture, I visited the detention room where my recalcitrant surfing basketballers and many others were now kept, and discussed the issue (and their feelings) with them. Once we had these students onboard we then approached various other teachers and in doing so we discovered that we were not alone in our thoughts and that in fact, we were some months behind a group of teachers from the NSW South Coast who were already lobbying the Education Department for surf-craft / surfboarding to be recognized as a valid school sport. Shortly afterwards we joined forces with these teachers and some months later as a result of our mutual lobbying and their hard work the NSW DET allowed a trial program to be run for 1 year at 2 schools only - Warilla High on NSW south coast and my school – Balgowlah Boys – in the Sydney Metropolitan area. By adhering to strict safety guidelines including surf-lifesaving bronze medallions, advanced resuscitation and first aid qualifications for students and teachers we each ran successful trial programs and as a consequence numerous other schools were allowed to run surfboard / surf-craft riding as a school sport in ensuing years.

Within my own school this took a significant degree of coordination as our numbers grew from a few students to close to 100 students either surfing or training for their life-saving credentials. With a student to teacher ratio of 12 to 1 this meant I was required to liaise with and coordinate 10 to 15 teachers including training them to the required standard. Because of my success and experience in this field I became regional coordinator for school surfing and later I joined (by invitation) the committee (of Surfers, LifeSavers and Life Guards) established jointly by Manly and
Warringah Shire Councils to oversee the allocation and running of Surf-craft and Surfing Carnivals and Competitions (including the prestigious Coca-Cola Surf-about) held along Sydney’s Northern Beaches.

Also within Balgowlah High my successful experience with school surfing and coordinating a team of teachers of various disciplines lead to my implementation and running of a school SCUBA divers group comprising students and teachers; and also to my being asked to investigate and set up the introduction of a computer education group within the school. I did this until leaving Balgowlah High to backpack around the world in 1981.

I returned to Australia in 1982 and was posted to Cremorne Girls High School (also in Sydney) where I was assigned to teach Mathematics and Science. As a member of a very small group of 4 mathematics teachers, I fell into a leadership role when one of my colleagues was designated as ‘unacceptable and not meeting requirements’. I was given the role of supporting and retraining this colleague, and as a result of this activity being designated successful I was occasionally given the role of acting Mathematics Head Teacher (in shares with another experienced colleague).

In 1984 I left Cremorne High for Lisarow High School on NSW Central coast where, as part of a talented and enthusiastic team, I became (among other things) Computer Education Coordinator and Staff trainer; and later acting Head Teacher of Mathematics. I believe it was the role of Computer Coordinator (on top of my earlier experience as Surfing Coordinator), where I was once again coordinating a team of teachers from across the curriculum, that significantly shaped my philosophy as an educator and as a human being. Also it was this philosophy and its enactment that led to my invitation to the schools’ TQM taskforce and later my nomination for the ‘National Excellence in Teaching’ award.

It was during this period at Lisarow that I believe I formalized my leadership theories and style. As part of a highly competent and dynamic team it was hard to stand out as an individual but easy to storm and form outstanding professional relationships and to learn so much from informed and committed colleagues. As part of the TQM working party/team I was to learn so much from my peers and
colleagues and I was also free (safe) to experiment with personal ideas and ideals with my classes and with my teaching colleagues. My interaction with colleagues from different learning areas as part of the TQM team and at the student teacher interface as a teacher / coordinator of Computer Studies gave me experience and expertise with a wide range of beliefs, values and strategies normally not accessible to other teachers of Mathematics. In addition I had teamed with a friend and colleague from the Science faculty to develop School Surfing at Lisarow High, and I had along the way trained several Mathematics teacher peers to assist with Life Saving, First Aid and to establish Learn to Swim classes for our junior years (7 and 8). Some of these colleagues were happy to take a similar chance and be trained to teach Computer Studies so I had at my disposal other mathematicians who were exposed to what I consider a whole school experience so often missing from the psychological viewpoints of many of our traditional mathematics teaching colleagues.

As I mentioned before, I believe it was this interaction with and acceptance of a variety of sometimes contradictory viewpoints that firmed my ongoing personal and professional philosophy. In addition, I feel that it was through observing my close colleagues make similar (professional and personal) connections and conclusions that I came to realize the validity of what I was coming to believe.

It was around this time – in the late eighties – that a lot of educational research impacted upon teaching and learning within the public sector. While I still believe the NSW DET [New South Wales Department of Education and Training] was primarily motivated by cost cutting, their actions in moving towards a more constructivist based and inclusive education for most students meant, among other things, a change to outcomes based assessment and inferred a greater need to view and evaluate student reasoning and critical thinking processes. In my own case it meant that I had a head start over many of my (traditionalist) mathematics teaching colleagues because I already had this kind of expertise and experience from teaching and assessing in criterion and skills based areas such as Life Saving and Computer Studies.
Facilitating an Empowering Mathematics Learning Environment

In addition to the shift to outcomes/criterion based assessment, the NSW DET had also changed the teacher promotions system from one of seniority to a merit based system. What this meant for me was that I was now a credible candidate for promotion and my across the curriculum leadership experience was considered a desirable attribute. What was more important to me was that it gave further credence to the way I thought and the way I taught.

As a consequence of all of this I was given the job of acting-Head Teacher of Mathematics when the current head resigned to go into private business. I found my new role very interesting because while I was now coordinating a very capable team of mathematics teachers (and long-term friends) I did notice a certain difference in attitude and approach when compared to many of the colleagues from other faculties I had coordinated as part of my role as Computer Studies Coordinator.

As new Mathematics Coordinator I tried to import and assimilate these varied approaches and with the help of two Mathematics teacher colleagues who had also worked with me on the Surfing project and again as Computer Studies teachers I believe I (we) achieved a refreshingly different and diverse mathematics learning environment. It was about this time that I was nominated by the Lisarow community for the National Excellence in teaching award. It was also about this time that through my exposure as a member trainer of the TQM committee and as teacher trainer for Information Technology (Computer Coordinator) that I was called upon to run teacher training courses on a wider regional, state and national level.

It was these significant experiences interacting with a wide variety of teacher talent, beliefs, values and expectations that further developed my teaching and leadership styles (of openness and connectedness).

In 1994 I left Lisarow to take on the role of Head Teacher of Mathematics and Science at Wollumbin High School on the beautiful and much sought after New South Wales Far North Coast. Wollumbin was set up to be different and as such (arguably) the first criterion (outcomes) based multidisciplinary school in the NSW DET system. It was also a very difficult place to work and a severe test of my (and other Head Teacher’s leadership credentials).
The trouble with the beautiful Far North Coast of NSW is that everybody wants to go there and very few people choose to leave. Teachers go there and stay until retirement, there are very few vacancies and under the DET’s old transfer system based on seniority there was little room for young teachers. Teachers such as myself who were transferred there as part of a very competitive promotion on merit system also have to demonstrate exceptional skill which is naturally developed through teaching experience. Needless to say, at 42 years of age I was one of the younger members of the Wollumbin High School staff. Many of my colleagues, with the exception of the other head teachers, were not chosen on merit but had transferred from nearby schools. While many were experienced and competent practitioners there is evidence that we received more than our share of convenience transfers. Principals of some of these schools it seems transferred their problem teachers to Wollumbin.

A second issue that arose was the unwillingness of many relatively traditional teaching faculty, some in the sunset of their careers, to experiment with new methods and ideas.

Add to these problems the reluctance of many of our students’ parents to their children being assessed without using traditional (number or letter) grades, combined with serious under-resourcing through government funding cutbacks, and you have a very testing environment for educational leadership.

I look back on this period of my career and my life with mixed feelings. I went through feelings of elation to absolute despair. I questioned my methods, my standards, my ethics, my philosophy, my purpose and I guess I grew stronger. I was not alone but is some ways I was luckier than some of my colleagues on the school executive panel. Of the original 4 head teachers at Wollumbin, one was to resign for reasons of a physical breakdown, one was to resign to ‘family reasons’ as a significant workload took its toll on the quality of her relationship, and one was to seek a transfer (unofficially) citing ‘he had had enough’. I managed to stay and, after much soul searching/reflection, continue with my work as a regional teacher trainer in addition to my job, now Head of Mathematics and Computing.
In this dual capacity as Head Teacher and Regional Consultancy Support person I was able to broaden my skills base, including establishing a District Mathematics Head Teacher’s Working Party which met regularly to share ideas on teaching and leadership in our area.

As part of all of this and I suppose because, with the exception of one antagonist the Mathematics and Computing faculty had stormed, formed and bonded albeit slowly under my leadership, I was promoted to the position of acting Deputy Principal. As Deputy Principal I was able to initiate and implement many of the systems I enjoyed devising, analyzing and evaluating. Most of these systems worked relatively well and my attempts to consult and delegate in the style of TQM were well received.

While I am strong in terms of my organizational skills, I consider myself poor with people skills. I lack the charisma of many people, such as my wife Dianne. Such people appear instantly unforgettable and have the innate talent to make people feel instantly at ease around them. I see myself as much more easily forgettable, and while I am not exactly awkward with strangers I take time to involve myself in in-depth conversation with them. As a result there are times I feel I lack the insights and spontaneity required to deal with people in crisis. For this reason I found the counseling sections of the job sometimes heavy going. I had and still have a good rapport with my students and similarly with the greater majority of my teachers, both I believe developed through familiarity and mutual understanding, but perhaps due to my own background as a child I found dealing with parents and children in crisis as particularly physically and mentally draining. As part of my professional development as Deputy Principal I attended mediation training courses organized by the Department of Education on a statewide basis and, these helped refine my approach to resolving disputes between members of staff or between members of the public with teachers. However, I felt with the heavy workload and the heavy emotional load that I was burning out. In addition I had a young family and a wife in questionable health. The long hours and the strain of doing the job were impacting on them. A further problem was that, despite the Deputy Principal’s salary looking good on paper, once you take out considerable taxes, superannuation, health insurance for a family, etc, there is not much left, and as my wife could only work part time we were struggling.
Facilitating an Empowering Mathematics Learning Environment

As a consequence of all of these considerations in 2000 I took leave to work as mathematics and computing lecturer at the University General Requirements Unit (UGRU) the foundation program at the University of the United Arab Emirates in the city of Al Ain.

At the time of my arrival a delegation from California State University was performing an accreditation audit on the university and was making recommendations for improving the quality of administration procedures and teaching.

One of their recommendations was the operation of a pilot learning program in UGRU that trialed and measured the success rate and community response to contemporary teaching and learning techniques (over the traditionally preferred rote learning methods). Because of my background and my familiarity with these contemporary methods such as student-centered learning, problem solving, critical thinking, cooperative and collaborative learning, etc I was approached to teach and shortly afterwards to lead the mathematics team who were writing and implementing curriculum for the program. The pilot program was scheduled to run for two years so that a wide range of strategies and approaches could trialed and evaluated. A comprehensive range of qualitative and quantitative processes of data selection and analysis were mapped out so that teachers and administrators could trial, analyze and refine technique (AlSuwaidi, 2001; Ward, 2005). Unfortunately, in the view of many of the teachers involved, myself included, the project was declared a resounding success after one semester and administrators were instructed to implement the approach it had used to mathematics classes across the whole Mathematics for Arts program. My opinion – given to my supervisors – was that this implementation was premature. I argued that most of our data was inconclusive, most of our techniques untried and unproven in an EFL environment.

Despite these reservations being expressed by leaders of other areas the implementation went ahead and I found myself leading/coordinating the Mathematics for Arts Track. I had refused this job on several occasions because of my feelings that we were extremely underdone and underprepared for what was to follow, but as my project supervisor and by now, good friend, Professor Richard
Karas pointed out, with the exception of the four teachers who had taught the mathematics section of the pilot project I was the only one with any idea of what was expected and, as I had been chief curriculum writer and evaluator, it would be better for the fifty mathematics teachers involved if I coordinated its implementation. This was another interesting point in my career and another test for my coordination and leadership abilities. Whereas my four assistant teachers had been keenly interested in the project and were committed to expanding their practical and professional horizons, many of the teachers under my leadership were far from committed to the project, or to a student-centered style of learning. Many were rote learners themselves whose ideas and methods of teaching were based on the ‘tabula rasa’ concept of students as a blank slate, as passive learners who received knowledge from the ever knowing teacher as expert – the teacher as conduit. These teachers did not like sharing the power in their classrooms with their students and many converted problem solving activities into demonstrations. This was a period when our team worked hard to develop and involve our colleagues in many teacher training activity / interactive sessions in an attempt to let them experience and enjoy what we hoped they would eventually expedite within their classrooms.

Unfortunately it was about this stage that an interesting cultural experience eventuated that was to frustrate us even further. It was rumored that Shaikhah Fatima – first wife of Sheikh Zayed, then President of the UAE persuaded her husband of the unfairness of the UAE university acceptance/entry criteria into its General Requirements Unit. Namely, that while female students needed a 70% cumulative score in their national examinations for admission, the male students only required 60%. His Highness responded almost immediately by mandating that the women’s entry scores also be reduced to 60%. Whatever the rumor, the Mathematics for Arts track which was geared for 2500 students suddenly had 4500 students, and some of these of an ability level below the expected norm. As a consequence teachers who had been contracted to teach 4 classes on a face to face basis were suddenly confronted with 5-6 classes and work hours which sometimes extended from 8 am to 8pm on many days. There was little time and less commitment for professional development activities but somehow through the help and selfless commitment of some very good assistant coordinators we made it through our first semester. A second semester followed during which many more teachers came on
board as they recognized that the new teaching method did in fact work better with those students regarded as less capable, and in fact allowed teachers to call on the assistance of peer tutors to help out as well.

Shortly after that semester it became time to prepare for my return to teaching in Australia. I stepped down from the position as Coordinator of the Arts Track and moved to the Faculty of Science as a Mathematics lecturer. In some ways I wish I had done this job before the pilot project and the coordination role, as I believe I would have been far less critical of some of my recalcitrant Arts teachers. The Calculus courses run by the Science faculty were significantly ‘chalk and talk’, where students expected to copy teacher solutions to textbook problems all lesson long. There was little response to problem solving activities and student complaints to me and my supervisor should I try to derive some important results. In many ways it was a humbling experience, in which I recognized the power of student expectations over curriculum. In retrospect, this had always been the case, however, as a teacher in the NSW DET I had had a predetermined course to run (curriculum as a course) and been given the freedom of how my students and I ran that course (as in running our own race). During most of my time at UAEU I had been given the freedom to choose and construct the very course (racetrack) before and as we ran it. In the Science faculty I was given a textbook and a culture, and very little time to navigate it. In such a competitive environment my students expected answers that would lead to neat solutions in examinations, and high grades that made both them and their teachers look good. They felt disadvantaged by my somewhat different and radical approach. My own problem was, that in my view, they didn’t understand what they were doing and they couldn’t really do what I believed to be mathematics. In addition to my students, I also had to navigate the culture of my teaching peers. Like many colleagues in UGRU, they were rote learners themselves and couldn’t appreciate the benefits of student-centered problem solving. In addition, my reputation as someone who had led and presided over a very turbulent introduction to this very aspect at UGRU had preceded me. The majority of these teachers were in my view, less than welcoming, although some were very supportive of the new and very different teacher. Perhaps the greatest indicator of this was that while our subjects were supposed to be taught in English the faculty coordinator chose to run his staff meetings predominantly in Arabic, a language that at that time I spoke very
little of. Fortunately a friend and colleague with whom I had worked while at the Foundation Program (UGRU), an appropriately named Dr Mohammed Ali, vociferously complained when this practice was carried out in my presence, and just as vociferously translated what was said into English for my understanding. While I considered this to be a reaction to my teaching philosophy and my recent history, I did discover some years later from a colleague that followed me across to the Science faculty that he was treated similarly.

As a leader I learned some very important lessons from this experience. I had always tried to be inclusive but as I mentioned earlier, I am not a very charismatic type of person and as a consequence I am not overly gregarious, often leaving the social aspects of my team to those I feel are better equipped. However, my period of professional isolation made me realize how lonely and discomforting it can be to work in a new and unfriendly environment. These days I make a point of watching for and including on a formal and informal basis, all newcomers to my spheres of influence.

I left the UAE in 2003 to return to a position of Mathematics Head with the NSW DET. Fortunately for me on my way out I followed the advice of a friend and dropped into the Petroleum Institute to introduce myself and look around. I must admit that I liked what I saw and seemed to hit it off immediately with the administrators and mathematics faculty that I met there. It must have been a mutual observation because the Chief Academic Officer offered me a job as I was leaving. I declined his kind offer and proceeded home believing that my compassionate transfer to return to my district or the neighboring district had been approved on the grounds that my wife as an MS sufferer (documented with recent severe attacks) should return home to somewhere close to her old support network of friends and family. Unfortunately for me the NSW DET is an immense bureaucracy whose officers have enormous and complex responsibilities, which leaves little time for what they see as sentiment and, I discovered upon returning, that my application had been refused and, that as all known positions were full in my district and the next, I was obliged to transfer to a region of the DET’s choosing. Even with representations from my former principal I was given no guarantees except that I could appeal the decision which would then be reviewed in 3-6 months time. As this was
unsatisfactory to my own situation I decided to return to the United Arab Emirates and take up the offered position at the Petroleum Institute. I believe my experience of returning to NSW DET was another experience that further forged my leadership philosophy. My surprise and my discomfort at being treated in such a dispassionate and impersonal manner, was significant. In spite of what my ex-Principals and other departmental referees described as my significant contributions to their schools, including significant awards and nominations for teaching excellence and leadership, I was told I had no special case and that my request for compassionate consideration would have to wait. My personal amazement at the inefficiency of the staffing section of driving away an experienced mathematics teacher at a time when the Sydney newspapers were running articles lamenting the shortage of mathematics educators in the state and the loss of technical expertise overseas, was also significant. In addition colleagues working in my old region had been doing some research on my behalf and told me of two upcoming positions in my old schools’ district I was eligible to fill. As it turns out I could have waited and I probably would have been given one of these positions at a later date. But I was so affected by how I was devalued by my DET handlers I chose the Petroleum Institute over waiting for a disinterested (to my perception) employer. I believe my final decision was a good one. The hospitals and health care system was far better in Abu Dhabi than it was in Al Ain (where I taught at UAEU), and better than anything at our disposal on the NSW far north coast. The Petroleum Institute management in its good grace agreed as part of my contract to purchase an expensive drug (we could not afford at home) to ameliorate my wife’s MS symptoms and attacks. The drug worked brilliantly and we reentered a stage/quality of our lives we had lost twenty years ago. My wife’s health improved dramatically and as a result she is now able to work full-time as a teacher again. For me the contrast between the two styles of management was enormous and, I promised myself to be as much of a people person my abilities would allow. I also pledged my loyalty to the Petroleum Institute and carried out my duties with a pride and commitment that went beyond what I consider are my usual personally-driven high professional standards.

Shortly after my return to UAE and my start at the Petroleum Institute I was contacted by a member of NSW DET staffing to apologize for the handling of my case. Shortly afterwards they offered me a position as Head of Mathematics at a
school close to my home, and upon my refusal a position at another nearby school. My refusal to that offer, in my view, was not me being bloody minded, but I was influenced by the significant difference in management and leadership styles between the two institutions. Other influences on my decision to remain with the Petroleum Institute included enjoying being part of a very capable team of teachers. It was a group which bonded well and was allowed to bond by some very good leadership from our immediate coordinator and the Petroleum Institute administration in general. In the case of our coordinator, while quite new to the task, he had excellent people skills and, was willing to seek and listen to advice. This way of doing things allowed us all to contribute and to feel valued. It made us a very cohesive little group. In my own case, with my own background, I was able to do my job and my research, experiencing little intrusion and significant support and, was consequently able to further develop as a teacher, team player and, as a leader in my own right.

As with all things there are periods or cycles of change and the Petroleum Institute was no different. While on a trip to our founding university, Colorado School of Mines, I learned that our directors had been replaced by one of the engineering professors. While our former directors had followed a relatively (in my view conservative) American style of management/leadership, our new director was more dictatorial and far less open to the views and input of has faculty and administrators. Since then the Institute has been rocked by numerous firings and resignations, with the morale of the people who remain changing significantly. Within the Foundation Mathematics faculty our own philosophy keeps us focused on maintaining the high standards/quality of the work we do and, hopefully, ride out the storm. While we have until recently remained relatively untouched by most of the events, our mathematics coordinator did struggle emotionally with his role as our interface with management. Constantly bombarded by edicts from above and immersed in the negativity of many colleagues outside (and inside) our faculty, he was starting to show symptoms of disillusionment and signs of distraction. He was also smart enough to start looking for alternatives. While he was doing this, it fell on another colleague and myself to fill the void he created within the faculty and, when he finally made his escape to an administrative position (ironically still within the Petroleum Institute) I took over the full-time role of mathematics coordinator. It is worth noting at this point that I include this period of classroom teacher/senior
lecturer as part of my leadership experience because I believe it was for me another significant time of personal leadership. While I was not faculty coordinator/manager I acted continuously in the role of mentor both to my students, my teaching peers and at times shared roles as mutual leadership mentors with my immediate boss (and good friend). I learned much as well from being in this rather desirable position and I believe that I experienced a time of high credibility, borne out by my election to represent the foundation faculty on the Faculty Advisory Committee (Faculty Senate) for three successive years; and as Chair of the Foundation Curriculum Committee, among many other tasks. I believe I am still regarded in this light, but of course, less brightly now that I am saddled with the added burden of faculty management and the inevitable accountability.

Mathematics Coordinator is the position I currently fill, although I did apply for and get the position of mathematics head teacher at the new high school the institute was setting up to improve the quality of its intake. While this position offered significantly more salary than my current position I finally declined the offer of the job when I realized / recognized the level of interference from outside, namely the school board members, including my current boss, went far beyond supporting and offering advice. To me this was never going to be allowed to be the school I believed a modern school should be. I declined with regret because I had begun working with the new principal the board had hired and found him to be on a similar educational wavelength to my own. My decision was, however, vindicated (in my eyes) when the board suddenly fired the new principal when he told some of them to ‘stop meddling and allow him the freedom to do his job of setting up a modern high school’.

Recent leadership experiences have found me being drawn too deeply into the politics of the institution, which is something I don’t want to be involved in. After reading some good reviews from my students and supervisor, and through reading my curriculum vitae and references for the high school’ position, the executive director of the Petroleum Institute recently invited me to his office to discuss my future with the university. During our discussions he offered me the position of Associate Director of the Foundation Program. We then discussed a position description in which I would take the role of curriculum coordinator among other responsibilities. I was happy with what we negotiated but I was not happy, in fact
decidedly uneasy about some of the descriptions of my current director, who in my view is doing very good job under very difficult circumstances. As a consequence of these comments, I included the performance of my director and his relationship with the executive director, in my consultative discussions with my faculty and my fellow coordinators, including my director. The most notable thing coming from these consultations was that the relationship between my director and the executive director was not good, and that most people had similar suspicions (to mine) that my promotion was a possible attempt to weaken and eventually supplant my current director. Fortunately as secretary of the Faculty Advisory Committee (Faculty Senate) in addition to abhorring the ‘politics’ (common to all institutions), I have experience in dealing with hierarchies and have learned over the years that the best method is to be as direct and open as possible. As a result I declined the Executive Director’s offer and, thus far, remain as head of Mathematics.

This is the present point of my leadership experience.

Personal Transformation

Personal transformation whether it is viewed as professional, practical or ethical (in my view) comes mainly, if not totally from experience. A significant contribution or catalyst for change comes from what Donald Schon describes as reflection upon action (Schon, 1991); and of course what others have coined as action upon reflection (Pring, 1999). In what I view as my own transformation as an educational administrator/manager and leader, I have had (as indicated above) many contributing experiences. In an attempt at humility, I would admit to being wizened through learning from my many mistakes. While I am not claiming to be wise in the traditional sense, I know I have adapted/changed my ways – ideas, beliefs values and actions - significantly as a consequence of reflecting on these actions and, as a consequence of reflecting further upon actions I have carried out in response to earlier reflection. As my journal entry above might indicate, I have not necessarily been (always) professionally lauded or rewarded for my actions, but to me, it is clear that a transformation has taken place in which I have become more personally satisfied and, in my view, more effective within what appears my limited sphere of influence. In particular, upon reflecting upon my actions, in response to my
reflection of earlier actions, I find it easier to live with myself – with what I am, and what I have come to believe.

**Conclusion**

I believe that to develop (what I have termed) a culturally empowering Mathematics learning environment one must venture far beyond the mathematics classroom. From my own experience, as a teacher, a manager and a leader, I believe that only people who are empowered themselves can truly empower others. I further believe that empowerment is a sharing, a mutual enactment of all involved parties, rather than a gift that can be bestowed, or the absence of shackles metaphorically removed by some altruistic being (white knight). From further experience I sense that complete individual freedom/empowerment is not effective when individuals come together in a social sense to form a mutual culture. Such a convergence appears to me to require coordination as individual stakeholders bring with them disparate beliefs and values from other cultures, within which they co-exist. In Chapter 4, I attempted to investigate using specific examples and samples, how the culture within an EFL Mathematics learning environment might be optimized, or at least, effectively managed within the best interests of all its stakeholders. In this chapter I have attempted to open that investigation to the wider world of the mathematics faculty/program within the Foundation Program at the Petroleum Institute, hoping that readers will make any connections between this and their own teaching and learning environment. In particular, I have attempted to make the connection in terms of empowerment and emancipatory practices, between these two obviously overlapping and interconnecting perspectival environments.

On a more personal and of course professional level, I have mapped my own transformational course within these environments and, have come to my own conclusion, or at least reached a temporary point of equilibrium. At this point, that is the belief, that the only way I can empower myself is to empower others and, that the only way I can empower others is to enact my own empowerment. From reflecting upon my own experiences within the confined spaces of my own deliberately restricted frames of reference, I believe this to be so.
Chapter 9

Constructing a Culturally Empowering Mathematics Learning Network

Introduction

In this chapter I discuss how mathematics and mathematical thinking can be more widely offered and how it can be structured to contribute to an effective and empowering mathematics learning environment for my students here at the Petroleum Institute and for those elsewhere who wish to be involved. In this chapter I consider the educational community within the Petroleum Institute which has connections to the Foundation Program, and in particular to Foundation Mathematics, and I also consider the broader community that lies beyond, but interacts with, the Petroleum Institute. My investigation considers briefly how programs such as STEPS (Strategies for Team-based Engineering Problem Solving), used by teachers within traditional mathematically based subject areas such as Engineering and Science, help to bridge the gap between foundation mathematics and their own courses. I consider the methods and reasons used by teachers in what are considered to be non-mathematical subjects such as English language, to encourage and engender mathematical reasoning and critical thinking by students in their lessons within the Petroleum Institute, and I look at the interaction between foundation mathematics and peripheral bodies or initiatives, such as the ADNOC Young Achievers’ Program (OASIS) and the Middle Eastern Teachers Conferences (METSMaC), especially the part they play in developing and or sustaining an effective and empowering mathematics learning environment for students and teachers at the Petroleum Institute.

In reflecting on my own transformation as a teacher and learner, and as an educational administrator and leader, I consider also how my interaction with other teachers and disciplines has affected my own philosophy and practice.
Then, once more calibrating the lenses through which I judge and evaluate these practices – my dynamic, ever adjusting schema, – I consider these activities in terms of their contribution towards constructing what I perceive to be a culturally empowering (mathematical) learning network.

At this point I believe it is worth reiterating that what I am about to describe are my perceptions as a teacher of mathematics. Although my colleagues in other disciplines might agree about much common ground in what we are doing, they are likely to see things from a different perspective, as determined by their own schemas based upon different personal and professional experiences and needs.

From my own perspective I believe that much common ground between teachers is negotiated rather than found, I also believe there are degrees of difference often generated through what teachers perceive as important. I mention this, in particular, in regard to my consideration of the STEPS activities in which my perception of the primary importance of mathematical reasoning would be considered as secondary (by engineers) to the importance of the engineering (problem solving) processes or cycles.

**Content-Rich English Classes**

In recent years there has been a shift in policy and approach within many English as a Foreign Language (EFL) classes in the Foundation Program here at the Petroleum Institute. This shift has been towards teaching more English language classes ‘in context’. The context in the case of the Petroleum Institute has been engineering.

Such a shift has not gone unchallenged, with many traditional English teachers seeing little value in stepping out of their traditional roles (Appendix 9.1.4) and/or arguing that students require mastery of the basic skills of English language first, and also that many of their students are unable to grasp the mathematical – particularly the spatial – concepts involved in such an approach. This criticism has not been taken lightly with administrators adopting a variety of approaches towards solution of the stated problems.
From my experience one logical approach to the problem has been a closer analysis of the way in which Arabic native-speaking students relate to and work with and within the English language, and (in my case) its structure, syntax and grammar in relation to mathematics.

Areas of interest to the Foundation Program teachers of the Petroleum Institute have included the way in which students make connections between Western and Arabic number systems and their assimilation and integration of an English-based technical vocabulary.

Much of my own understanding of these differences, identified personally within my own classroom and teaching experiences, has been formalized and explained during my interaction with EFL teaching colleagues. This understanding has developed informally through sharing common classes and formally as part of scheduled professional development sessions organized by the foundation professional development committee.

One significant example has been the training I have received, along with others from colleague Wael Al Sokkary (Appendix 9.1.1). In a series of teacher training workshops and also in answering individual questions on an ad-hoc and informal basis, Mr. Al Sokkary has in addition to stressing the wide differences in alphabets, grammar, syntax, phonology and semantics between the two languages, (Does thinking in Arabic affect our students.ppt) (El-Sokkary, 2007), included the number system, stressing the following critical differences in Table 9.1.
The Numerical System

- Gulf Arabic uses Hindi numerals. 
  -٠٩٨٧٦٥٤٣٢١
- The numbers are read differently:
  - e.g. the number 25167 reads Five and twenty thousand one hundred seven and sixty
- 1,500 is not easily read as fifteen hundred
- 1,500.67 is written as ١٥٠٠٫٦٧ (٠٠٥١,٧٦)
- Arabic: millioon – milliaar – billioon – billiaar – trillioon
- English: million – billion (thousand million) – trillion ….etc

Table 9.1 Arabic vs. English Numbers

<table>
<thead>
<tr>
<th>Arabic</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>٠٩٨٧٦٥٤٣٢١</td>
<td>٠٩٨٧٦٥٤٣٢١</td>
</tr>
<tr>
<td>١٥٠٠٫٦٧</td>
<td>١٥٠٠٫٦٧</td>
</tr>
</tbody>
</table>

Part of his shared solution to addressing the problem of the differences in structure and subsequently thinking encountered by students, is to expose students as much as possible to such concepts as part of their everyday ‘doing’, using the words, structure, syntax and ideas in the context of problem solving and immersion in engineering and oil industry related activities.

Included in this approach is the proviso that students are treated with courtesy and respect and allowed to learn that any misinterpretations and misconceptions are perfectly normal and allowable, but are certainly brought to their attention. Such an approach provides students with a ‘safety net’ and encourages them to take risks in using and learning ‘technical English.’ It is this kind of thinking and its demonstration, I believe, that has encouraged and supported other English teachers to take a similar approach to contextualized teaching of and in English.

Another complement to investigation and information sharing about Arabic learners and their strengths and weaknesses in interpreting technical terms and number systems is exemplified by colleague David Thomson (Appendix 9.1.2). As an English teacher involved in teaching EFL in the context of the oil industry, David is part of a group that has argued consistently (and successfully) for the introduction of ‘relevance’ to English lessons. This group regularly develops technical worksheets
focused on the oil industry with which students engage in a variety of activities including problem solving and working mathematically.

In response to Wael’s workshops and in collaboration with his team members, including consultation with some mathematics teachers, David has developed a series of worksheets designed to address some of the problems that Wael previously identified.

**Example 1**

**Reading Numbers**

<table>
<thead>
<tr>
<th>BIG Numbers</th>
<th>billion,</th>
<th>million,</th>
<th>thousand,</th>
<th>hundred,</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 8, 3,</td>
<td>4, 6, 9,</td>
<td>7, 5, 2,</td>
<td>1, 3, 8,</td>
<td></td>
</tr>
</tbody>
</table>

- hundred billions
- ten billions
- billions
- hundred millions
- ten millions
- millions
- hundred thousands
- ten thousands
- thousands
- hundreds
- tens
- units

*In British English ‘thousand millions’

The number written above is read:

- one hundred eighty-three billion,
- four hundred sixty-nine million,
- seven hundred fifty-two thousand,
- one hundred thirty-eight.

**Directions:** Express the following in numbers.

1. Twenty eight billion, thirty million, twenty-eight thousand, fourteen.

The example above is a sample of David’s worksheet (Appendix 9.2) which he designed to address those basic issues identified by Wael as critical and requiring resolution before we could expect students to begin to work effectively with the mathematics that we require at the Petroleum Institute.
In addition to developing worksheets and activities designed at introducing technical vocabulary and its structure to students, this team of EFL teachers has also embraced problem solving and critical thinking as vehicles for their lessons. A typical example is the team’s use of (oil) industry data for the UAE and the world as material for reading, comprehension and discussion exercises. Such data often include mathematical tables and graphs, and its interpretation regularly involves (mathematical) data analysis skills.

Example 2: (Level 2 English Comprehension Activity – David Thomson)

**Questions: United Arab Emirates (EIA DOE)**

**Instructions:** Write complete sentences to answer the questions.

1. What is the title of the bar chart on page 3?

2. In the bar chart at the top of the page, what unit of measurement is used to calculate oil reserves?

3. How much oil does Iraq have in reserves?

4. What percent stake in new major oil projects does ADNOC maintain the right to take?

5. What organization sets energy policy in the UAE?

6. What is the third largest oil field in the Middle East?

7. How much oil is the Zakum field estimated to have?

8. Who are ADNOC’s partners in the Upper Zakum project?

9. The last sentence on page 3 says that “…new exploration has been disappointing.”

10. Why do you think it has been ‘disappointing’?
While I have omitted the actual data it is obvious that the activity above is rich in mathematics. Students working through this and other related activities are clearly applying simple mathematics and problem solving skills to data and issues very relevant to their intended professional aspirations. In doing so they are bridging their academic and professional life worlds. In addition they are interpreting the data in the context of (to them) real-world issues, such as oil reserves and oil exploration, which goes hand in hand here with national wealth and Emirati quality of life. It is this enhanced sense of connectedness that they bring to mathematics classes (and others). Thus, when their mathematics teachers set a problem they are more prone to consider the bigger picture and to question the credibility or the possible consequences of what they are working with. With such exposure we not only address their thinking and language differences, but we also encourage them to be more than the isolated problem solvers described in Chapters 4 and 5.

A good example of the mutually beneficial collaboration evolving between English and Mathematics teachers based upon the contextualization of teaching activities was evidenced by the recent use by English teachers of current oil prices. They used this data to get their students reading, researching, discussing and writing about what trends they see in the price of oil and making predictions as to the consequences or the outcomes of these trends. While they showed the students the raw data (example 3) and elicited discussion on what they (the students) perceived, and the subsequent mathematics was relatively simple and managed using computer spreadsheets, they also provided us (mathematics teachers) with data and real-life scenarios for our own further and more in-depth analysis. This in-depth analysis included the polynomial regression techniques and interpretation of complex polynomial functions usually taught as part of the normal mathematics syllabus, but in this case more familiar, personal and of greater meaning to students.

Example 3 below is how English students encountered the data as part of a discussion activity. The students were asked about the trends and to predict the future of oil prices. While the activity was about improving their reading and speaking skills it also involved table and graph reading which were once regarded as an exclusively mathematical activity. It also went a long way towards informing them about their own 'backyards' and getting them to think and speak of how they thought
these issues affected them. Thus these English classes contained mathematically rich activities, but in addition they could also be considered as examples of social and/or critical constructivism (see Chapter 6).

As such these ‘close to home’ discussions allowed students to reflect and connect. They reflected on what this information meant to them at a more personal level and they connected critically their personal, academic and professional lives by participating in these informed discussions. Of particular value to all stakeholders (especially as a motivator for the mathematics teachers) was student recognition that, despite some familiar trends and beliefs, these are relatively complex issues and which may require more sophisticated thought and methods of analysis, including methods such as polynomial analysis.

**Example 3: Trends in Oil Prices (Discussion Material for English Level 2)**

Table 6.1

<table>
<thead>
<tr>
<th></th>
<th>WTI</th>
<th>DME Oman</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-Aug</td>
<td>$ 114.51</td>
<td>$ 110.09</td>
</tr>
<tr>
<td>2-Sep</td>
<td>$ 111.58</td>
<td>$ 111.36</td>
</tr>
<tr>
<td>9-Sep</td>
<td>$ 105.22</td>
<td>$ 101.53</td>
</tr>
<tr>
<td>16-Sep</td>
<td>$ 97.03</td>
<td>$ 92.05</td>
</tr>
<tr>
<td>23-Sep</td>
<td>$ 109.74</td>
<td>$ 94.33</td>
</tr>
<tr>
<td>30-Sep</td>
<td>$ 98.33</td>
<td>$ 93.61</td>
</tr>
<tr>
<td>7-Oct</td>
<td>$ 89.69</td>
<td>$ 79.27</td>
</tr>
<tr>
<td>14-Oct</td>
<td>$ 80.57</td>
<td>$ 71.71</td>
</tr>
</tbody>
</table>
A Foundation Mathematics ‘complement’ to this worksheet has been to introduce students to more ‘sophisticated’ methods of analysis (see Example 4). We approached this by getting students to enter the data (values) into their graphics calculators and to use the regression functions to locate polynomial functions of best fit. These functions have then been used to make predictions about daily prices and about future prices and trends.

Example 4: Foundation 3 Mathematics Worksheet – Oil Prices

1. The table given shows the recent price of oil (per barrel) across a period of 8 weeks beginning on August 26th 2008 as reported by WTI and DME (Oman)

<table>
<thead>
<tr>
<th></th>
<th>WTI</th>
<th>DME Oman</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-Aug</td>
<td>$114.51</td>
<td>$110.09</td>
</tr>
<tr>
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<td>$111.58</td>
<td>$111.36</td>
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<tr>
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<td>$ 79.27</td>
</tr>
<tr>
<td>14-Oct</td>
<td>$ 80.57</td>
<td>$ 71.71</td>
</tr>
</tbody>
</table>
Let $x = 0$ correspond to 26-Aug, and $x = 2$ correspond to 2-Sep. and so on

(a) Use quadratic regression to find a model for the WTI data.

(b) Use cubic regression to find a model for the WTI data.

(c) Use quartic regression to find a model for the WTI data.

(d) Which of these functions best models the WTI data?

(e) For the WTI data is this ‘best function’ a realistic choice to model actual oil prices? Explain your answer.

By doing these exercises, students (I believe) have had opportunities to developed a better understanding about the usefulness of these methods of analysis and prediction and perhaps opinions about the accuracy and the perceived fallibility of mathematical modeling. On what I see as a more significant point they have been given the chance to bridge the cultures of student mathematics and their engineering life-worlds. In particular, as many of these students are aware of their privileged status because of their nation’s oil wealth, they are also able to readily connect the mathematics to the postulated trends and to the realities and the implications impacting on their own lives, and that of their families – many of whom are employed in the oil industry.

One memorable and satisfying example was the (obvious? – to the teachers anyway) statement that the data could not be modeled by a cubic function ($y = ax^3 + bx^2 + cx + d$) because that would imply oil prices would continue to fall and eventually reach zero dollars. While students were aware of the behavior of polynomial functions they had previously reported no physical significance in this regard. Ongoing discussion included comments for example, that the function had to be of even degree such as a quartic to facilitate an upturn in prices, to laughter at the desirability (to students) of the prices continuing to rise. About this stage of the discussion some students suggested that this would not happen because demand would fall and prices would come back down again. Final consensus was that we would require a periodic function such as a sine curve but one which would be continuously changing in response to other factors. While this discussion bloomed in the mathematics rooms it
generated questions that students decided to take back to English lessons for further clarification and confirmation.

In Chapter 3 of this thesis I went to considerable lengths to discuss the perceived shortcomings of the traditional engineer and engineering undergraduate courses.

*Engineers are still viewed by many as exhibiting few verbal skills, and as appearing inarticulate, prejudiced, conservative and non-involved.* (Florman, 1968) (Chapter 3 of this thesis)

*In general then many observers see engineers as anti-social types who make poor leaders and managers as they are unable and unwilling in many cases to extrapolate engineering ideas into the necessary functional social, interpersonal and consensual action required as part of, and inherent in effective contemporary leadership and decision making.* (Chapter 3 of this thesis)

Like Florman, I also argued that ‘engineers should be ‘liberally educated’ in order to enrich their own lives, their profession and society in general’.

I believe that through such collaboration, as demonstrated above, through the examples of Mathematics and English teachers sharing common ideas and putting them cautiously into action, that we are indeed enriching the lives of our students as they make the cultural border crossings from their own experience to their academic experience in a broadening range of contexts.

*Journal Entry – October, 2008*

*In the Spring Semester of 2001 I was employed by UGRU (UAE University General Requirements Unit) to write mathematics curriculum for the unit’s upcoming pilot project. This project was to implement and assess student centered learning activities. Part of my job was to collaborate with teacher / writers from the three other academic disciplines/faculties of English (EFL); Arabic (language and culture) and Information Technology (computer applications). While we all put lot of time,
energy and writing into our collaboration it just did not seem to align the way we hoped it would. There were a lot of reasons for this failure including a protectionist attitude from all involved as each team’s ‘sacred cows’ were in some way, shape or form threatened. In the case of mathematics although I was experienced enough with student centered and collaborative learning practices and was willing to release some of the control of my classrooms to my students, I was unwilling to completely break down the sequencing of my courses. I felt that as a relatively new teacher I myself was not empowered to do something so radical which I felt would have big implications for my fellow mathematics teachers, many of whom were fervently traditional and considered themselves masters of their classroom. Looking back at this time I believe we were all considering curriculum as a course (to be run), rather than as currere, the actual running of the course (Doll, W., & Gough, N., 2002; Doll, 1993; Doll, Jnr. W., 2002). As a compromise we – the designer/writer/implementers took a step back from a wholly integrated curriculum and instead chose to write common units of supplementary work or projects which involved all areas wherever possible. In my own case I wrote student centered investigations or problems to be solved which kept the integrity of our course sequences but used other areas as points of context. As such I considered that I was partially writing curriculum as currere.

In regards to the common work that has evolved at the Petroleum Institute I see a much more appropriate set of activities. Instead of searching for common ground as a group activity this collaborative group is freer in that it operates only under constraints of common interest within which no one feels obligated to the others. Instead of being bound by a common set of objectives, rules or guidelines I believe we share a common philosophy of learning, and from this we recognize/realize the need for our students to be doing something relevant. As it happens, in an engineering college problem solving, critical thinking and applying (mathematical, linguistic, scientific, technological) skills are pertinent, useful and motivating in all classrooms.

Like my English teaching colleague, David Thomson (Appendix 9.1.2), “I am a pragmatist and I do whatever I think is useful and effective to assist the leaning of my students”. I described myself in similar terms in Chapter 4 where and when I said
I was a neo-pragmatist. My perception then is that the key to our evolution as a cross-discipline teaching/learning community lies in our sharing a similar pragmatic belief and approach which allows us to share ideas and establish common areas of practice.

So in my experience we have the beginning of a successful collaborative exercise/community which began and continues to grow in a very informal mutual environment. While we have the support or at least the freedom to pursue this approach we have had nowhere near the logistical framework that I had experienced in 2001, yet at this stage I feel we have achieved as much (already) as did the organized and top-down driven teams of UGRU. What I believe is critical for our continued evolution as a teaching learning group trying to span traditionally distinct academic cultures is a common ethos and teaching philosophy which has been allowed to develop within the environment that is the Foundation Program of the Petroleum Institute.

*What should be very clear is that only through the actions of the teachers in the classroom supported by the interventions undertaken by the change facilitators, that the action plans will be implemented and the possibility of achieving the planned outcomes realized.* (Matthews, R., O'Mahony, G., & Barnett, B., 2006)

The positive feedback from many teachers and students adopting this approach has further encouraged others and by way of facilitation through formal bodies such as the Foundation Program Professional Development Committee, and informal collaboration of individual teachers, to develop, implement and mutually evaluate other collaborative endeavors. One subsequent approach which emerged from the collaboration between English and Mathematics teachers was the Calculator Project described in Chapter 3, in which students use the internet and library resources to research and investigate certain functions of their mathematical calculators which they then present to both teachers (English and Mathematics) in written and verbal form, thus practicing, exposing and enhancing their written and verbal skills in English language. A second approach, also the product of English – Mathematics
collaboration has been the introduction of puzzles and conundrums as part of English discussion lessons in the basic level classes.

Journal Entry – September 2008

I started at the Petroleum Institute in August of 2003. Part of the reason they offered me the position (they said) was due to some outstanding and innovative work I had done (it had been more widely recognized than I had realized) with the foundation program Mathematics for Arts courses at the UAE University. Some of this recognition had been through the training courses I had run for UAEU teachers and some small number of outside teachers.

The team I joined at the Petroleum Institute was a tight group of very outstanding but traditional mathematics teachers. I had not been part of such a talented and open group since what I consider as my halcyon days at Lisarow High School. Despite their traditional viewpoint and a relatively conservative approach to teaching mathematics my colleagues, while confident in their abilities, were not just content to ‘rest on their laurels’ and were open to suggestions and ready to take onboard new ideas and approaches. My students could be described in a similar manner. Relatively talented they had been successful in mathematics at school albeit, once again, the traditionalist classroom that they had learned in.

I think they viewed my approach with some trepidation at first, but soon came to realize that what they were doing was interesting and enjoyable, if somewhat riskier and perhaps scarier than they had been used to. Once they realized that all the problem solving and risk-taking was supported by a safety net of mutual respect and a willingness to share ideas, mistakes, successes and failures, I also believe they came to value my classes. As this relationship developed so did my reputation as Foundation Mathematics teacher. My student reviews, both formal and informal, were very good. I started to receive nominations from students and staff for teacher achievement awards and performance bonuses, and more importantly my colleagues both within mathematics and other areas starting asking me for advice, strategies and ideas to enhance their teaching. In response I ran my own series of workshops for mathematics and other faculty within the foundation program and this in turn
lead to an invitation to run some workshops for English teachers in the Abu Dhabi chapter of TESOL Arabia. Unbeknownst to me was that at the time the Higher Colleges of Technology, which was the UAE equivalent of the NSW TAFE (Technical and Further Education) system were experiencing a double problem. First, they had a shortage of mathematics teachers. Second, the English language and numeracy skills of their lower ability intake were so low that traditional mathematics teachers were finding it extremely hard to deliver the curriculum content written in those courses. As a result my courses were well attended by English teachers who were teaching mathematics classes and mathematics teachers in desperate need of some new strategies to help their low-level learners. Much of what I had learned teaching lower level classes as a mathematics and as a computing teacher in NSW high schools became very useful in the open forums I held at the end of these sessions. Indeed as I mentioned in Chapter 1, it was one such interaction with one such mathematics teacher that inspired the initial direction and jump-off point for this thesis.

The good response(s) that I received for these workshops on top of my own in-house workshops, led to further invitations to run workshops and present papers at numerous conferences, locally and internationally, and provided the motivation needed to continue with this thesis and other activities during periods of high workload and low morale caused by changes in the ethos, philosophy and practice of the Petroleum Institute.

One valuable by-product of all this activity has been the ongoing professional relationships I have established with peers from a wide range of teaching areas. One particular incident I consider significant happened in 2006 when, in response to calls from our Chief Academic Officer, our Foundation Program Director and our English coordinator for a greater focus on the teaching of English language within content-area subjects such as Mathematics, Physics, Chemistry and Information Technology, I argued that what was needed was in (our) reality a greater contextualization of the English classes to include more technical ideas, riddles, puzzles and conundrums. To make my point(s) I argued for what I called the mathematization of the other curriculum areas in the form of problem solving to further engage and challenge our students. While my belief was that some of my
colleagues had trouble with terms such as mathematization, I was also aware that many colleagues didn’t and that some had in fact already started this process within their classrooms. It is these colleagues who have now worked closely with each other and with members of the Mathematics faculty to develop contextualized problem solving activities such as the calculator project.

I would like to stress that I am not claiming kudos or responsibility for what went on in this regard. I was and am one of many independent players who recognized a need and by independent means, pragmatically addressed it. Fortunately for all of us we taught in an environment where research into teaching, either formally or as reflection in/on action cycles, was supported as was clear channels of interfaculty communication.

As the teacher coordinating the English faculty side of the Calculator Project, Jamie Baird is another excellent example of an EFL teacher mathematizing and contextualizing his lessons. While the mathematics teachers have adopted a content-focused method of evaluating the calculator project Jamie and his team have designed a rubric which assesses students’ speaking and presentation skills (Appendix 9.3).

While the targets are different from those of the mathematic rubric this other method of assessment, I feel, helps students develop greater knowledge, understanding and skills of application in regard to their calculators as they approach learning the device in a whole new way. Namely, through teaching it to their English Language peers as they go about demonstrating its uses and answering questions asked by their fellows. So while Jamie and his colleagues are happy because the students are more motivated and willing to read and research about something they see as important and intrinsic to their everyday Engineering/Mathematics courses, my Mathematics colleagues are also happy. This being because they recognize in their students a greater understanding of the strengths, weakness and functions of one of our important learning tools and evidence of less inertia in using the calculator or troubleshooting when things don’t work as expected.
In addition to the Calculator Project, Jamie and his team of English teachers have adopted a variety of mathematically and technically based units of work to motivate and engage their students. One excellent example of this has been their use of tangrams. In this unit students are encouraged to convert a variety of standard tangram shapes (squares, parallelograms, triangles, etc) to create a variety of common shapes.

While introducing and confirming a wide range of general and technical terms which are then open for explanation and discussion, this unit of work sits and fits very nicely with our similarly timed work on word problems/problem solving in which we have students using geometry and algebra to calculate perimeter, area, diagonals, dimensions, etc, of a wide range of shapes and objects.

In addition, this initial work on simple geometric shapes and their properties fits in well with the ‘simple machines project’ which is a collaborative effort primarily between English and Science but which starts shortly after students have studied geometric problems as word problems, and also through maximizing and minimizing areas and volumes of certain standard and complex shapes.

These combined projects lead in turn to projects taken by the first year engineers in what is called the STEPS program. (Appendix 9.4)
Example 5: Freshman STEPS Project – Gasket Design

Geometric Construction.ppt

Geometric Constraints

- When making a 2-D drawing, constraints are necessary to produce the exact shapes and sizes
- Constraints define the geometric relationship between the elements making the drawing
- Types of geometric constraints include:
  a) Parallel
  b) Perpendicular
  c) Vertical
  d) Horizontal
  e) Tangent
  f) Concentric
  g) Coincident, etc.

Sketching in CAD

Before you begin, analyze the drawing
Identify components and relationships

Tools we will use to complete drawing: scale, centerline, tangent, concentric, trim, mirror
As Example 5 indicates, the STEPS project relies heavily on students having a complete awareness (in English) of basic geometric terms and relationships. Through working in English lessons using tangrams and simultaneously in mathematics on area maximization and minimization problems they become not only familiar with terminology but also develop a working understanding of many of the properties.

**Reaching Downwards – ADNOC High Achievers Program (OASIS)**

The ADNOC (Oasis) High Achievers Program was introduced as a summer school program in EFL in 2003. Its goal was to expose talented students to the Petroleum Institute (as an option for future study) while enriching and improving their English language skills. While the program was regarded as successful, the limited numbers of students applying meant that it could hardly insist on talented students only, and so from the outset students of all ability levels were admitted. Owing to the wide range of ability levels some teachers did find it difficult to motivate students, who in some cases, had little or no English and who were clearly never going to be accepted into undergraduate studies at the Petroleum Institute.

In 2005 I was approached by a colleague and (at that time Oasis coordinator) Mr. Tom Le Selleur to mathematize the Oasis curriculum. Tom had been one of the English teachers who had shown an early interest in my workshops for TESOL and METSMaC and had gone on himself to run similar workshops from a purely English perspective. As a result he already had a large body of accumulated work he could use in the classes. After looking at the structure of the Oasis course and the problems its teachers were encountering we decided that I would write a separate Mathematics/Problem Solving Unit of work to which the students could come as a break from the English language class.

The curriculum that I wrote for this course was an attempt to engage and stimulate the students as problem solvers in both an individual and a collaborative capacity. As content I used a lot of the puzzles and conundrums I had recommended in my earlier workshops and I also integrated into it components of a ‘Math Strategy’ elective course I had designed and run with great success at Lisarow High School in the 1980s. As such, I taught my students to play (develop through practice/painful
experience) games such as Nim, Draughts and Chess, carefully omitting some card games for cultural reasons.

In addition to giving students problems which would use or highlight the technology we ourselves employed at the Petroleum Institute, such as graphics calculators and applications software, I also focused on problems that challenged their spatial abilities and technical vocabulary, both of which had been identified as possible weaknesses by the Basic Skills / Baseline Test given to our own incoming students.

Example 6: Oasis Worksheet #1 – Reading Simple Diagrams/Technical Vocabulary

In the picture above, locate (by shading) each of the objects listed below.

Each object scores 2 points, unless it shares a line with another object, then it is only 1 point. Maximize your score.

a) horizontal line  
b) vertical line  
c) two parallel lines  
d) two perpendicular lines  
e) a right triangle  
f) an isosceles triangle  
g) a rectangle  
h) a trapezium  
i) an acute angle
Example 7: Oasis Worksheet #2 – Reading Simple Diagrams/Sequencing

Focus Problem – Geometry

Student Name: .............................................

Fort

Mosque

Khasab
(Mussandam)

Lighthouse

Problems:

1) A dhow passes the Mussandam coast near the village of Khasab. The captain recognizes a number of points – the mosque, the fort and the lighthouse. The captain took these 6 pictures as he sailed past Khasab. Unfortunately he mixed them up. Which picture was taken first?

In which order were the pictures taken?

CALCULATORS OK!

Uncited example which has been borrowed and slightly modified by this researcher
In Examples 6 and 7, the worksheets are designed to engage the students in reading and interpreting diagrams. Each has a secondary focus. Example 6 (Oasis Worksheet# 1) is a simple way to get students to research technical (physical) vocabulary and make the natural connection between word and visual image. Its eventual goal is to develop visualization skills in students who appear primarily accustomed to algebraic manipulations connected to memorized algorithms and often disembodied from the world of physical/practical/applied mathematics. Example 7 (Oasis Worksheet # 2) has two secondary goals. The first is to encourage students to share ideas and opinions, and the second is to get them talking about sequencing some simple scenes based on visual and common sense so as to develop these abilities so essential for later mathematical problem solving as an engineer.

Exposing interested students to such basic engineering/mathematics related activities as reading and interpreting diagrams and sequencing pictures and/or events gives them a feel for things to come if and when they eventually enter the engineering programs where interpreting diagrams, blueprints, graphs and tables of data is commonplace. As such we have a double edged sword in that as well as teaching English language in a technical and contextual sense we are also directly preparing students for undergraduate courses such as STEPS and data modeling. In addition we are identifying and assisting our students to identify within themselves who is suited to, interested in and motivated by studies in engineering.

**Reaching Outwards – Middle Eastern Teachers of Mathematics, Science and Computing (METSMaC)**

*The annual conference for Middle East Teachers of Science, Mathematics and Computing, or METSMaC for short, is dedicated to providing a forum wherein teachers and educators of Mathematics, the Sciences, Computing and Engineering may share their ideas, research, and pedagogical expertise to enhance the professional development of all educators in the United Arab Emirates, its surrounding regions, and beyond.*

*METSMaC Vision Statement (Appendices 9.5.1, 9.5.2, 9.5.3)*
METSMaC was conceived in 2004 in response to a perceived need in the Gulf region for professional development activities for teachers of disciplines other than English as a Foreign Language (EFL).

This is not to say that EFL teachers were excluded, indeed many such as my previously mentioned colleagues – David Thomson, Wael El-Sokkary, Jamie Baird, Tom Le Selleur - were sought to run workshops and show other teachers what they were doing in their classrooms at the Petroleum Institute. However, while EFL teachers had a highly sophisticated support network in the form of TESOL-Arabia, the other disciplines had a limited forum for communication and very few conferences to attend and or present at, within the Gulf region.

The original idea and groundwork came from Petroleum Institute Foundation Science coordinator, Dr Jim LeAnderson in response to comments made by many teachers about the need for training and support networks within the region for Science and Mathematics teachers

[Something I mentioned earlier as my own experience and the catalyst for initiating the research that comprises this thesis.]

Dr LeAnderson set about canvassing colleagues and Petroleum Institute management with the idea of setting up a feasibility study for the staging of a conference in Abu Dhabi. The response he got from both groups was very positive and a working party was set up to investigate the areas of need and the logistics of staging such a conference. After much research and discussion it was agreed that such a conference was not only feasible but highly desirable from the point of view of the Petroleum Institute, its parent organization Abu Dhabi National Oil Company (ADNOC), other local universities, private and public schools.

It was decided that the initial format would be a conference covering four overlapping areas of interest which we (the working party) designated as Mathematics, Science, Information Technology and General. Each area would have its own invited guest keynote speaker and would run related workshops. The schedule would be such that interested delegates could attend most keynote addresses
if not all. In addition the conference would be opened by a plenary speaker of significant stature.

It was easy for me to involve myself with such an excellent idea/enterprise and because of my own background of research and involvement in such activities as the UAEU – UGRU pilot projects, etc, within the Middle East and the setting up of Mathematics, Science and Computing Studies Departments at Wollumbin High School in Australia.

I was welcomed onto the organizing committee and immediately put to work where I took on the role of Chair of the Invited Speakers sub-committee. As such I headed the group which researched and sought out high-profile researchers, educators and or speakers who could provoke entertain and educate a wide variety of teaching professionals.

After investigating a wide range of speakers the committee finally agreed to invite Professor Richard Karas, former Physics Professor at California State University, San Marco and also the man who oversaw the process of change at UAE University from 2000 to 2003. From personal experience – Dr Karas was my boss for the UAEU/UGRU pilot project and resulting implementation – I recognized Dr Karas to be an outstanding educator, teacher and leader. In all my experience with him he was always available, deeply interested in every aspect of what we were trying to achieve and able to backup his philosophy / talk with some very relevant action. In addition he was, in my view, the ideal person to open a conference in and on teaching in the Middle East. In addition to providing ideas, examples and support for his own teacher innovators at UGRU Dr Karas lived (and died) the politics of the place (to the highest level) on a daily basis. In short he knew from experience the minds and the hearts of all stakeholders at all levels.

Dr Karas opened METSMaC-I (2005) to wide acclaim. His plenary/keynote speech titled ‘The Noble Quest: Graduates who think mathematically’ (Karas, 2005) gave his audience more than just an understanding of the need to develop critical thinking and collaborative leaning skills, it involved them in an actual learning experience. Dr Karas’ ability as a teacher was evident and instead of just telling of his experiences,
he cajoled, provoked and engaged his audience with puzzles and conundrums which, while related to the areas of Physics and Mathematics, could be logically resolved by all individuals regardless of background. He empowered all present to participate in this learning experience, and much to everyone’s delight we did, and much to everyone’s further delight those of our students attending did as well. As a matter of fact it was one of the students who came up with the first viable solution to his master problem.

Dr Karas then continued this opening speech with a further series of questions, samples, anecdotes, examples and answers that gave a very clear message: that scientific education was changing in response to some very clearly perceived needs. The change was not only desirable but (as evidenced by his examples) achievable and that we (teachers and students working together) were the facilitators of that change.

*Getting a student trained in basic mathematical skills and educated to think mathematically is not easy especially when he or she arrives at his or her college, university or higher education institution with a primary and secondary education rooted in rote learning.* (Karas, 2005, p. 4)

Dr Karas’ time spent in the Middle East meant that he had an insight into the issues and problems faced daily by most teachers of mathematics, science and technology.

In addition to sharing empathy with his audience Dr Karas further demonstrated that as an educational leader and researcher he and his team had developed some general and specific teaching strategies to address those of particular significance to the Middle East.

Suggested strategies included active engagement of students, regular evaluation and feedback, identification and actual delivery of consequences, focusing on applications rather than abstractions and the explicit teaching of problem solving strategies.
In addition to Professor Karas, the committee had found what they believed were other outstanding educators to demonstrate to us those things they were achieving in their own fields of endeavor. Dr Glenda Anthony from Massey University, New Zealand, was the invited speaker for Mathematics Education. As a teacher educator, Dr Anthony had considerable expertise and experience with student-centered learning, collaborative and cooperative learning activities. Part of her work was in developing a generation of new teachers who despite being taught by traditionalist/modernist / behaviorist teachers, would understand, appreciate and embrace the new constructivist ethos and apply its principles to the teaching of mathematics. Dr Anthony also ‘walked the talk’ as she engaged and empowered her audience to ‘share the learning experience’ in her keynote presentation titled “Effective learning strategies for mathematics education. (Anthony, 2005) Overall we believed METSMaC–I was a very successful experience. The feedback we received was positive from all quarters, and all participants spoke of the quality of the presenters and of the ideas, strategies and practices they were taking back to their classrooms and administrative circles.

METSMaC-II or METSMaC (2006) as it was renamed was also considered to be very successful. Dr Jere Confrey proved a very good choice of plenary speaker as she demonstrated in her presentation titled “From constructivism to modeling” (Confrey, J., & Maloney, A., 2006) just how knowledge is constructed and she explained the ensuing implications for teachers and their choice of methods inside and out of the classroom. This was, I felt, particularly pertinent because due to the success of the first conference a lot of our colleagues from the engineering programs were in attendance, many of whom were involved in the ABET accreditation process which demanded, for some professors, significant changes in the way they designed their curriculum –syllabi, teaching programs and indeed ran their own ‘classrooms’.

Of particular significance to me as mathematics teacher was the presentation by Mr. David Marsh who was the invited generalist speaker. In his keynote presentation titled ‘English as medium of instruction in the new global linguistic order: Global characteristics, local consequences’ (Marsh, 2006, pp. 29-38) he discussed the benefits and losses occurring in various cultures/communities because of the switch to English as a learning language. Marsh concentrated on Content and Language
Integrated Learning (CLIL), a term which had been coined by European educators as an umbrella for the many diverse methodologies in operation where attention was given to both topic content and language of instruction.

The CLIL ‘generic umbrella’ includes many variants. Some of these may be considered primarily as language teaching. Some can be seen as mainly content. The essence of CLIL leads to it having status as an innovative ‘new’ educational approach which transcends traditional approaches to both subject and language teaching. (Marsh, 2006, p. 33)

The significance for me as a researcher was that I could see many direct connections between the scenarios and associated strengths and weaknesses that Marsh was describing, and the evolution of the informal collaboration that was beginning to happen between the English faculty and other faculties – particularly Mathematics from my perspective – within the Foundation program at the Petroleum Institute.

Indeed it is my belief that through mutual participation within/at the METSMaC conference a lot of excellent ideas and strategies had been learned, adopted or reinforced, and that with this new validation many activities were continued to a successful level of development or inclusion that may have otherwise been allowed to atrophy.

By the third conference METSMaC 2007 organizers had included engineering studies (content and teaching methods) to satisfy the large number of engineering educators applying to present at the conference and to justify the large amounts of money being spent by the Petroleum Institute and major (engineering) sponsors such as Abu Dhabi National Oil Company (ADNOC) (Appendix 9.5.1).

METSMaC 2007 plenary speaker was Mr. Douglas Butler who we ‘grabbed’ after seeing his pertinent and entertaining multimedia presentation at the Texas Instruments International Conference in Denver Colorado the previous year. Butler did not let us down and provided all, but mathematicians in particular, with an insight as to how our teaching of mathematics could be enriched using technology. Indeed some of the samples and examples I have listed in Chapter 5 of this thesis
have been inspired and or enriched from my interactions with people such as Douglas Butler. In addition to providing an outstanding and thought provoking opening to METSMaC 2007, Douglas followed the tradition set by our previous plenary speakers in running a series of workshops for conference delegates. Proof of Butler’s quality and impact was that he was invited back to Abu Dhabi a month later to open the Higher Colleges of Technology (HCT) Annual Mathematics Day.

In addition to Butler an outstanding array of guest speakers, including Professor Stephen Heppell, Dr David Tall, Professor Norman Reid and author David Graddol, provided all involved with experiences and activities which in most cases bonded all disciplines covered at the conference.

Unfortunately, METSMaC 2007 was to be our last conference – or at least until another college takes up the challenge – as a new Petroleum Institute management with a focus on Engineering Education withdrew our funding to concentrate on its own Energy2030 conferences, and our attempts to find alternate sponsors were discouraged.

**Summary**

Chapter 9 provides evidence of important factors contributing to the construction of an effective and empowering mathematics learning environment for EFL students which lie outside of the traditional mathematics courses and classrooms of the Foundation Program. In addition to the expected interaction between mathematically based disciplines such as Physics, Chemistry and Engineering Science, there is compelling evidence of the evolution of significant collaboration between these disciplines and the English language (EFL) programs. In particular, the collaboration between certain EFL teachers and their counterparts has been of significant interest and has, as the evidence in this chapter suggests, been both productive and beneficial to all stakeholders, including the students who appear to be getting a more relevant and contextually relevant education. Evidence also exists on a wider scale to suggest that the mathematical environment is not a closed system, closed neither in the context of the Foundation Program nor the Petroleum Institute. Examples or scenarios depicted in this chapter indicate a mutual and beneficial mathematical
interaction occurring at the pre-intake level (OASIS) and at the professional development level (METSMaC).

Conclusion

This chapter indicates that the concept of an effective and empowering mathematics environment being limited to the classrooms and faculty offices of the Foundation Mathematics Program at the Petroleum Institute is a naïve perception. Scenarios and examples of a suggested best-practice scenario, as indicated in Chapter 8, have been shown to be part of a much wider and more open system or environment.

This in turn questions the relevance of my answers to the original research questions of this thesis being restricted the context of the mathematics programs/classrooms. It would appear that answers, and indeed the very questions themselves – e.g. ‘What is mathematical competence?’- need to take into account the broader socio-cultural context within which this investigation is situated.

It is within this broader frame of reference that I intend to position this research when, in Chapter 10, I attempt to address directly my original research questions.
Section IV: Research Questions and Answers

Introduction

In Chapters 7 to 9, I have addressed the original research questions indirectly by presenting professional scenarios and samples of pedagogical strategies that I have developed over many years to engage engineering students at the Petroleum Institute – and others – in what I believe to be the meaningful learning of mathematics. I have done this in an attempt to immerse readers in my learning environment so they can relate to it and choose to take on board anything that may be useful to them. However, I still need to provide direct answers in order to give these questions due credence. In particular, it is important that I incorporate in my answers an awareness of what I have called the ‘second strand’ of this research, something that emerged during the course of this inquiry.

This is the realization that while I am fulfilling my original aim in providing technical and practical assistance to key stakeholders (i.e., colleagues and students) I am also aspiring to provide deeper – philosophical and idealistic – meaning to my teaching practice, especially expressed from within the domain of Habermas’ emancipatory interest which influenced me to empower my students through the teaching and learning of mathematics.

This second strand arose from an emerging awareness of something that I recognized early enough in this inquiry for me to change the focus of this thesis from ‘effective’ learning to ‘effective and empowering’ learning and finally to ‘culturally empowering’ learning. It is in recognition of something I see repeatedly as I look back on my pedagogical strategies and consider how and why I offered them to my students and to my colleagues. It is a recent awareness of something that permeates my professional career. It is an awakening brought about by this research to the fact that over the course of my professional career a significant personal and educational philosophy has evolved.
Through the enactment of this critical reflective inquiry my philosophy has been strengthened and refined, as I recorded recently in my Journal.

Journal Entry – April 2009

I am reflecting upon the influence of this research on my own transformation as a teacher and learner. While some of the change I have undergone came about as a direct consequence of my reflection upon and within this research, not all could be directly attributed to it. As I asked myself why and how I did (and still do) what I do and asked what (I believed) was of value in what I did - along with other ponderings which later comprised the majority of my research questions - I became aware of other, earlier changes. Some of these had occurred in my earlier experience and couldn’t be directly attributed as outcomes of my recent deliberations. This was not an uncommon experience. There were many instances when I looked back at what I considered a purely pragmatic decision, only to now realize that I had been strongly guided by beliefs, attitudes and values that I was unable to mentally enunciate at the time.

So while this research has indeed been, and still is, a major transformative experience, it is not the sole stimulus for my transformation. Instead I see it as another major iteration within many (self-regulating/equilibrating) transformative cycles. From this perspective the essence/enactment of this research is also ethnographic and autobiographical in that it unearths, exposes, invokes and reports upon (in addition to its own primary realizations) those other earlier significant bifurcation points within my professional-personal existence.

Part of the ongoing inquiry process, constituted by my writing of this section (Richardson, 2000), is to consider what I have learned throughout this research. To do this I reflect directly on my original research questions and further synthesize the thoughts developed here and in previous chapters. To help substantiate my impressions I draw also on questionnaire data obtained from colleagues and students. These questionnaires (see Appendices 9 and 10) were completed mostly ‘on line’, although some students responded on paper, and their responses were refined further through subsequent open discussion with individuals or with small groups. Not all
responses were used because some were found to be contradictory, confused or less clear. In most cases, while the data were objectively derived and general patterns or the absence of patterns were recognized, there was also a subjective component in that the data came from the idiosyncratic responses of individuals. Through the process of reflective analysis of these responses deeper insights were sought as to the influence of the students’ cultural paradigm on their learning practices.

**Restating the Research Questions**

My initial research questions were:

1. What am I really trying to teach in Foundation Mathematics?

2. What are the perceived benefits for my students of learning the mathematics we teach at the Petroleum Institute?

3. What is mathematical competence in the context of my students and in the eyes of my colleagues at the Petroleum Institute?

4. How do I define and measure the mathematical competencies of my students and my colleagues?

5. Do I hold the same professional beliefs and values as my teaching colleagues and administration at the Petroleum Institute? Is my interpretation of mathematical competence the same as that held by my colleagues and/or my students?

6. Over what levels ‘of being’ does the value of mathematical competence extend?

7. What innovative pedagogical practices - teaching strategies and management protocols - employed by this Foundation Mathematics teacher are culturally empowering for both me and my students?
8. What beliefs and values are manifested through the learning of Mathematics?

9. How do cultural differences – ethnic, gender, generational, socio-economic – influence the effectiveness of teaching and learning strategies? What strategies can be adopted to produce successful cultural border crossings?

10. How can educational technologies, such as graphics calculators, computers, the world-wide web, assist the process of constructing an empowering learning environment?

In considering the credibility of my answers, and of the answers provided by students and colleagues in the questionnaires and interviews that I used to position some of my answers, it is worth remembering that none are definitive. Each individual stakeholder – student, teacher, administrator and/or researcher – has his or her own beliefs, values and perceptions. This is because the ideal or concept of best teaching practice can be considered subjective, even idiosyncratic, in its interpretations and its applications.

However, from my experience as a teacher and through working with teachers, I believe (recognize) that some agreement exists. Common perceptions are arrived at through consensus or mutually through exclusion or perhaps tacitly as ingrained behaviors. For example, while different pedagogical approaches and preferences exist within the small sample of responses obtained in this investigation (see Appendices 9.1, 10.1 and 10.2), it is my perception that many of my colleagues seem to be similarly pragmatic in their approach to choice of teaching strategies, as the following extracts from the teacher questionnaire and interviews suggest.

Q2. What are your preferred teaching styles?

Experiential, getting the students to do all the work, learning through doing
[English Teacher JB] (Appendix 9.1.3)

As a teacher who believes in the notion of ‘principled pragmatism’ I try to first determine the needs and levels of the learners and their purpose for learning,
and then use one of my ‘styles’ to fit the situation I am involved in. My styles range from drill-and-kill to go-away-and-figure-it-out-by-yourself and all points in between - whatever is appropriate for the learning situation. I use a variation of the Socratic Method fairly routinely. I think Richard Feynman said it well: “First figure out why you want the students to learn the subject and what you want them to know, and the method will result by common sense.

[English Teacher DT] (Appendix 9.1.2)

I like to motivate students first. Once they get started, I tend to move around them as they work. [English Teacher WES] (Appendix 9.1.1)

In my own postmodernist view, inquiry into why something works is secondary to inquiry into how well it works. I recognize the value and usefulness of the scientific effort not as leading to universal laws, but as identifying, testing and preserving those practices which produce (intended) results. (Graeme Ward, Chapter 1 of this thesis.)

My claiming to be pragmatic does not mean I that am not going to answer my questions, rather it means that my answers may at times appear subjective and limited to my own perspectives – attitudes, beliefs and values – and to my interpretation of the responses given by the other stakeholders. That means the answers you are about to experience have been filtered through my schema, the prejudices of which you should already be aware of if you have read my stories, thoughts and interpretations in the preceding six chapters. That they do not necessarily reflect fully the attitudes, values and beliefs of the other stakeholders should not be problematic because I believe we share enough commonality in that we are all ex-patriot teachers contracted to teach engineering undergraduate students in an EFL environment at the Petroleum Institute (Abu Dhabi). We are influenced by very similar social forces and cultural expedients, and through dialogue some of it is expressed in this research. Many of us share what I consider to be more idealistic goals than we had realized previously, particularly empowerment through the democratization of learning.
Structural Outline

In this section I attempt to address the 10 research questions I posed at the beginning of this dissertation.

In Chapter 10, I address research questions 1 and 2 related to what I and my stakeholders believe are the benefits of teaching and learning mathematics. In an attempt to find a suitably relevant answer I consider what it is that we, as teachers, believe we are teaching when we teach mathematics, and I also consider student responses to what it is they see is happening in our classrooms and what they think is beneficial in what we are all doing.

In Chapter 11, armed with the findings of Chapter 10 I attempt to define just what it is we mean by mathematical competence and how this can be related to engineering studies and the requisite mathematics.

In Chapter 12, I consider ways and means of developing student competence while at the same time empowering them as learners and members of various sub-cultures.

In Chapter 13, I conclude by summing up what it is I have found in this inquiry and how I believe it has affected me as a researcher and a teacher administrator.
Chapter 10

The Nature and Perceived Benefits of Learning Mathematics

Introduction

In this chapter I will answer research questions 1 and 2 which relate to the nature and benefits of learning mathematics within our classes at the Petroleum Institute. In addition to giving my own perspectives I will share some other stakeholder’s viewpoints as gathered from students and mathematics teachers within our program.

Question 1: What am I really trying to teach in Foundation Mathematics?

I believe that the learning of mathematics should extend beyond the technical domain that some of my colleagues extol and within which they practice with great passion and vigor (Milne, 1993). While I enjoy being a ‘proficient mathematician’ and take great pleasure in solving mathematical problems, I also believe there is more to mathematics than its elegance and beauty. As an applied mathematician I believe mathematics has, among other things, utilitarian purpose, the existence of which I have tried to convey and to pass on to my students.

To me, the application of mathematics in solving real-world problems adds considerable worth, and, as a teacher of engineers, it is something that I get ample opportunity to demonstrate. In working and thinking this way it is worth noting that I am still functioning very much in the technical domain of human interest (Habermas, 1972; Young, 1990) so desired by my institution and its sponsors.

Also known as instrumental knowledge, the technical interest lies in how we can manipulate and control our environment. (Chapter 6)

The technical cognitive interest arises from the fundamental need of the human species to survive and reproduce itself, and is manifested in attempts
At one level I am presenting mathematics as a tool which my students can use for purposes of problem solving. They can use this tool both as students trying to master a complex science and as future engineers trying to solve some complicated problems. In doing so it seems that I am assisting my students to develop as people trained to ‘control and manage their environment’. However, my intent as a transformative teacher goes beyond what I consider to be mere control of one’s environment. While I recognize and applaud the achievements of Western science in regard to the technical domain I also perceive a vacuum within human and spiritual relations that has formed because of it (Afonso, 2007; Luitel, 2006).

When I teach mathematics I try to impart or share my own wonder of mathematics and of life to and with my students and I try to develop within them and within us a feeling of adventure, of challenge and of community. As a consequence many of my chosen problem-solving activities are collaborative, discursive and community based. (Appendix 10.3)

In addition to solving problems in a technical sense I attempt to interweave a variety of applications and implications including situations designed to perplex my students (Hewson, 1996). At these moments of cognitive conflict while my students seek and individually construct and assimilate solution strategies they also seek out each other to refine or validate their strategies in communal acts often described as acts of social. constructivism (Anthony, 2005; Schoenfeld, 1992; Youngs, 2003)

In working in a cooperative (or collaborative and communicative) manner, I encourage my students to think globally about the logistics and the cosmological consequences of what they are looking at and doing, and at how these interact and impact upon one another. Thus, I am endeavouring to move my mathematics lessons beyond traditional boundaries, placing myself as a teacher within the second of Habermas’ domains – the practical interest.
Practical interest (interactive knowledge) refers to human social interaction by way of what is called communicative action. Such knowledge and ensuing action is governed by binding consensual norms between individual members of society. These can be related to empirical or analytical propositions, but their validity is verified through mutual understanding. Many of the historical-hermeneutic disciplines such as social science, history and law constitute examples of practical (or interactive) knowledge. (Chapter 2)

Cooperative learning is more than a teaching strategy, more than an instructional technique. It is an entirely different way of viewing the educational process of schools, reshaping them into communities of caring in which individual students take responsibility for the learning of their classmates and respect and encourage each other’s diversity. (Sapon-Shevin & Schneidewind, 1992, Ch. 3)

By teaching mathematics in this manner and allowing some negotiation of our curriculum (Boomer, 1992) I am attempting to develop an environment of awareness and critique (Chickering, 1987, 1999; Fosnot, 1989) in which stakeholders feel free to involve themselves in critical discourse or constructive criticism of their course on both macro- and micro-educational scales. (Hauser-Kastenberg, 2001; Kittleson, 2004; Taylor, P., & Cobern, W., 1998)

In this manner it is my intention to empower my students and myself from within the mathematics classroom so that, among other things, they are aware of much more than simply the mathematical content of the course. My goal is that they also become practiced and skilled at seeking and sharing viewpoints on a wide range of issues related to their studies and feel empowered enough to take control of their own learning and ultimately their lives.

The emancipatory interest/emancipatory knowledge manifests as self awareness or self-knowledge generated via personal analysis as enacted in self-reflection. (Chapter 2)
I don’t believe that one human being can empower another, instead that people empower themselves. However, I do try various motivation techniques, which range from carrot to stick. I’ve found that by using Newton’s 1st Law (inertia) as a metaphor I can have some common vocabulary that I can use to try to communicate with them and hopefully motivate them. I also think that it’s imperative for me to work one-on-one with my students, to get them to see that I value them as individuals. (Teacher DT, Appendix 9.1.2)

This extends my teaching, I believe, into the third domain of human interest, the emancipatory, wherein I attempt, albeit never fully successfully, to provide my students with enough freedom to take leading roles as their own decision makers.

Question 2: What are the perceived benefits for my students of learning the Mathematics we teach at the Petroleum Institute?

Looking at responses to this question in the questionnaire (Appendix 10.2) I see a broad variety of student attitudes and values showing through. For example, their responses to the questions on problem solving range from an absolute love of problem solving experiences to a severe dislike of problem solving, and include responses which even question its value for them. While the later responses surprise me coming from students enrolled in an engineering degree they also remind me of the cultural influences so pervasive within all educational institutions. That the Petroleum Institute has its own set of influences has been mentioned earlier in Chapters 2 and 3 of this thesis, including the rote learning systems so entrenched in the Emirati High Schools and the perception by many students that engineers are people managers rather than problem solvers. Add to this the situation that (anecdotally) many students take courses to please their families, rather than to meet their own vocational aptitudes and desires, and thus there is fertile ground for almost any kind of response at all. Indeed follow up interviews with contributing students, predominantly on an individual basis and occasionally within small groups, indicated that not all students were consistent in their responses and that some answers were open to very wide interpretation. In this case I chose to eliminate these responses from data used in discussions.
The Nature and Perceived Benefits of Learning Mathematics

The Foundation Mathematics faculty members of the Petroleum Institute have their own narrow and often conflicting and contradictory perceptions of what are the benefits of learning mathematics, and these may be used to navigate our courses and to concentrate on what is emphasized. So there are overall institutional interpretations and guidelines to assist teachers in their lesson facilitations as well as teachers’ own personal deliberations. However, these guidelines are open to interpretation by the individual teachers based on what is perceived as beneficial to students, and range from my own pragmatic views upon the importance of empowerment (Henderson, J., 2001) which focus widely across Habermas’ three domains of human interest (Habermas, 1972), to some colleagues whose viewpoints and philosophies are highly objectivist and primarily focused upon the technical domain (Kitchener, 1990).

While the mathematics faculty at the Petroleum Institute is considered a ‘fairly tight unit’ by other faculty members, differences of opinion are clearly evident in mathematics teachers’ responses to question 6 of the teacher questionnaire (Appendix 10.1).

Question 6: “What benefits or costs do you see in your students learning some mathematics by doing collaborative projects?”

_Not a believer in project based learning……._
Projects as a small part of a Maths course with independent learning is a good thing
[Teacher NM - Appendix 10.1.1]

_Teamwork, debate, social skills, infectious enthusiasm given the right subject matter, reinforcement through teaching each other; “teach something, learn it twice”_
[Teacher MG - Appendix 10.1.2]

_Weak students can get help/understanding from peers, especially if they feel uncomfortable asking teachers knowing/feeling they are weak._
[Teacher DM - Appendix 10.1.3]
Collaborative projects teach students to work together cooperatively, as they will have to do in the workplace. They learn that not everyone learns the same way, or even the same “thing”, from a given lesson.

[Teacher JN - Appendix 10.1.4]

Cost: the lazy ones get by

Benefit: they have a chance to learn at their own pace, and they may even discover time management skills.

[Teacher GM - Appendix 10.1.5]

The benefit is to instill in them independent learner skills because life is a continuous learning path.

The cost that I see in these collaborative projects is that there are some students that do not collaborate and only seek a mark the easy way.

[Teacher MAH - Appendix 10.1.6]

While there are differences of opinion, there are also many similarities, in that most colleagues agree on the overall benefits (and costs) of something – collaborative / project based learning. These differences and similarities are represented in Table 10.1 where I attempt to condense stakeholder responses to Questions 2 and 6 and summarize what I see as the preferred teaching styles within our team (based on individual responses) and also how I see them as their team leader and supervising teacher.

Table 10.1 - Summary of Teacher Responses

<table>
<thead>
<tr>
<th>Question</th>
<th>Teacher Centered</th>
<th>Differentiated</th>
<th>Student centered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2. Preferred Teaching style</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>Q6. Collaborative learning</td>
<td>Costs outweigh</td>
<td>Balanced</td>
<td>Benefits outweigh</td>
</tr>
<tr>
<td>Benefits vs. Costs</td>
<td>12.5%</td>
<td>50%</td>
<td>37.5%</td>
</tr>
</tbody>
</table>
However, it is the degree of the benefits and the level of commitment that remains in debate. On the other hand, student responses to similar questions – Questions 6 and 7 of the student questionnaire (Appendix 10.2), also alluding to problem or project-based collaborative learning - are in general, much shorter and more varied.

Question 6: “Did you learn much mathematics by doing research projects?”

Question 7: “Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain”

Yes, it is very useful
I like to do it in groups because I think it is important to share our opinion with other students
[Student # 1 – Appendix 10.2.1]

Not really much, but new information
First alone then if I give up on a few questions then I can ask other students to help me
[Student # 3 – Appendix 10.2.3]

No nothing, they don’t really help me at all.
I use two ways sometimes alone and sometimes with group.
[Student # 4 – Appendix 10.2.4]

Yes
HW sheets alone because it helps me to depend on myself and any question that I don’t know how to solve I will ask the teacher next day.
[Student # 7 – Appendix 10.2.7]

No.
Alone, makes me independent, besides taking responsibility alone, not to blame anyone but myself.
[Student # 8 – Appendix 10.2.8]
Not really. I learn mostly from teacher’s examples. Of course with group because working with group we will have less mistake. [Student # 10 – Appendix 10.2.10]

Similar to the teacher responses the student responses while displaying a wide range of reasons and or explanations could be reduced to the 3 basic preferences summarized in Table 10.2.

Table 10.2 - Summary of Student Responses

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q6. Did you learn much from collaborative projects?</td>
<td>40%</td>
<td>15%</td>
<td>45%</td>
</tr>
<tr>
<td>Q7. Preferred learning</td>
<td>Group</td>
<td>Mixed styles</td>
<td>Individual</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>10%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Looking at both sets of responses – teacher and student – it appears evident that each measures benefit in terms of their own preferred teaching-learning paradigm and in a significant number of cases this paradigm appears to be the traditional teacher as conduit/master/dispenser of knowledge paradigm.

However, what is heartening to me as researcher (into my own teaching development) and as a team leader/innovator attempting to introduce a paradigm shift within my own team of teachers and students is that there is a significant number of teachers and students (within our relatively small populations) that are moving away from this model to a more student centered approach.

So, although what I perceive as beneficial to my students through learning mathematics – in terms of Habermas’ 3 areas of human interest – may appear somewhat different through the eyes of some of my colleagues and some of our students, there does appear evidence of a shift towards greater student empowerment and an appreciation of that shift as being beneficial (in addition to student development of technical expertise).
Chapter 11

Mathematical Competence

Introduction

In this chapter I look at the idea of mathematical competence as I offer commentary and answers to research questions 3, 4 and 5, as stated in the introduction to section IV. In particular I look at what is mathematical competence in the context of my students and in the eyes of my mathematics teaching colleagues at the Petroleum Institute. I take this idea further in my answer to research question 4 about how I can define and measure mathematical competence within my students and within my teaching colleagues. Finally in answering research question 5, I compare my own interpretation of mathematical competence with what I perceive as those of my teaching colleagues and of my students. In doing so, I expand my discussion to look at my overall professional beliefs and values as compared with my other stakeholders.

Question 3: What is mathematical competence in the context of my students and in the eyes of my colleagues at the Petroleum Institute?

I believe from my experience(s) in both conducting this research and from 35 years of teaching mathematics that ‘mathematical competence’ is something that can only be defined when it is ‘situated’. By this I mean it is best defined when situated in the context of the learning goals and/or objectives of the students within the frame of reference of the given syllabus, course and/or institution. This is not to say that there are no indicators of mathematical competence but that these indicators/descriptors are ineffective in measuring ‘mathematical competence’ in students until they are situated within the context of the programs or courses being studied.

In the context of the courses being studied in Foundation Mathematics at the Petroleum Institute ‘mathematical competence’ appears to be a slippery or tenuous concept to my teaching colleagues, as indicated by, a wide range of definitions and
responses to the two questions (7 and 8) that I asked in the teacher questionnaire. (Appendix 10.1)

Question 7: How do you define the term ‘mathematically competent’ in the context of your teaching activities?

Question 8: In what ways could you identify or measure the mathematical competence of students in your lessons?

For me it means that the students have the ability to use mathematics to solve a new problem; the ability to recognize their mistakes and have the willingness to rectify those mistakes. Mainly through assessment, both academic and project based and also by discussion.
[Teacher MG - Appendix 10.1.2]

Is when they can apply the knowledge they have obtained to real world problems.
Quizzes and Tests
[Teacher DM - Appendix 10.1.3]

A student should have a working knowledge of material taught in all previous Maths courses. A student should be able to apply the lesson to a “real life” situation.
[Teacher JN - Appendix 10.1.4]

A mathematically competent instructor knows the origin and the further application of each item.

A mathematically competent student is able to connect new material with old.

I invariably pause in writing out steps on the board to suggest a false step, saying “right?”

Again and again the students have been reminded that when I say “right?” I mean that there is something wrong. And they are invited to point out the mistake.
[Teacher GM - Appendix 10.1.5]
Mathematical Competence.

Mathematically competent is a student that can find patterns and relationships.

Sometimes from the questions they ask during the lessons, sometimes from the questions that I make during the lessons, sometimes from questions in the quizzes.

[Teacher MAH - Appendix 10.1.6]

The student responses cast little light on the concept of competence with a significant number of students giving responses that indicate they are not clear on the meaning of the word. This is something we must be constantly alert to – often we incorrectly assume that our students understand something, when upon further investigation, they have a completely different idea or perhaps are just being polite and have no idea what we are talking about. Although from my own experience this occurs less in classes in which students are exposed to critical or discursive practices as students appear less afraid to stop the lesson in search of clarification.

So, although I am not able to give a clear and definitive answer as to what mathematical competence is, from the overall responses of my small sample of teachers and students while not large enough to use to generalize an argument, there is an indication of a wide diversity of ideas and beliefs (and ensuing practices) that molds our concept of mathematical competence as being ‘relative’ rather than definitive. In my view it is this relativity/relativism that allows us to compare students and directs our using it (competence or competencies) as a useful/viable form of measurement of student ability and or performance.

Question 4: **How do I define and measure the mathematical competencies of my students and my colleagues?**

Following on from my responses to Research Question 3 it becomes clear that to me, measurement of competency can be a useful and worthwhile tool provided it is calibrated to fit within the frame of reference/context within which it can be applied (by teachers). To me an important part of this calibration would involve consensus-building in that stakeholders – teacher and student – should agree on the descriptors used to identify competence and on how they will be applied.
Mathematical Competence.

Reading the responses of my teaching colleagues there seems to exist some form of consensus/commonality of opinion that a mathematically competent student in an engineering college is one who can recognize patterns and relationships which will enable them to connect new problems with the old familiar ones they have experienced in school, and then extend these understandings and practices to solve more unique real-world problems.

As a relatively long-term researcher in mathematics education, I believe I have more experience than my colleagues and that I have had wider exposure to addressing student / educational needs in Mathematics by way of the many curriculum development (implementation and evaluation) activities I have mentioned in the earlier Chapters of this dissertation.

In this capacity of curriculum developer I have often found it necessary to borrow from the significant works of the National Council of Teachers of Mathematics (NCTM), and in doing so I have considered and applied their five skills-based concepts – Problem Solving, Reasoning and Proof, Connections, Communication, and Representation – to assist me in evaluating my resources and in identifying a means for measuring mathematical competency. [http://standards.nctm.org/document/chapter1/index.htm](http://standards.nctm.org/document/chapter1/index.htm).

What is noticeable to one who uses the NCTM standards is that in order to cover all desired competencies, the NCTM Principles and Standards are a significantly extensive and detailed list of descriptors of mathematical outcomes situated from within the context of the mathematics classroom. Such competencies as suggested by my colleagues in their responses is assuredly ‘covered’ within the NCTM list, but those of my colleagues are still not as exhaustive or definitive as I would personally like, while the NCTM ‘list’ is too broad and generally too non-specific to suit my purposes in assessing and evaluating undergraduate engineers.

A less exhaustive list was compiled by the Danish Kom Project, commissioned in 2000 to investigate, among other things, ‘which mathematical competencies need to be developed with students at different stages of the education system’ and ‘how to (do we) measure mathematical competence?’ (Niss, 2003, p. 4) The much smaller,
yet still extensive list of competencies (or descriptors) generated by the Niss project was something that I could apply to my students (to some extent) when trying to evaluate their performance and or determine their levels of mathematical competence as users / learners of mathematics (within the context of engineering studies and practice). This list gave me eight areas of definition and/or description which I felt were more appropriate to my needs as a teacher and as an administrator; and which possibly represented the matrix within which the Lorenz curve (Capra, 1996, pp. 132-135) of my own culturally negotiated/mediated interpretations/representations of mathematical competency were more closely embedded.

In terms of Habermas’ 3 areas of human interest these competencies listed below clearly go beyond our (my teaching colleague’s and mine) common culture of teaching and learning in the technical domain with that of the student-centered practical domain many of us are striving to develop. In addition to bridging these two teaching paradigms/cultures of practice, I believe this list hints at our inevitable progression towards greater student empowerment situated, I believe within the emancipator domain.

This list is as follows;

- Thinking mathematically (mastering mathematical modes of thought)
- Posing and solving mathematical problems
- Modeling mathematically (i.e. analyzing and building models)
- Reasoning mathematically
- Representing mathematical entities (objects and situations)
- Handling mathematical symbols and formalisms
- Communicating in, with, and about mathematics
- Making use of aids and tools (IT included) (Niss, 2003, pp. 6-9)

This list was easier to work from and extensive enough to cover most of my thoughts on the subject of identifying and attempting to measure mathematical competency. But having realized in the early stages of this research that mathematical competency is very much contextual and that its actual identification and measured outcomes are
very much dependent on the initial inputs determined by the teaching environment (curriculum as currere) (Doll, 1993), it was even more useful in my case to apply or refer to these competencies within the added context of the engineering competencies already noted as viable in this thesis (Chapter 4), which were originally compiled in 1996 by the Australian Institute of Engineers (Beder, 1999) and listed again below as ‘expertise that an engineer would require in 2010 in addition to traditional skills’.

- enhanced communication skills
- leadership skills beyond those of technology
- more innovative and creative
- better life-long learners more adaptable to new learning situations
- better managers of people and systems
- more accountable for results of decisions within context of economic, political, ethical, cultural and environmental issues
- operate within and across professions that are global
- utilize quality improvement practices in all aspects of their work.

From a perspective largely determined by my own teaching preferences and or experiences and through observing my teaching colleagues in the Foundation Mathematics program at the Petroleum Institute, I believe that (as a team) our overall interpretation of mathematical competence is emergent. By this I mean that as time passes and as we interact and work more and more as a team, the more our concept of mathematical competency transforms from the basics of numeracy and pattern recognition to the demonstration (by students) of wider (more cosmological) skills, beliefs, attitudes and actions somewhat fitting the criteria listed immediately above, as situated within the context of engineering studies and application.
Question 5: Do I hold the same professional beliefs and values as my teaching colleagues and administration at the Petroleum Institute? Is my interpretation of mathematical competence the same interpretation held by my colleagues and/or my students?

While I am happy and willing to work towards my students becoming mathematically or technically competent, as defined by my colleagues in their earlier responses, and I am eager to develop in them the expertise required for the engineers of 2010, I am not happy to do only this. I feel that there are far greater competencies than the technical or even the practical ones. In feeling (and acting this way) I believe that there appears to be many significant differences between what I think, believe and practice and what my colleagues in the wider Petroleum Institute do.

The preference for lecturing by many of my colleagues is one indication that they do not share the same (critical) constructivist ideals as mine. While I do my share of lecturing, it is not my primary or preferred method of teaching. In fairness to all those of us involved in this comparison I do recognize that many of my colleagues are being pragmatic in their choice of almost one hundred percent lecturing. I recognize that lecturing allows them almost complete control of their learning spaces, course content, curriculum deadlines etc, but unfortunately in my eyes it does not facilitate deep learning or empowerment of the learners. In my view, quite the contrary, it disempowers the students and with the aid of a traditionally heavy (engineering) workload it forces students to select superficial learning strategies over learning for understanding.

This is not to say that all of my colleagues are into full-time lecturing. It is clear from responses to the question “What are your preferred teaching styles?” in the teacher questionnaire (Appendix 10.1) that many close colleagues working in Foundation Mathematics do more than lecture.

I like to have an interactive class as much as possible although the fetters of a fixed syllabus can make this difficult.

[Teacher MG - Appendix 10.1.2]
Try to incorporate as many teaching styles as I see fit depending upon the situation
[Teacher NM - Appendix 10.1.1]

I’ve gotten used to lecturing, but prefer to have more time to allow the students to teach each other (in small groups, or as one large one).
[Teacher JN - Appendix 10.1.4]

This is to be expected from teachers working closely/collaboratively in a small close-knit team whose goal is to redevelop curriculum to suit class sizes of 12-16 students working entirely in a foreign language. However, this doesn’t seem the case higher up in the Petroleum Institute in the Engineering programs where larger classes and less pedagogically qualified teachers (usually highly qualified in their fields of research) with limited training as teachers, fall back continuously on lecturing.

So while I have similarly evolving views on teaching and learning to my colleagues within Foundation Mathematics I believe I have, for pragmatic reasons and other, very different views and practices to some of these team members and to the majority of lecturers teaching Mathematics at the Petroleum Institute.

In particular, as I have stated from the outset of this thesis, the goal of my teaching is to emancipate and empower my students as learners, mathematicians, engineers and human beings (Ernest, 2001). These I firmly believe, through observation and discussion, are not views and values necessarily shared or aired by my colleagues many of whom, while recognizing and realizing the practical domain of human interest within their teaching, do not necessarily see or support the concept of the emancipatory domain. These other colleagues with a more traditional view of teaching and learning (in my opinion) remain firmly focused upon the technical domain and see many ‘deep learning’ activities as time wasting and not really necessary.

However, while there appears to be a wide range of beliefs and values enacted within even the small group of teachers that comprise the Foundation Mathematics teaching faculty at the Petroleum Institute, there also exists a healthy dynamic perpetuated within the dialectic or ongoing philosophical and practical debate about what good
teaching and learning means and indeed just what mathematics is or means (Khait, 2005).

**Question 6:** Over what levels ‘of being’ does the value of mathematical competence extend?

One consequence of the ongoing debate within this faculty (and to a lesser extent, across the Petroleum Institute) seems to be an agreement by these teachers that - no matter how idiosyncratic teacher’s beliefs seem and regardless of what they as teachers personally believe about the benefits of learning mathematics are - within these courses our students will learn in an environment and a manner that stimulates conceptual change (Confrey, J., 1990; Hewson, 1996; Karas, 2005). What is further agreed upon, as evidenced by the work samples and examples offered in Chapters 7 and 8 of this thesis, is that our students will be cognitively challenged (Roscoe, 2002; Youngs, 2003), meta-cognitively practiced (Anderson, 2002; Baird, 1996) and exposed to a wide variety of methods, techniques and technologies (differentiated instruction) (Gregory, 2002; Schoenfeld, 1992) designed to take them beyond the traditional bounds of a technically focused education.
Chapter 12

Culturally Empowering Practices

Introduction

In this chapter I attempt to answer research questions 7, 8, 9 and 10 which relate to what I call culturally empowering practices. In doing so I present samples and examples of learning exercises and teaching strategies that I believe have a positive influence on the development of student beliefs, attitudes and values leading to student action – learning strategies that are constructive and beneficial to long term learning and personal development and empowerment. In attempting to answer question 7, I look at what I believe are positive beliefs and values manifested within my students through the learning of mathematics.

In answering Question 8, I provide examples of what I consider innovative teaching strategies and management protocols which are culturally empowering for my students (and me).

In my answer to Question 9, I give further examples of differences between student learning and other cultures can affect their learning and subsequent empowerment and I offer numerous examples and strategies that I believe take these cultural differences into account and can be used to facilitate cultural border crossings and allow for greater learning success for all stakeholders regardless of cultural group. Finally, in Question 10, I offer and explain in detail, a variety of ways that educational technology can be used to promote student understanding, independence and provide culturally empowering learning experiences.

Question 7: What beliefs and values are manifested through the learning of Mathematics?

I have used the term ‘manifested’ above to indicate that I am not talking about the creation of new beliefs and values, but rather the development, enhancement and / or
encouragement of some beliefs and values. As a teacher and a learner I believe from experience that learner beliefs and values contribute towards and also come from the learning of mathematics.

What is necessary for me as a teacher of mathematics is that I recognize the existence and importance of these beliefs, values and attitudes and that, during the course of my teaching, I foster the development of those I see as positive and in the interests of the learner.

*Any good mathematics teacher would be quick to point out that students’ success or failure in solving a problem is as much a matter of self confidence, motivation, perseverance, and many other non-cognitive traits, as the mathematical knowledge they possess.* [Lester, Garofalo & Lambdin Kroll (1989) p 75 cited in (Kislenko, 2005)]

In terms of student beliefs and values, there is sufficient debate as to what they are (Kislenko, 2005). I see them as both the desirable beliefs and values that students bring with them to start a course, and the ideal beliefs and values that students have developed as a result of doing the mathematics (course).

From my own experience I recognize these as student’ values and beliefs which manifest as the (arguably) desirable qualities or characteristics (mathematics) teachers prefer their students to possess, and which, of course – through association – many self aware students wish to develop in themselves.

While the description and prioritized order of these qualities varies from teacher to teacher there are significant common descriptors, I believe, that we can describe as common values and beliefs which are enhanced through the learning of mathematics (among many other disciplines and areas of learning)

Beliefs such as recognizing the value in developing a love or desire of life-long learning and developing personal and or cultural autonomy and independence through independent learning activities are of major importance. Other important characteristics include the ability to cooperate and communicate, as enhanced by
means of participation in collaborative learning activities and the ability to sequence, analyze and synthesize. These are some of the qualities that, I believe, develop through student participation in problem solving activities.

While all of the values above are not exclusive to mathematics, I believe from my own teaching and learning experiences that what I see as the ‘confrontational nature of mathematics’ allows for (learner) understanding to develop through the resolution of cognitive conflict on the part of the individual. While the product of that resolution may be then validated or rejected by one’s peers (social constructivism) (Driver, 1994; Noddings, 1990; Tobin, K., & Tippins, D., 1993) and the process of cognitive conflict resolution may be structured, supported and mediated through social interaction, I also believe that the actual act of resolution and the acquisition of understanding and connecting with the learner’s real-life world(s) is an individual or personal act of radical constructivism (von Glasersfeld, 1990b). In doing this, I see this confrontational aspect of mathematics and the resulting resolution of cognitive conflict by the learner as leaving within them a sense of achievement and satisfaction. To me, doing mathematics is character building. Such character building I believe leads to an appreciation of mathematics and confidence in mathematics and one’s self. Given the right - critically constructive - learning environment (Taylor, P., & Campbell-Williams, M., 1993; Taylor, P., & Cobern, W., 1998), in which collaboration and critique is encouraged, I believe students are adequately prepared to take the next steps to personal empowerment and emancipation of themselves and of others. This being what I see as social empowerment through mathematics (Ernest, 2001).

Question 8: **What innovative pedagogical practices - teaching strategies and management protocols - employed by this (Foundation Mathematics) teacher are culturally empowering for both me and my students?**

I believe that I have already extensively answered this question through my answers, discussion, examples and samples that comprise Chapters 7, 8 and 9, and to some extent through my recent answers to the previous research questions. However, to reiterate and re-emphasize, I offer further examples comprising worksheets/projects
that have been developed recently with the same aims in mind as those presented in the earlier chapters, but with the added advantage of being produced after my reflection upon the results and outcomes of previous work. In my giving further answers which are illustrated by recent teaching/learning samples and examples, I hope to demonstrate the presence of the technical, practical and emancipatory intentions therein, and within the direction taken by my teaching at the Petroleum Institute.

Of particular relevance to me (in this regard) is the example in Appendix 10.3 – The Engineering Applications Project for The Fast-Track course, which is currently being evaluated by Petroleum and Chemical Engineering colleagues for relevance, accuracy and applicability before its distribution as an assessment and research project.

This is a student centered project which entails individual and collaborative (teamwork) in and outside of normal lesson times. It is highly contextual in that the cases or scenarios are adaptations of genuine oil industry problems in a relatively simplified and therefore do-able form. It draws on the mathematics the students have studied already in our course (at the time of issue - week 8 of a 16 week semester), and it extends through the coursework subsequently studied in the second half of the semester and possibly further.

Due to its direct relationship to engineering it is considered pertinent by students, and at this stage, as its primary developer, I believe it will motivate my students to research and solve the problems that have been set. In addition, I believe that it engages students further, by means of a number of ‘across-the-curriculum’ activities which in due course sees them consulting with Chemistry, English and Information Technology teachers so as to collect, analyze and present appropriate data.

To properly address, solve and present this project my students are required to apply a wide range of techniques and technologies including visualization, interpretation of verbal, textual, numeric, symbolic and diagrammatic data. They are required to use mathematical modeling techniques; and technology in the form of graphics.
calculators and computer internet and applications software (such as Geometer’s Sketchpad, Mathematica, Maple and or MatLab).

In addition student teams are required to discuss and describe findings in terms of their mathematical and cosmological strength and weaknesses, and their global and cosmological consequences.

*In addition to giving mathematical solutions to these three problems you are also instructed to explain your answers in detail, including any strengths or weaknesses you see in each solution.*

*Your discussion should include all logistical, cultural and environmental issues that come up in your discussions with other team members or members of the public.* Appendix 10.3 - Engineering Applications Project – Case 1

I believe this project is innovative, particularly for students attending a traditional engineering college, because it empowers these students by allowing them within a given time frame to manage their own learning. In encouraging them to research, analyze, discuss and present their findings in a variety of written and oral forms it attempts to meet goals described in earlier research question as additional expertise that an engineer would require to practice effectively in 2010.

This is a project whose intent is to encourage or foster deep learning (Houghton, 2004; Rhem, 1995) within students whose previous experiences and activities could be mostly described as surface learning. From previous experience with these students I see their earlier motivational forces as extrinsic, and largely evaluated by students as the acquisition of ‘good grades’. For example, at local high schools and within the Petroleum Institute itself most students appear driven by grades. For the students there are sound pragmatic reasons for this attitude. Burdened by the traditionally heavy workload of the engineering curriculum it makes more sense to the students to surface learn. In this way they memorize and compartmentalize what mathematics they use and then put aside what (to them) appears to be a collection of unrelated facts.
As long as teachers and lecturers continue to overload courses with content and to assess students by means of written tests and quizzes there is no incentive for students to take what they see as a less rewarding approach.

In Foundation Mathematics we recognize the need for our students to do and apply some surface learning strategies, but we believe that if our students are going to develop those skills and abilities ‘required of engineers in 2010’, then we must change our curriculum (both as content and currere) to accommodate deep learning.

When considered in terms of Bloom’s Taxonomy of Educational Objectives (1956), "deep" learning requires higher order cognitive thinking skills such as analysis (i.e. compare, contrast) and synthesis (students are required to integrate components into a new whole, e.g. what is the relationship...). (Rhem, 1995)

In this project (Appendix 10.3), I attempt to connect the cultures of the student, namely their learning of mathematics (student/learner culture) and their academic-professional life-world of engineering (professional/practical culture). By attempting this, I try to make the students’ primary sources of motivation be intrinsic. Instead of learning their mathematics from teacher examples my goal is to see our students searching their textbooks, suggested references and their own resources to solve the engineering-based problems that we have put before them.

My intended outcomes are that our students are more personally driven to ‘interact more vigorously and critically with the (mathematical) content’, to connect what they are doing with other areas of learning and with their own previous knowledge and experiences, and subsequently to become more critically aware of their own organization and their own thinking.

Simply stated, deep learning involves the critical analysis of new ideas, linking them to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts. Deep learning promotes understanding and application for life. (Houghton, 2004)
Question 9: **How do cultural differences – ethnic, gender, generational, socioeconomic – influence the effectiveness of teaching and learning strategies?**

**What strategies can be adopted to produce successful cultural border crossings between these cultures?**

From my perspective there are several distinct and easily identifiable cultures in existence within the Petroleum Institute. In addition to the ethnic cultures which could be divided into two prominent groups – the Emirati nationals and the expatriates – student groups which operate under very different conditions within the institute, there are other contrasting and sometimes complementary groups. One of these being gender, with the separation of students into two distinct campuses and subsequently two distinctive sets of rules and behaviors. Other contrasting cultures are the student and teacher groups, and within the institute’s faculty body one could consider, due to philosophical and practical differences between the engineering / research faculty and the teaching faculty, that these be seen as two separate cultures. In recent times under a new and research focused management there have been decisions made to downgrade the status and working conditions of the Foundation Program faculty to such an extent that some faculty members now regard the Foundation Program as a separate entity and as a culture which operates independently from the rest of the university.

In relation to the different cultures I have described as in existence at the Petroleum Institute, I am going to look briefly at how these differences have impacted upon the day to day teaching and learning of Mathematics within the Foundation Program and how we go about attempting to connect/bridge them to produce an effective learning environment for our students.

My rationale for the above is that, as I stated earlier when discussing the nature of this research and its auto-ethnographical style, it is my intention to report on the happenings here in Foundation Mathematics and allow my readers to draw their own conclusions and or observe and identify their own generalities and patterns which could then be adopted and applied across a wider educational landscape.
As I explained in Chapter 2 of this thesis, there are two contrasting cultures co-existing within the United Arab Emirates and within the Petroleum Institute. The members of these constitute the local Emirati students and the expatriate children of Abu Dhabi National Oil Company (ADNOC) employees. Since its inception in 2000 the Petroleum Institute has always maintained an approximate ratio of Emirati to Expatriate students of about 4 to 1. This has meant greater competition for places amongst the expatriate students. In addition, until recently the Petroleum Institute provided free education for the Emirati students as long as they were passing the courses (including permission to fail each course once) and it paid them a stipend based on performance and provided free lunch and free accommodation to those who came from the other emirates outside of Abu Dhabi. In contrast, the expatriate students only get free tuition if they maintain a B average (> 80%) for their courses. In my experience the outcome has been noticeably different performances from each group, with the majority of expatriate students arriving better prepared to tackle the Petroleum Institute courses. With an expatriate entry score of 95% or above it means that most of these students have been taught in predominantly private schools with English language as the medium of instruction. In addition, many of these private schools are expensive so students attending them are more accountable to their parents or their parent’s sponsoring companies who are paying these relatively high tuition fees. In contrast, for the majority of Emirati students there is no major entry requirement outside of some relatively flexible TOEFL scores. Many of these students come from government sponsored high schools where until recently content areas were taught in Arabic. Government schools are often controlled and limited by public budgetary constraints and teachers within this system are reputedly overworked and very poorly paid. Many have a rudimentary understanding of the English language, themselves being natives of Arabic speaking countries. In addition the approach with rote learning is seen as the one and only way to learn subjects such as mathematics and science. Upon reaching the Petroleum Institute students from these schools have difficulty. Many lack the work ethic required of tertiary students and do not have the experience or understanding of English as an instructional language. In some cases it appears their high school assessment grades are inaccurate with many stories arising of students’ grades being inflated to increase the school’s
number of entries into various universities and to enhance the reputation of these
schools and of their teachers so as to maintain overall teaching contacts and
government subsidies. The existence of these two very different cultures has led to
some very unique situations occurring at the Petroleum Institute. One is the
relationship that exists between the two groups, with some Emirati students feeling
that the expatriate students ‘look down upon them in their own country’. One
consequence of such a relationship is the firm Emirati resolve to keep control of the
agenda and give little recognition and support to expatriates other than what is
necessary. One example of this attitude/dilemma became evident to me in 2006 when
the committee I was involved in which was investigating a student awards system,
was disbanded after our recommendations were passed to administration. Though no
official explanation was given for disbanding the committee and disregarding its
recommendations to give annual awards for academic performance, service to the
university, service to the community, and an academic commitment award, the
unofficial feedback via the committee chair was that most of these awards would go
to expatriate students. Situations such as this in turn impact upon the sentiments and
attitudes of expatriate students who occasionally express feelings of frustration at
being held back or lack of recognition and opportunities. Fortunately for the
community there are still large numbers of very talented and committed Emirati
students willing to take on the roles of leader and mediator. Quite often these
students come from the private schools and have been taught in English. As a result
they don’t experience the same disadvantages faced by their fellow Emirati students
coming from government schools. These students assimilate more easily because
they have been in a minority in these high schools and have already developed long-
term friendships with the expatriate students. It seems that the combination of these
Emirati ‘cultural bridge-builders’ and the culture of acceptance carried by the
expatriate students (that they and their families are guest-workers in a foreign
country) that allows both groups to work (in some way) together. To this end the
Foundation Mathematics faculty employs a variety of strategies to connect two
relatively different cultures. One such strategy employs collaborative teamwork in
which students work together in mixed groups to solve problems posed by their
teachers. This is not a common strategy within the classroom because often classes
are geared for one group (Emirati) or the other (expatriate). More significantly this is
an approach that is very alien to students who have progressed through a traditional
school system. Normally it is introduced slowly and often by means of (team) projects such as the calculator (research) project, and / or through the introduction of the weekly problem solving sheets. In my recent experience it is the latter which encourages interaction between the two groups as Emirati students seeking help with the English language component of these worksheets turn to expatriate students for help, then once the ‘ice is broken’ productive working relationships tend to build up. To encourage these relationships and this system of support, in general, the mathematics faculty use the data taken from the Basic Skills Tests to identify ‘students at risk’ and ‘mathematically talented students’. The students identified as ‘at risk’ are encouraged to voluntarily attend weekly support tutorials which are ‘manned’ by Foundation Mathematics faculty and supported by those students identified as ‘talented’. It is in these tutorials that mentoring relationships are often established when / where students help one another and provide advice and support that goes beyond the aims of the normal program.

Another interesting strategy employed to bridge these different cultures has been the introduction of a fast-track course in Mathematics designed to reduce the time taken for students to progress from Foundation to freshman years (from two to one semester). While many stakeholders originally considered this an initiative to reduce the amount of time and money spent on preparing expatriate students for the freshman courses, it has yielded some interesting results. In addition to lowering frustration levels in those students who believed themselves trapped for a year in a course they felt was unnecessary, it has also allowed for some of those students to look upon Foundation Mathematics from a different perspective. Particularly in regard to the content of the Mathematics course where talented students now taking the challenge exam for entry into the ‘fast-track’ course actually encounter areas - problems and approaches - vastly different from those they encountered at school. For some students who actually fail the challenge exam and subsequently don’t make it into the fast track course there is now a realization that there is actually something to be learned within the Foundation Mathematics standard courses. For the teachers this is a welcome contrast to previous years when some slightly disillusioned students would make minimal effort within our courses and suddenly find themselves - and often those within their zones of influence - at serious risk of repeating the course.
One observable outcome already has been greater initial cooperation with teachers and peers by those students who have not made it into the fast track. There is also, it seems, according to the anecdotal evidence of some teachers, more interaction occurring between the two groups both in the predominantly expatriate fast-track and the predominantly Emirati standard course.

However, in addition to these positive reports there have been reported other interesting changes as a result of decisions made by senior management which threaten to polarize rather than conjoin the two groups. For example, one recent (and sudden) decision to eliminate (Emirati) student stipends retrospectively affected many students from poorer families and/or from outlying areas. Students who relied on this income to pay for their board and lodging and/or other education related expenses found themselves in difficult situations. A second decision to charge students for food had even further reaching consequences in a community where the offering of food is considered an essential hospitality and the withdrawal or non-offer of food to a guest a serious insult.

These actions coupled with an increase in the number of competing universities in Abu Dhabi who are still offering scholarships and stipends has led to a serious fall in the number of ‘academically acceptable’ Emirati students applying for places at the Petroleum Institute. To maintain its numbers the Petroleum Institute has recently lowered (further) its criterion (entry scores) for Emirati students.

One outcome / consequence of this decision appears to be a more highly divided student community based on academic and ethnic lines. For example, Table 10.3 shows the shift or difference in the distribution of academic grades for our initial pre-calculus 1 courses for our Spring 2008 (PC1) intake and our more recent intake of Fall 2008 (PC1). While the distribution of Spring 2008 somewhat resembles a ‘skewed normal distribution’ and is similar in shape to previous semesters the distribution for Fall 2008 is bi-modal (or as we call it in the land of the camel, a bactrian distribution).
Table 10.3 – Distribution of Student Grades - Precalculus 1 Fall and Spring 2008

<table>
<thead>
<tr>
<th></th>
<th>Fall 2008</th>
<th></th>
<th>Spring 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>males</td>
<td>females</td>
<td>both (BOTH)</td>
</tr>
<tr>
<td>A</td>
<td>22</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>B</td>
<td>21</td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>D</td>
<td>18</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>F</td>
<td>26</td>
<td>12</td>
<td>38</td>
</tr>
<tr>
<td>SUM</td>
<td>105</td>
<td>52</td>
<td>157</td>
</tr>
</tbody>
</table>

If you analyze the composition of data in this latest distribution you find that the hump at the higher levels is composed of mainly expatriate students and the hump at the lower end is composed primarily of Emirati students. This new intake has reinforced our commitment to maintaining the new fast track courses in addition to our regular courses so that the better qualified students regardless of ethnicity are given the opportunity to get through their mathematics in one semester while the
weaker group regardless of ethnicity are given ample time and support to develop and learn the requisite mathematics.

Male and Female Campuses

In 2006 the Petroleum Institute established a campus for female students. In many ways this very act was an indication that the values in the country were changing. Previously it had been believed around the Petroleum Institute that there was no place in engineering for Emirati women in that ‘families would never allow their daughters to work in the oil-fields’. Then suddenly it was realized that there was indeed a demand by female students supported by their families to study as engineers. Anecdotally it is believed still that these graduating women engineers will not go into the field but will be employed in the offices of ADNOC, however, no one denies how quickly the structure and the culture(s) of the Emirates is changing. Part of that belief remains through observation of the cultural norms of Emirati society wherein while women are encouraged to study they are still expected to marry at a relatively early age and to start families. Based on stories coming from many long term professors within the Emirates many female students/professionals finish promising careers almost before they start, shortly after graduation.

My own early middle-eastern experience teaching at United Arab Emirates University (UAEU) was to this effect. There were three Foundation Mathematics courses at UAEU when I started there in 2000. These were the Mathematics for Arts, Mathematics for Business and Mathematics for Science tracks. Final results for the Arts and Science tracks regularly indicated that the girls outperformed the boys. In the Science track results were a lot closer but once again it was not uncommon for the girls to have better results. In fact one of the reasons the university administration accelerated the pilot project I mentioned in Chapter 3 (AlSuwaidi, 2001; Ward, 2005) was that early results indicated the male students were more competitive with this style of learning and it reduced the gap in performance.

I recognize that a similar perception seems to exist about the gender cultures here at the Petroleum Institute. As mathematics coordinator it is my job to maintain mathematics learning on both campuses and in doing so I make a point of working
and teaching on both campuses. My experience is that I find that the girls are far more interested in their studies and far more committed than the boys. While office hours are relatively quiet and visits sporadic on the men’s campus, they are far from quiet over at the women’s campus with numerous students arriving for help or for a quiet educationally related chat during what seems a teacher’s every free hour. The general perception of this greater commitment at class times, based on anecdotal evidence collected through discussions with teachers at faculty meetings, is that the female students, in general, get higher grades for coursework – homework, classwork and projects – but that they do not necessarily outperform their male counterparts in the tests.

The source of this perception possibly stems back to cultural norms of the United Arab Emirates. In general the boys are allowed to run free. There are very few restrictions placed on males in the society, who are free to go where and when they pretty much please. It is not the case for the females. The female students at the Petroleum Institute’s Arzanah campus are restricted to that campus from 8 am until 5pm, unless they have permission to arrive later or leave earlier, escorted by a relative. Consequently the female students have and do spend more time on their studies, whereas the male students have more distractions. This, I believe, explains why, in general, the girls seem to perform slightly better on assignments, homework and class-work. However, in the tests the situation appears to be reversed with the (more adventurous / risk-taking?) boys performing slightly better.

However, data collected over recent semesters from within our own classes at the Petroleum Institute does not bear this out. Overall examination and project results - and their component parts – indicate that both genders are very comparable. If there is a difference it appears to be slight and our more recent results/data indicate that it is diminishing.
Table 10.4 Student results for the year 2008

<table>
<thead>
<tr>
<th>Coursework</th>
<th>Project</th>
<th>Common Tests</th>
<th>Final Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td><strong>Spring 2008</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>84</td>
<td>64</td>
<td>79</td>
</tr>
<tr>
<td>Women</td>
<td>88</td>
<td>64</td>
<td>75</td>
</tr>
<tr>
<td><strong>Fall 2008</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>85</td>
<td>65</td>
<td>79</td>
</tr>
<tr>
<td>Women</td>
<td>78</td>
<td>66</td>
<td>70</td>
</tr>
</tbody>
</table>

Since my experience with the student centered problem-solving approach to teaching Mathematics that we trialed at UAEU – UGRU in 2001 (AlSuwaidi, 2001), I have as a coordinator and a teacher monitored and compared preferred learning styles of students, both at UAEU and at the Petroleum Institute. Although it is a generalization, I would agree that from my experience, while the female students show greater commitment to their studies, work harder and work more efficiently at reducing errors in their work, they are more reluctant to embrace new techniques and technologies than the boys. This trend, however, seems to be changing as teachers attempt a number of simple strategies aimed at getting the boys to work harder in their coursework and involving the girls more in technology related projects and problem solving activities. This could explain the closeness of many recent scores (see Table 10.4).

In my opinion even with this simple data there are too many variables/influences to get a clear picture. In particular, here in Foundation Mathematics we have only been consistently entering common data for three semesters and as I have mentioned already there have been some very big changes in our student intake in that time.

In terms of specific strategies aimed at bridging these different (gender) cultures, it was felt by my colleagues that the introduction of the calculators project had gone a long way to familiarizing the girls with the calculator and that the format of the project was more in keeping with their style of learning. This may be clearer at the
end of the Spring 2009 semester when we analyze the results of those student in regard to the problem solving / applications section of their coursework and the final exam.

Until further data comes on hand then I can only consider from the numerical data available and the anecdotal responses of teachers that the boys were performing slightly better in the exams and possibly overall, and that our strategies to bridge/connect the two groups as evidenced through similar performance statistics appeared to be working.

Student and Teacher Groups

An alternative title/description I could use for here would be the cultures of Secondary and Tertiary Education within the United Arab Emirates. This is because the Foundation Program is the interface between these two cultures and or the bridge that connects them. With an attrition rate usually around 30% some might also consider that we are a gateway, however, I hope I have already described enough in earlier chapters to convince readers that gate-keeping is a very minor intended function of this program.

In general the teaching population of the Petroleum Institute is either Western or Western trained. The greater majority have undergone rigorous training to earn their doctoral degrees from universities in Canada, Australia and New Zealand, USA, UK or the European Community. In recent years there has been a noticeable increase in the number of professors trained in Japan or China.

A significant number of our teachers are Arabs who trained in the West and after completing their studies became naturalized citizens of the country of their training. As such, they have what they see as the double advantage of knowing the hearts of our students in addition to being aware of what these students need to succeed in an EFL environment.

While the professional population of the wider Petroleum Institute has shifted noticeably from one that was predominantly Western (born) at our time of its
inception to one that is predominantly Western-educated Arabic, the population of the Foundation Program has remained predominantly Western.

This is largely due to the presence of our English language faculty which makes up 60% overall of Foundation and consists largely of native English speakers. The ethnic composition coupled with the mission of the Foundation Program means that it is necessary for teachers to abide by and support the relatively strict rules and regulations of a Western university or school.

In addition, I believe that many teachers, possibly all of us at times, place themselves in the position of their ideal student, forgetting that they never were and never will be the person they look back upon as themselves. As a consequence our students are sometimes faced with the almost insurmountable task of meeting some very high expectations. Further to this is the reality that our students often come from a very under-resourced system where overworked and undertrained teachers are reported to pay lip-service to many of the un-researched requirements placed upon them by a managing bureaucracy often removed from the realities of the schools.

In such an environment the Arabic ‘culture of negotiation’ thrives and students arrive at the Petroleum Institute skilled in this regard but under skilled in areas the teachers deem to be necessary. Taking all of these influences and or situations into account then, a noticeable and incomplete outcome of our teaching assignment in the Foundation Program is to merge these two cultures of expectation. We must genuinely meet the expectations of our Western style leadership and maintain the integrity of our courses, processes and procedures, and we must at the same time be flexible enough to connect both personally and academically with our students.

While I believe that at times we all pay lip service to some unattainable requirements established by our own management, I also believe that some colleagues are too flexible and smirch their personal and professional reputations when they are too empathic with our students. Personally (from experience) I believe strongly in maintaining the integrity of our policies and our assessment processes so that they communicate clearly to the students that we operate fairly and truthfully, and they communicate to them how we operate. Most importantly I believe communication is
two-way and that we should also ask our students for their opinions and input about these processes.

I suppose this is why I am interested in empowerment, because to me critical thinking, problem solving and discursive practice naturally extend from the mathematics we practice and discuss in our daily lessons to the systems and methods that govern these daily practices.

By encouraging student input into the discussion and decision making about our daily practices and beyond, I feel that I am meeting with their expectations on negotiation, and by allowing their voice in classroom activities I have found (I believe) that they listen to my own voice when I explain to them the reasons we may not be able to change a certain policy or process to suit their individual or group requirements.

**Question 10:** How can educational technologies, such as graphics calculators, computers, the world-wide web, assist the process of constructing an empowering learning environment?

As a teacher of content to EFL students I am aware of the importance of representing data and ideas in a variety of ways and forms. As a matter of fact, it is, in my view, highly advantageous to work in this way in any educational environment.

In 2007 I presented a paper at the second conference of the Middle East Teachers of Science, Mathematics and Computing (METSMaC 2006) which I titled “Using Multiple Representations to Promote Understanding in the Learning of Mathematics” (Ward, 2007). As the name implies I proposed, demonstrated to and interacted with, an energetic group of participants to show how I believed we could make learning more relevant and fun using a variety of techniques and technologies to present our ideas in more than one way. In doing so I argued that our students were more involved with, and got a bigger picture from, a variety of perspectives and subsequently made more and wider connections to develop in turn, a wider and deeper understanding of what they were doing. In proposing this I used a term that I borrowed from literacy, that of ‘scaffolding’. My use of scaffolding is significantly
different from its use to describe a framework for essay, report and narrative writing in that the scaffold I had in mind was more like a mutually supporting frame such as a tripod or even two cards leaning together each suspending or supporting the other.

Another term I should clarify more fully here is my definition of the term technology. The technology I refer to here includes intellectual technology such as techniques and strategies as well as the more widely known electronic technologies such as computer applications, graphics calculators, DVD machines and smart-boards (to name but a few).

While there are many other ways of approaching and answering the research question addressed here, my approach will be to argue that these technologies support learning by enhancing our ability to provide information in a variety of forms or representations.

I have listed some of these forms of scaffolding below and would like to point out that not all could be considered ‘physical’ scaffolds as some are more conceptual and some still are rather dialectically or diametrically opposed as in playing the ‘devil’s advocate’.

In some cases they are supporting each other through contrast, but in all cases the use of intellectual or physical technology supports their effective use to challenge learners – in this case both student and teacher – to think and compare and debate.

**Multiple Representations (complementary – opposing – contrasting ) of Mathematical Data and Processes.**

- Textual / Symbolic / Numeric / Graphical / Diagrammatic
- Calculation – Estimation
- Algorithms – Modeling
- Context – Abstract
- Meta-cognition – Memorization
I interpret these as the forms in which mathematical information can be represented. In our basic skills / baseline tests I included algorithmic as another perspective in which learners can see and process mathematical data. I will also include algorithmic here in this section, but have mainly reserved it for later discussion when comparing the use of algorithms as a problem solving method as a representation for the processes of mathematical modeling.

When presenting data and or information to students whether it is for explanation, demonstration or assessment purposes it is always useful to present it in a variety of forms. I believe this is important in all situations, but it is particularly critical in a foreign language situation where the learners are less familiar and experienced in the language and its usage than the teacher. Using second or further representations acts as a backup or as a prompt for the learner trying to make sense of a particular question or explanation.

Examples of multiple representations may consist of words and an assisting diagram, a function and a supporting graph and / or table, diagrams with measurements and a supporting algorithm, and any combination of the above.

Example 1 [Consisting of textual, diagrammatic and algorithmic representations]

The conical (cone shaped) evaporation tank (shown below) is open at the top and holds a volume of $400 \pi \text{ m}^3$. 

![Diagram of a conical evaporation tank](image)
Volume of a Cone = \( \frac{1}{3} \pi r^2 h \)

Curved Surface Area = \( \pi r \sqrt{r^2 + h^2} \)

Area of a Circle = \( \pi r^2 \)

(a) Find the dimensions of this tank that would minimize the amount of material needed to build it. [Answer to the nearest tenth of a metre]

In this example students are given the relevant information in the form of a diagram, a written description and some supporting algorithms / formulas from which they must choose the one to solve the problem.

Example 2 [Consisting of textual, diagrammatic and numeric representations]

The cam-shaft below is made from two equal sectors. It rotates about its centre position O with an angular speed of 120 rpm (revolutions per minute).

a) Calculate the linear speed of point P in metres per second.

In this second example students are given the relevant information in the form of a diagram, a written description and some supporting numbers (as measurements). They must use this information plus their own knowledge of geometry such as notation and symmetry and the appropriate approach or algorithm to solve the problem.
**Example 3** [Consisting of textual and symbolic representations]

An angle $\alpha$ in standard position has the line $3x + 4y = 0 \ ; x \geq 0$ as its terminal side.

Evaluate **exactly** $\cos \alpha$ **and** $\tan \alpha$

Evaluate $\sin(\alpha - \frac{\pi}{2})$

In this third example students are given the relevant information in the form of a written description and in symbolic terms as an equation and as a positional operator i.e. $x \geq 0$. They must use these to develop their own diagrams and select the appropriate expansion for $\sin(\alpha - \frac{\pi}{2})$ from a provided list of expansions.

The advantage of technologies such as graphics calculators and computers is that they provide ready access to tables, graphs, diagrams and even animations that act as supporting information. In the case of the TI-84 calculator issued to all incoming students to the Foundation Mathematics courses, students are able to generate at least three different representations almost simultaneously. In the case of the new TI-Nspire calculator, currently under evaluation by members of the Foundation Mathematics faculty, and the TI-Smartview emulation software used in our classrooms, this representation is simultaneous with all three representations shown on the same screen.

**Example 4** [Symbolic/ algebraic, graphical and numerical representations of a function]

<table>
<thead>
<tr>
<th>Symbolic / algebraic</th>
<th>Graphical</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbolic plot" /></td>
<td><img src="image2" alt="Graphical plot" /></td>
<td><img src="image3" alt="Numeric table" /></td>
</tr>
</tbody>
</table>

These representations of the same function [e.g. $f(x) = x^3 - 9x$] are available to our students using the TI-84 Graphics Calculator, but not simultaneously on the same screen.
The use of these multiple representations helps the learner connect the three ideas and to better understand such terms and related concepts as intercepts, zeros, maximum and minimum points, in terms of spatial and numeric relationships. By using the trace function on the calculator students get to experience a clearer picture of what is meant by increasing and decreasing functions, turning points, rates of change, rotational and line symmetry, and so forth.

**Example 5** [Symbolic/ algebraic, graphical and animated representations]

**Note:** A print-out of the simulation is provided below. If you run the program with Geometer’s Sketchpad you will see that as the rectangle’s shape/area changes (with a constant perimeter) the numbers in the table change and the graph maps out a parabolic arc representative of the new area, clearly indicating a maximum area exists (and where, in connection to the rectangles shape or dimensions

Using Sketchpad coupled with TI-84 data to generate a function to maximization problem …..  *Field.gsp* 

**Method:**

1. Use sketchpad to relocate boundary of rectangular field - fixed perimeter
2. Generate graph and table of data from sketchpad simulation
3. Enter data from table into TI-84 to determine suitable regression function
4. Use chosen function to interpret and predict.
Animations are excellent vehicles for the development of visualization skills within students. This particular example is used to assist in a teacher (and student) training exercise on promoting cognitive conflict within learners. (Appendix 10.5)

Animations are regularly used to help students visualize when doing optimization problems such as minimum distance-time-cost when construction feeder pipelines or laying optical cable. Other excellent animations used by this teacher are those connecting the unit circle, trigonometric ratios and trigonometric graphs/curves found regularly and easily on the internet.

**Example 6** [Symbolic/algorithmic, graphical and animated representations]

The diagram given below is a still-picture screen shot/adaptation of one (of many) very useful animations found at the web address:

http://curvebank.calstatela.edu/unit/unit.htm

**The Sine Curve**

I believe that the first step to mathematical empowerment is to gain awareness that mathematics is not some magical black box in which the rules or laws of a definite universe are processed. By making students aware that mathematics is a language or method contrived by human beings to describe and interpret phenomena which can
be used in a variety of ways or forms empowers them to not only use this language but to be critical of its use and its uses (as well). By showing my students or at least allowing them to see for themselves, that mathematics can describe the same phenomena in a variety of ways is to me my first and simplest act of emancipation, enacted within the bounds of a tightly regulated curriculum.

In addition to different physical representations of mathematics there exists what I consider to be the practical representations.

*Calculation and Estimation*

Here I briefly consider the relationship that I sometimes see existing between everyday mathematics and classroom mathematics. What I see quite often is that my students (and some colleagues I have known) treat these as two very independent domains. In particular there seems to be an over-reliance on using the calculator for all mathematical procedures. If, however, this is treated by teachers as curriculum developers sensitively I believe that technology such as the calculator can be used to merge (or converge) two very different perceptions that are held by students.

One such sensitive approach I believe is to challenge the student perception of the calculator as infallible by bringing the validity of some of its processes into question. This can be done simply by showing that the calculator is wrong or only partially correct or that in some problems using the calculator is in fact an inappropriate choice for reasons of efficiency.

An example of where the calculator gives a wrong or incomplete result is in the graphing of functions such as radicals or logarithms. In these situations the incremental method used by the graphics calculator often breaks down when the graph of the function steepens. In these examples shown below the calculator graph is clearly wrong or at best inadequate.
Example 7 [Incorrect graphical representations used to challenge perceptions about calculator]

a) While the graph of the function \( y = \sqrt{3x+36} \) appears to start well after the point \((-12, 0)\) the table indicates that the point IS part of the function. Also analysis of the function indicates a domain \( x \geq -12 \) and a range \( y \geq 0 \).

b) The graph above of \( \log y = \log(x+1) \) clearly shows it terminating / starting close to the point \((1,-1)\) BUT by the definition of a logarithm its domain is infinite. Clearly this graph is wrong.

The end result being that while the analysis and even the calculator analysis itself shows clearly that these functions exist over a certain domain and range, the graph does not agree.

This confusion is often overcome if the student has a basic awareness of the general attributes such as shape of various functions. In this way they can estimate the behavior of the function which can be used to check the calculator response. But how do we get students who believe that the calculator will solve all their problems to accept this. To me posing problems which include such conundrums as the above or other contradictory examples is the best way to make students aware of this (rather than filtering them out – as some colleagues seem to prefer).
Once students have had to resolve such contradictions they are more aware or wary of the calculator and less likely to take it at face value. Another method is to make students aware that while their calculator is a useful tool its answers still require interpretation by an alert and informed user.

**Example 8** [Estimating/interpreting a bigger picture]

**Modeling - Diesel in a Tank**

1. The graph shows the amount of diesel \( y \) being filled in a 200 litre tank after \( x \) minutes.

   a) What is the **initial** amount of oil in the tank?
   b) At what **rate** is the tank filling?
   c) Write the equation of the function \( f \) in slope-intercept form.
   d) How many litres of diesel are in the tank after three minutes?
   e) After how many minutes is the tank \( \frac{3}{4} \) full?
   f) Assuming the process of filling the tank started at noon, what time would be displayed on a digital clock when the tank is \( \frac{3}{4} \) full? Give your answer in hours, minutes and seconds.
   g) Determine how many litres of diesel are in the tank after 9 minutes.
   h) What period of time does the tank contain **less** than 125 litres?

Often the act of estimation in mathematics allows us to see the bigger picture. How technology makes this happen is by eliminating the distraction of messy or difficult calculation and allowing the problem-solving time and resources to focus on the actual problem itself.

I consider Example 8 part g. indicative of this in that students who in this culture prefer algebraic methods tend to substitute into the equation of the function to evaluate the amount of oil in the tank. The mathematical answer they get is 205L which is of course incorrect and impossible for a 200L tank. Coming to this realization is made easier for students because they are not bogged down in unnecessary calculation. It is also very easy to see in that they all accept a 200L tank
cannot contain 205 L. In addition it is something that can be easily verified by looking at the graph which acts as a supporting scaffold to the written and numeric data.

A similar kind of example to this which is easily facilitated or focused on its particular learning issues exists in Chapter 5, where the extrapolation of a (decreasing) linear regression line calculates minus14.6 fires in year 2005. Students trained to look at the big picture are less likely to settle on these nonsense answers.

In this sense I use the term ‘estimation’ to mean taking an imprecise overview and or an inexact glimpse at some part of a problem. I use the term ‘calculation’ to refer to the as-precise-as-possible mathematics involved at getting an accurate answer.

That an answer perceived as accurate can turn out to be irrelevant surprises many students and makes them vigilant to the idea that both estimation and calculation are necessary to reach a valid result or conclusion.

In particular it makes them aware that these are not opposing perspectives but necessary complements to one another. By removing much of the hard work and providing calculating power technology makes it easier to demonstrate or discover the presence of such complementary relationships.

*Algorithms and Modeling*

Here I couple these two mathematical approaches or perspectives to investigate whether they are really opposites as some might perceive or whether there is a degree of complementariness between them that could be utilized by mathematics teachers in using both approaches, either together or as supporting one another.

Perhaps I sound somewhat naïve here because quite often we use a modeling approach in the West to develop a formula/algorithm which will later be used by students to solve relatively standard mathematics problems. In my experience with the EFL learners of mathematics here in the UAE this hasn’t been common. Usually because of the language constraints and associated teaching and learning difficulties
many teachers will ‘cut their losses’ by introducing the formula (no explanation or derivation given), demonstrate its application using a few standard examples then give the students their own exercises mimicking those examples as class-work and for homework. The end result appears to be that students learn to follow a recipe which they usually learn in a rote fashion. The problem I have encountered with students who have learned this way is that they lack problem solving strategies and they lack understanding and awareness of the problem they are solving and the concepts supporting it. Even to the point that if the teacher poses a problem in which the formula requires some adjustment only the best trained students seem to be able to do it. One good example of this is when teachers teach students the midpoint formula in English.

Even though the students have supposedly learned this formula and its underlying proof in Arabic it is clear they only know the formula and its direct application and many cannot find an endpoint using the midpoint, if given. The solution to this, according to some teachers, is to do one such problem as an example. Their reasoning being the students will become familiar with the problem and memorize the method.

After much discussion our team decided they wouldn’t do this and spoil such an obvious opportunity for ‘resolution of cognitive conflict’. Rather than presenting a pre-packaged example they chose to model the situation using computer software [in this case Microsoft Powerpoint] to demonstrate the geometry/physical representation and then derive the formula. As a result (it is believed by those involved) that while the students still memorize the formula for the midpoint they do so with some connection to the physical representation. This is something evident in the solutions offered by some of our students who will now solve the endpoint problem graphically.

A similar approach is followed below in example 9 in that the students are walked/talked and questioned through a power-point slide-show which models the data and arrives at the distance formula (G\The Distance Formula.ppt ).
A second approach used by Foundation Mathematics teachers has been to integrate standard algorithms and or formulas into the modeling process in an attempt to demonstrate that modeling and the use of algorithms are not opposite forces but once again complementary and or supplementary.

This I believe is evident in example 10 below in which we use both standard algorithms and linear regression from the calculator to come up with a selection of possible answers to the problem.

Example 10 [Algorithms coupled with Modeling to arrive at contrasting solutions]

Modeling Linear Functions Analytically

1. Estimates for Medicare costs (in billions of dollars) are shown in the table.

<table>
<thead>
<tr>
<th>x (year)</th>
<th>y (cost)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>236</td>
</tr>
<tr>
<td>2001</td>
<td>249</td>
</tr>
<tr>
<td>2002</td>
<td>264</td>
</tr>
<tr>
<td>2003</td>
<td>281</td>
</tr>
<tr>
<td>2004</td>
<td>299</td>
</tr>
<tr>
<td>2005</td>
<td>318</td>
</tr>
</tbody>
</table>

Using the data we can determine a linear function by choosing any two data points that the line should pass through.

Let \( x = 0 \) correspond to year 2000
Let \( x = 1 \) correspond to year 2001, etc.
a. Find a linear function $f$ that models the data using the data points $(0, 236)$ and $(5, 318)$
   Write all coefficients to the nearest tenth.

b. Find a linear function $g$ that models the data using the data points $(1, 249)$ and $(3, 281)$
   Write all coefficients to the nearest tenth.

c. Are both functions in approximate agreement?

d. Use functions $f$ and $g$ to predict Medicare costs in 2006

e. Make a scatter diagram of the data on your calculator using $L_1$ and $L_2$

f. Use your calculator to determine a function $h$ using linear regression (LinReg).
   Write down the function $h$ giving the coefficients to the nearest tenth.

g. Compare the function $h$ with functions $f$ and $g$ to confirm they are in approximate agreement.

For students coming from a rote learning environment such as the UAE high schools these activities must be very disconcerting. Indeed I can vouch for strong student reactions ranging from looks of confusion to open questioning and challenge of the results. ‘How can the same scores come up with different results?’ This is something students are not accustomed to. Their mathematics classes until now have (often by their own admissions) consisted of example and copy sessions in which the algorithms provided churn out one correct answer. Modeling data in this manner is a completely new perspective. Through the use of technology such as graphics calculators, calculator pads and projection screens students are able to participate in and contribute to the modeling exercise. They experience first-hand (and quickly, easily) the scatter-graph of the data and the lines of best-fit they have generated by means of manual use of the familiar old algorithms and by using calculator regression techniques. I believe this is a real eye opener for them in that it challenges
their preconceived ideas about mathematics and through their own participation it realigns them and eventually adjusts their schema.

**Contextual and Abstract**

Possibly, one of the more significant areas of debate which occurs within this faculty is that of the contextual versus the abstract. This discussion and resultant activities is played out between those of us with an applied mathematics and physics backgrounds, and those with a pure mathematics background. While this is not necessarily a debate in which students take a position I would conjecture that the standard position of any new student beginning our courses would lean to the abstract with them displaying little awareness of the applied nature of mathematics while being able to demonstrate an ability in the manipulation of symbols etc. While my colleagues point out to me that there is far more to abstract thinking than the mindless manipulation of symbols I would still argue that this successful manipulation by students often gets recognized as mathematical ability (in the abstract) leading to their passing of placement tests and other and their being recognized as mathematically competent.

So while I accept my colleague’s claims to the necessity of including exercises in mathematical reasoning in abstract form in our curriculum I prefer to develop skills and reasoning through more contextual means. This is because I am more convinced through my own experience as teacher and learner that these are less likely to be in reality surface learned learning strategies designed to reflect (but not equal) deep learning. To me the fact that my strategies genuinely are contextual makes them more likely to be relevant for the learner and more likely to motivate learning on a wider and deeper scale.

**Metacognition and Memorization**

I offer these as possible concepts and or points of view embedded within a (learning strategies) matrix. I’d not even consider them end points or even any points on a continuum because I believe that while they are contrasting in many ways they could also turn out to be complementary strategies under certain specific conditions.
Culturally Empowering Practices

Put simply, I regard cognition as the act of thinking, an attempt at understanding by the learner or an attempt to make connections and or look at the bigger picture involved in the learning scenario. In my experience, when this process actually happens it inevitably leads to metacognition. This is the process of thinking about our thinking and analyzing the thought processes and strategies we, as learners and thinkers, have used.

Through reflecting on my own learning and on the success and failures of my teaching in encouraging students to think about what they are doing and, how they are learning, I have even encountered numerous and often tenuous definitions for meta-cognition and cognition. To avoid getting too bogged down in such definitions I am going to talk in terms of meta-cognitive and cognitive activities or strategies of which I believe memorization is a useful but extremely limited sub-strategy. In other words I am going to talk about the efficacy and desirability of cognitive and meta-cognitive activities in promoting sustainable deep learning in students that will benefit them as lifelong learning strategies compared to what I call short-term grade grabbers.

Meta-cognitive and cognitive strategies may overlap in that the same strategy, such as questioning, could be regarded as either a cognitive or a meta-cognitive strategy depending on what the purpose or using that strategy may be. (Livingstone, 1997)

It is difficult to separate cognitive and meta-cognitive strategies. Indeed even memorization and or rote learning techniques are examples of both.

But identifying or defining activities and strategies was not the intent of this discussion so I will choose to step around his difficult issue by answering my original question – namely, how does technology assist empowerment?

In terms of meta-cognition, and cognition and memorization technology allows us to provide (among other things) quick and clear feedback. This allows teachers to challenge students in a variety of ways using a wide range of supporting, contrasting or contradicting scenarios and perspectives. These can be done with or without the
teacher present but the availability of rapid feedback means there are many more times when the student can be made to think about their answers, solution methods, their management strategies and of course their thinking processes.

For example the question below [Example 11] uses the quick response of the graphics calculator to show students that their algorithmic/algebraic solution to a trigonometric equation is incorrect. Normally what follows is a self review of the student problem solving strategy including its management. Posing a problem in this manner, I believe, is far better than showing an example and getting students to remember it.

Example 11 [Cognitive conflict induces metacognition]

a) Amplitude  \(|a| = \) ___________

b) Period  \(T = \) ___________

c) Vertical shift  \(d = \) ___________

d) Locate the zeros over \([-\pi, \pi]\)

(i) Analytically________________________

(ii) Graphically _________________________

\[ y = 3\cos2x \]

Students who solve the problem in example 11 by analytical means usually overlook the domain restrictions / considerations involved. Consequently they solve the function for 2x (then x) using the original restrictions place on x. The outcome is they only get half of all possible answers. The quick use of graphics calculators to get the correct number of solutions makes them soon aware that something is wrong. Usually this then prompts a complete review by the students of their methods/strategies and thought processes in an attempt to resolve the conflict.
In summation then, technology such as graphics calculators, computer software allows us to do more in real time through presenting and supporting ideas and concepts from a variety of physical and conceptual perspectives such as graphs, pictures and animations. It provides quick feedback, verification and even rebuttal on information, conjectures, theories and perceptions that learners may have.

It can present contradictions and often resolve them in a time frame that was impossible before, and it allows clearer more precise and eminently more relevant explanations.

This, in my view, is empowering for learners because they are made more aware and meta-cognitively they are aware of this awareness.

Such awareness means that as learners they are more confident in what they know and how they came about knowing it. That in turn means that when they take ‘learning risks’ they now have experience on their side and are on the way to developing a relatively familiar means of resolving any conflicts and issues they may encounter.

**Conclusion**

There are many factors that contribute to or comprise what I perceive to be an effective and empowering mathematics learning environment. Philosophical issues such as ‘what are the benefits of learning mathematics’, practical issues such as ‘what are our students really learning’ and issues of analysis or definition such as ‘what is mathematical competence’ are important considerations because they provide all of those involved with the areas for debate and negotiation so necessary for reaching consensus and establishing and maintaining an effective environment. In fact these very acts of negotiation focused upon these issues are themselves empowering.

In this chapter I have provided numerous samples and examples as to how I go about empowering my students and my colleagues by seeking their involvement within the learning process. Primarily if I want their involvement I believe I must engage them
in activities which relate to their real lives. These can be making connections with their everyday life-cultures of age, gender, ethnicity etc, and/or what I consider (also) to be their aspirational cultures such as academic or professional frames of reference. In the majority of cases my stakeholders aspire to be engineers or better teachers so most of my examples / activities are designed to engage them in these areas. As my colleagues are themselves teachers of engineers it makes sense that most of our activities are designed to engage engineers and in doing so give them knowledge and develop skills related to that area. Hence in developing our indicators of competency it made sense to use engineering competencies such as those of the Accreditation Board of Engineering and Technology (ABET) and The Australian Institute of Engineers (now called Engineering Australia).

While some of us felt we had higher ideals or aspirations for our students, others were happy to focus on the technical and practical aspects and leave the emancipatory outside the ‘out-side’ of their classrooms.

However, all of us being teachers and for that matter, teachers of ‘innovators’, we did agree that the established rote learning methods of our students are inadequate and need an overhaul. Consequently, we agreed to constantly review and revise our programs and activities, which has in itself led to what I see as greater involvement, empowerment and harmony within the faculty, something which has, as a result of its own example, moved into the classrooms of teachers who initially expressed opposition to sharing the power of their classrooms and syllabi with their students.

So, the samples and examples I provide in this (and other) chapters are not the end all and be all of an empowering and effective mathematics environment. They are to me the focal points through which we come to view empowering processes. This, to me, is their importance. Their relevance or context and their somewhat enhanced feasibility by virtue of modern educational technology enables them to overcome linguistic and cultural differences and operate as vehicles to stimulate and sustain learner engagement so that (in my opinion) other more important processes can occur.
Conclusion

Temporarily Closing the Research

In this the final chapter I attempt to bring together much of what I have done and learned in the preceding chapters.

As I have already summed up much of what I was trying to say by means of my introduction, I promise (myself) that it will be a short and hopefully ‘to the point’ exercise.

My metaphorical journey to develop materials needed to ‘construct an effective and empowering Mathematics learning environment for EFL students’ began as a search for resources and strategies that would assist my colleagues within the Foundation Mathematics program and other teaching peers within the Gulf region who I saw as in need of professional support.

One experience that I had with a fellow mathematics teacher while running a training program at the Higher Colleges of Technology in Abu Dhabi led me to realize something that is now very obvious to me. Namely, that much of what I had been suggesting as good material and strategies were in fact highly situated. That is, they were clearly case or context dependent.

My coming to this realization made me take a close look at the multiple contexts and the many different cultures that contributed to my own teaching environment (Aikenhead, 1999, Shi, 2006). These were varied and certainly overlapping and interdependent, rather than existing as individual sets of mutually exclusive viewpoints, paradigms or scenarios. Some dominant influences on what I was trying to do, both as research and in my everyday practice as a mathematics teacher and teacher-administrator, consisted of the cultural context of the Arabic world, the Islamic religion and politics, and their influence on education in general within the United Arab Emirates. Other important influences were the culture surrounding the
profession of engineering and the separate culture of academic engineering or engineering studies (Florman, 1976).

If the situation (or situated-ness) of my classroom was to be effective and empowering I felt (or perhaps learned through this research in action) that it had to be effective for engineers and had to deliver what engineers needed and or believed they needed. Consequently much of my early research involved looking at the issues that involved engineering and which subsequently affected engineering education.

Fortunately for me there was a fair amount of literature available on this very subject, much of which pointed towards the need for changes in the thoughts, attitudes and practices of engineers. While some of what I read described engineering from an engineering perspective, others pointed out shortcomings within the profession and practice of engineering, including a lack of global awareness and a notable inability to articulate the issues and consequences implicit in their engineering projects, and made suggestions as how to remedy this (Hauser-Kastenberg, 2001). It was the latter readings that interested me because in addition to identifying a need for greater effectiveness, they also hinted at means, many of which supported my evolving views on greater effectiveness through empowerment in learning.

Through my readings and through involvement on academic teams and committees I discovered that in response to widespread criticisms professional engineering, engineering associations such as ABET and Engineering Australia, were developing (and insisting upon the inclusion and enactment) of new operating criteria for engineering faculties and colleges, such as the Petroleum Institute, to follow in order to train, educate and develop engineers suited to the new millennium.

These criteria or list of desirable outcomes included teaching engineers to be more articulate problem-solvers, cross cultural team players more aware of the wider consequences of their actions who were more able to think and act globally. This, to me, describes a professional engineer who is free to think and act using informed judgment. Namely, someone who through empowerment is more effective at, and relevant to, what it is they are doing.
Conclusion

It was my emerging belief that such professionalism could be developed and nurtured in the right environment, but whether the Petroleum Institute, or any other engineering college was the right environment remained to be seen.

Through my research I then took a brief look at what other colleges were doing or planning, but found that in many cases what was happening was either irrelevant to our own case or possibly just ‘lip service’ to the professional/accreditation bodies.

As a consequence I decided that the criteria I would use to guide my research and my teaching/curriculum development would be based upon the principles espoused by ABET (and other professional bodies) but be embedded within the realistic context of the Petroleum Institute, that is, EFL learners and their needs and expectations.

As I mentioned earlier, my life and my learning are not linear. Often when I reflect upon my experiences I recognize and realize that something that I first thought was the consequence or response to some earlier and significant incident was in fact part of a whole tangle of ongoing events and adjustments. Often when I look beyond what I thought was a ‘life changing’ event I find that I had already been there before. I suppose this is why I am so willing to accept the concept of autopoeisis (self regulation) into my philosophical musings and my practice. As a result much of what I did both as research or professional practice accepted the role of self-discovery, self-realization and personal resolution of cognitive conflict within a socially mediated environment.

As an experienced teacher I had long been aware of the benefits of sharing power in my classrooms. Part of this had been to teach my mathematics within the context often dictated to me by the learners themselves. A natural spin-off had always been being sidetracked by students wanting to discuss the issues involved, whether they were technical, political, environmental, or some other. From my experience these detours were not problems for my teaching, they were enhancements. I found my students more willing to commit to the tasks I set, more involved in what we did and always more willing to connect and communicate what we did, with what they saw in their real-life worlds. I learned a lot in those classes.
Conclusion

In researching the issues involving engineering (education) into the twenty first century I came to believe that much of what I was doing in terms of power sharing through contextualized learning was relevant to the issues raised and went a long way towards providing solutions on a micro-educational scale to some of the problems raised both by my students and by the researchers I had earlier read.

This in turn led me to reflect upon and think more deeply about what I was doing and about why I was teaching mathematics at all. My realization somewhat surprised me at first. I realized that I did in fact teach this way for more than pragmatic reasons. In addition to the fact that it made my classes fun and more enjoyable and it made my students more involved and less like strangers. After much reflection I came to the self realization that as an educator I actually needed to feel that I was doing more than just teaching the technical, I needed to know that I was assisting my students towards fulfilling their own destinies.

Further reflection on my action led me to believe to achieve this meant that I had to begin and end my task by meeting student expectations. That meant beginning by delivering most of what the students believed they needed and then by means of demonstration, realization and negotiation curb those expectations to meet a set of mutually beneficial (and eventually negotiated) goals.

Consequently many of the samples and examples presented in earlier chapters, as taken from our curriculum, were designed with (these) deeper goals in mind. They are, I believe, intended as examples of curriculum as currere in that each is designed with the greater purpose of the actual journey (as opposed to the map) in mind. In addition to demonstrating skills and methods they aim to provoke students into thinking and acting in context. Such contexts include engineering as a profession, engineering studies and leading through relevance to greater awareness and to our student engineers becoming more responsible global citizens. All of this may sound a ‘tall order’ but I believe we can achieve much by informing our students more effectively, and by presenting our information and asking our questions from within a multi-perspectival framework designed to argue and explain from a wider range of views.

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With the regular assistance of modern technology (physical and intellectual) our curriculum is primarily presented as problems - questions and activities - which are designed to provoke as well as inform. Their intent is to destabilize our students by creating situations of cognitive conflict within a familiar and supportive environment.

Many of the examples and the problems I presented in earlier chapters were developed in this spirit. While they attempted to provoke and challenge our students at both a mathematical and a global/cultural level, they attempted to do so with a minimum of ‘noise’ (confusion) in that their authors went to great lengths to research and consult with each other and our students so as to provide sufficient cognitive support or scaffolding. As I have shown in Chapter 9, this philosophy and practice flows over into other areas such as a classroom management and inter-curricular or cross-curricular collaboration.

Once again I point out that this expansion out of the classroom is not a linear cause-effect relationship but rather, what I see as, an interactive, interdependent, iterative and cyclic process of converging towards an acceptably valid position. That is, equilibrium in a personal and socially moderated context. I state this because in my own case it was not through realizing the ‘effectiveness’ of my classroom that I came to be an adherent / practitioner of Total Quality Management (TQM) as described in Chapter 10, but rather it was a matter of each practice or emerging belief affirming the other, and then in coming together allowing me the confidence to apply what I had experienced in both my classroom and my departmental leadership.

Subsequently much of what I have presented in Chapters 9 and 10 as examples of establishing an effective and empowering faculty, program and institution have co-evolved simultaneously through my experiences in the classroom and in managing and leading various mathematics departments, tracks, programs and faculties.

As such I offer them only as examples of practices that have worked for me in that they have generally been met with approval from the majority of students and teachers that I have collaborated with, and they have usually assisted us to achieve mutually negotiated (expected) outcomes.
What did evolve significantly over the course of this research was me – Graeme Ward – the professional educator and the person - although these are really one and the same. I cannot say when this happened because I believe my personal and professional development began when I took my first breath.

However, I do recognize that during all acts of reflecting upon my teaching (in both micro and macro details), there existed moments at which I suddenly recognized that what was happening to me was every bit as important as what I was trying to achieve. That my personal transformation was as significant as was the development of my teaching resources. Two sides of the same coin I think, but nevertheless two aspects, or strands as I referred earlier to them, worthy of individual reference.

As a result of these moments of realization part of this research then came to look at my own transformative experience(s) as a teacher and as a researcher (Mezirow, 1990b). To herald the arrival of this new perspective I then described my research as ‘two intertwined strands’ in recognition of my view that one of the most important resources I could now provide for my readers was the awareness that teaching and learning is (and should always be) transformative. By heralding this realization it was my aim to (role) model a very desirable but less obvious aspect of the teaching/learning process. Namely, reflection and action with the aim of personal transformation, which I now consider to be a meta-cognitive activity leading, I believe, to the development of higher-order thinking within the individual (Kitchener, 1990).

Once again I find myself in loop (or iteration), in that as I develop such awareness or skills in myself I see their value to my colleagues and students and consequently I attempt to include them or their practice (even if somewhat naively and rudimentarily) in the scheme of my teaching and learning.

Implicit to all my research then is the theme of self development. As I reflect upon my teaching and as I muse upon my teaching and management strategies I also reflect upon what I see as my growth and my liberation as a teacher, as a manager, as a human being and as a thinker.
Closing Remarks

In this final chapter, as in the opening conclusion of this thesis, I have attempted to describe what I believe this research is. To clarify further let me try to say what I believe it is not.

This thesis is not an attempt to prove any truth about any objective reality or any parts thereof. In my view, except perhaps for some of the data collected and analyzed in an attempt to confirm or deny any trends or issues that have come up for discussion, there is little objective at all about what I have written here. Nor can I claim that the preceding pages contain the impartial musings of a teacher manager reflecting upon his methods and practices in a totally unbiased manner.

As I stated in my opening chapter, the original intent of this whole undertaking was to come up with something that I believed would assist my colleagues to improve their teaching / learning environments. While I have, at times, mentioned by and large, examples and experiences that may appear to some readers to contradict this, I have in the main presented my ideas and examples with the intention to help.

One likely criticism could be that I have seldom attempted to present these items as ‘open for discussion’ within the framework of this document. However, as I have stated on several occasions this research is largely written in autobiographical form. It is in effect, my field-notes as I ponder my success and some failures on a year to year, week to week, day to day, sometimes even encounter to encounter basis. As I had intended for these notes to provide some assistance for others I have written it in terms of what I found useful for me and often in terms of why I think it was useful. Whether or not it is useful for my readers is really up to them to decide. So while there is discussion both within our classrooms and our faculty offices it is rarely registered here, and similarly I would argue for any ensuing discussion generated by somebody reading these pages. The discussion exists and is ongoing but outside of these pages.

In general the research I have conducted and reported within these pages consists of my field-notes and my deliberations as to whether what I was doing was of value to
me, and often why I thought it was of personal value. As I have gained experience as a teacher and as teacher manager and an educational leader I have had to reconcile all kinds of anomalies within my frames of reference. Any effort to adjust my schema, to reconcile and justify my conclusions and actions has led me to think deeper and more broadly about the issues, inferences and consequences that created these original events and that came about later in part as my responses and my actions. These deliberations have taken many forms but usually, in keeping with the life and times of a teacher, they have often been done ‘on the run’.

One very noticeable outcome, however, is that I feel at ease with my own educational and personal philosophy and what I see as its scientific basis which, if not completely stable or conclusive, underpins and sufficiently explains (to me) what I experience and why I act as do.

In short, this thesis represents my evolution as a cognitive being seeking to adapt to my personal and professional environment (cultures which exist as non-mutually exclusive entities). It is my story told from my own perspectives and includes within itself my own musings – my beliefs, attitudes and values – and of course my doubts, questions and reassertions as I reflect upon my experiences both recent and distant as I travel within the cycles of my own equilibriation and self-regulation.

I have gained much from its creation and as initially expressed it is my wish that many other teachers benefit from it as well.
References


References


References


Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.
Appendices

Appendix 2.1   Mission and Goals of the Petroleum Institute

Mission and Goals

The Petroleum Institute will provide a world-class education in engineering and applied sciences in order to support and advance the petroleum and energy industries. The Institute is committed to academic excellence, and to fostering an intellectual environment that leads to the development of our graduates as whole persons and as the future leaders in their respective fields of expertise in the United Arab Emirates and beyond.

Institutional Goals

To achieve its Mission the Petroleum Institute will:

1. offer programs of instruction leading to baccalaureate degrees to produce graduates that have the skills, knowledge, and competencies that meet the needs of ADNOC and our other sponsors;
2. practice and infuse in our students the highest standards of health, safety, and environmental awareness;
3. manage the content, quality, design and continuous innovation of its academic programs in a manner that creates and sustains a reputation for institutional excellence and earns local, regional and international accreditation;
4. provide programs of study leading to relevant post-graduate degrees and foster the creation and dissemination of knowledge that is pertinent to the needs of industry and enriches the academic programs of the PI;
5. provide professional outreach and continuing education programs that serve the on-going needs of practicing professionals;
6. operate as a center of excellence for education, research, and professional service that interconnects globally with regional and international industrial constituents, and with international partners in education and professional societies;
7. foster technological innovation and entrepreneurship leading to development of advanced processes and products that provides for economic expansion and promotes business development opportunities.
Appendix 2.2   Profile of the PI Graduate

Recognizing that the most immediate and dominant product of the Petroleum Institute will be baccalaureate graduates, the institutional educational goals for baccalaureate degrees are captured in the following attributes that reflect “the whole person development” of the graduating student:

- The graduating student will exhibit applied and theoretical competence in a field of technical specialization, and will be oriented in engineering practices germane to the oil, gas and petrochemical industries. The student will have the resourcefulness and capability to apply scientific and engineering principles in solving a wide variety of technical problems.

- The graduating student will appreciate the critical role played by verbal, written and graphical communications in engineering practice and project management, and will have the corresponding skills to communicate with a range of audiences, and the skills to employ information technologies where appropriate.

- The graduating student should acknowledge that technologies, economies and societies are in a continuous state of evolution, and should therefore have the flexibility to manage a career path that changes over time, and that is supported by life-long learning, critical thinking, teamwork, leadership and the ability to span several disciplines.

- The graduating student should understand the global nature of modern engineering and business, and in order to succeed in this international arena the student should have an awareness of customary practices in different countries and the influence of diverse cultures.

The graduating student should have the professional integrity and maturity to serve humanity and its highest values, and should always make ethical decisions as they relate to society, corporate operations, technology, and the environment.
Appendix 5.1 Stakeholder Information Sheet

Foundation Mathematics Program
Petroleum Institute.
PO Box 2533 Abu Dhabi, UAE.

To Foundation Mathematics Students / Guardians / Teachers; Petroleum Institute

In addition to my role as Senior Lecturer, Foundation Mathematics, I am a Doctoral student at Curtin University, Perth, Western Australia.

In order to conduct my research and complete my thesis dissertation – Constructing a Culturally Empowering Mathematics Environment for EFL Students – it is necessary for me to collect and analyze student and teacher data.

This collection will be conducted by means of classroom observations, surveys, questionnaires and interviews - and with your permission could include information about your personal attitudes and beliefs on the teaching and learning of Mathematics within the context of your own goals and purposes.

When recording and reporting this data I will respect the confidentiality of all consenting participants, and ensure their privacy through use pseudonyms to describe individual responses. I will also provide interested participants with prompt and regular access to all written and recorded personal data, and guarantee them editorial rights, so that they can satisfactorily amend or completely withdraw any related information from my data and / or conclusions.

Please also note that students and teachers are free to exclude themselves from the research endeavor or withdraw completely at any time.

Regards

Graeme Ward  BSc, MA(App Maths); Dip. Ed
(PhD student)
Appendix 5.2 Stakeholder Permission Note

Foundation Mathematics Program
Petroleum Institute.
PO Box 2533, Abu Dhabi, UAE.

Consent Form / Interview Permission.

Name: ______________________________________________________

Position: Student / Teacher / Other (please specify___________________)

ID number: __________________________________________________

I consent to Mr. Graeme Ward observing, interviewing and / or surveying me about my beliefs, values and opinions re the teaching and learning of Mathematics as part of the preparation for undergraduate studies in Engineering.

I understand that Mr. Ward will:

- not use my real name in recording my information.
- provide me with prompt access to any data recorded about me
- amend or delete any relevant personal data at my request.

I also understand that am free to exclude myself or withdraw from these research activities at any time.

Signed
__________________________________________________
Appendix 7.1 Basic Skills / Baseline test for Incoming Students

Name__________________________       ID #_________       Section #_____

1. **Physical Vocabulary**

(10 marks)

Match each ‘figure’ with its diagram

<table>
<thead>
<tr>
<th>For example</th>
<th>Square</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. angle</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>2. vertical line</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>3. rectangle</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>4. circle</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>5. hexagon</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>6. right triangle</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>7. curve</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>8. cone</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>9. horizontal line</td>
<td></td>
<td>...........</td>
</tr>
<tr>
<td>10. pyramid</td>
<td></td>
<td>...........</td>
</tr>
</tbody>
</table>

---

[Diagram showing shapes and labels: A, B, C, D, E, F, G, H, J, Z]
## 2. Algorithms

(10 marks)

Match each application with its ‘formula’

For example. Area of rectangle ..........Z........

1. Distance formula ........................................
2. Midpoint formula ........................................
3. Slope of a straight line .................................
4. Area of a triangle ........................................
5. Area of a circle ...........................................
6. Pythagoras’ Formula ....................................
7. Volume of a cylinder ...................................
8. Volume of a prism ......................................
9. Slope-intercept form of a straight line ............
10. Equation of a vertical line ............................

<table>
<thead>
<tr>
<th>Application</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Distance formula</td>
<td>( d = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2} )</td>
</tr>
<tr>
<td>2. Midpoint formula</td>
<td>( \left( \frac{x_1+x_2}{2}, \frac{y_1+y_2}{2} \right) )</td>
</tr>
<tr>
<td>3. Slope of a straight line</td>
<td>( m = \frac{y_2-y_1}{x_2-x_1} )</td>
</tr>
<tr>
<td>4. Area of a triangle</td>
<td>( A = \frac{1}{2}bh )</td>
</tr>
<tr>
<td>5. Area of a circle</td>
<td>( A = \pi r^2 )</td>
</tr>
<tr>
<td>6. Pythagoras’ Formula</td>
<td>( a^2 = b^2 + c^2 )</td>
</tr>
<tr>
<td>7. Volume of a cylinder</td>
<td>( V = \pi r^2h )</td>
</tr>
<tr>
<td>8. Volume of a prism</td>
<td>( A = lb )</td>
</tr>
<tr>
<td>9. Slope-intercept form of a straight line</td>
<td>( y = mx + b )</td>
</tr>
<tr>
<td>10. Equation of a vertical line</td>
<td>( x = a )</td>
</tr>
</tbody>
</table>
3. Logical/Positional (10 marks)

List all the elements of set $U = \{1, 2, 3, 4, 5, 6\}$ which are ..... 

*For example*  \(\text{odd}\) \(\{1, 3, 5\}\)

1. even  

2. more than 3  

3. less than 3  

4. from 1 to 4  

5. between 1 and 4  

6. greater than or equal to 5  

7. smaller than 1  

8. either odd or less than 4  

9. odd and less than 4  

10. neither odd nor less than 4
4. Symbols

Choose one correct symbol for each of the following

For example  Is equal to  …….=……..

1. sum  
2. empty set
3. divide
4. less than
5. greater than
6. subtract
7. does not equal
8. percent
9. square root
10. subset

%  x  =  +  -  >  ≤  <  ∞  ϕ
√  ⊆  ⊂  ∈  ≠
5. Algebra

(10 marks)

Simplify

1. \(2a + 3a = \ldots\)

2. \(2y - 3y = \ldots\)

3. \(2a \times 3a = \ldots\)

4. \((8y) \div (2y) = \ldots\)

5. \(a^2 \times a^3 = \ldots\)

6. \(a^6 \div a^3 = \ldots\)

7. \((a^3)^3 = \ldots\)

8. \(2a + 3b = \ldots\)

9. \(2a \times 3b = \ldots\)

10. \((12 a^3b) \div (3a) = \ldots\)
6. Problem Solving

1. Given the points A (-2, 1) and B (1, -3)

a) Find the midpoint M of points A and B.

b) Calculate the distance from A to B

2. How many triangles in this drawing?

3. Congruent shapes are identical. [same size and same shape].
Draw lines that will

a. Divide \[ \square \] into 3 congruent shapes

b. Divide \[ \square \] into 2 congruent shapes

c. Divide \[ \square \] into 4 congruent shapes
Appendix 7.2  

Student / Teacher Learning Contract

1. Read the contract carefully
2. Discuss the contract with your friends and your teacher.
3. If you agree, sign the contract.

As a member of this class I will……..

- Participate {make notes, attempt all work, ask/answer questions, collaborate}
- Attend lessons regularly, on time and prepared to learn.
- Show respect for my teacher and my peers {listen, wait, cooperate, ...}
- Study {attempt all homework, revise, summarize, seek help}

As teacher of this class I will……..

- Participate {give notes, provide LOTS of work, ask/answer questions, collaborate}
- Attend lessons regularly, on time and prepared.
- Show respect for my students {listen, help, cooperate, … speak clearly and slowly}
- Study {Promptly check/mark/record all homework, assignments, quizzes and tests; provide feedback & help}

Name___________________  ID___________________  Section__________________

Student’s signature          Teacher’s Signature

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Appendix 8.1  Condensation of Deming’s 14 Points for Management

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.

2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus consistently decrease costs.

6. Institute training on the job.

7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

12a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

12b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and of management by objective.

13. Institute a vigorous program of education and self-improvement.

14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.
Appendix 8.2   Faculty Procedures Manual Entries

**Procedure # 41 – Organizing Common Tests & Examinations**

Examinations and Assessment Team (TOB, GW, GM)
Two staff members to oversee exam procedures – they will

1. Determine examination rooms required from ‘official’ class lists.
2. Create seating arrangements for selected exam rooms.
3. Determine suitable common exam times from ‘official’ timetable.
4. Survey PC2 repeaters for freshman class / communications class clashes with exam times and determine a suitable common exam time for all students or make provision for a ‘second sitting’ preferably on following (marking) day.
5. Determine dates of common tests.
6. Book exam rooms (agreed dates and times) using online site.
7. Book extra chairs / desks via help desk (GSD section) for booked sessions.
8. Allocate exam setting duties – 2 persons per paper per session. – including setting Mid Term and Final Exams.
9. Allocate exam supervision duties – 2 or more supervisors per exam room
10. **Book selected examination rooms (or alternative rooms) for midterm and final examination when official dates and times received from registry office.**
Procedure # 42 – Setting Common Tests & Examinations

Two staff members to set each common test and examination (as per 41.8) – they will

1. Set draft examination paper covering selected syllabus content and ‘skills’
2. Solve exam problems and prepare a solutions paper – record solution time.
3. Negotiate a draft marking scheme
4. Distribute draft paper, solutions and marking scheme for discussion and amendment at faculty meeting preceding test day.
5. Amend exam paper in response to (agreed) suggestions at faculty meeting
6. Make a second version (if one is required).
7. Destroy all prior exam drafts and inform other faculty to do the same with distributed copies. (soft and hard copy)
8. Cross check final copy including marks and solutions.
9. Print required number of exam papers the day before the exam.
10. Arrange in bundles according to exam room numbers.
11. Store securely in coordinators’ office.
12. Issue bundles to exam supervisor prior to exam time.
13. Issue solutions sheet to staff on marking day for cross-checking and marking
Appendices

Appendix 8.3 Resolution of Faculty Grading Discrepancies

In the sample shown below there were 5 teachers involved.
Those designated Z were working at the Zarkuh (men’s) campus with the arguably less motivated male students.

Those designated as A were working at the Arzanah (women’s) campus where the students are said to be much keener.

<table>
<thead>
<tr>
<th>Teacher</th>
<th>HW %</th>
<th>Common Tests %</th>
<th>Mid Term %</th>
<th>Project %</th>
<th>Final Exam %</th>
<th>Course %</th>
<th>Av coursework %</th>
<th>Av testables %</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z2 av</td>
<td>72.8</td>
<td>78.0</td>
<td>73.3</td>
<td>68.3</td>
<td>69.5</td>
<td>72.5</td>
<td>72.8</td>
<td>72.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Z1 av</td>
<td>83.6</td>
<td>75.4</td>
<td>69.7</td>
<td>63.9</td>
<td>65.6</td>
<td>72.5</td>
<td>83.6</td>
<td>69.4</td>
<td>1.2</td>
</tr>
<tr>
<td>A1 av</td>
<td>82.6</td>
<td>72.4</td>
<td>66.7</td>
<td>64.4</td>
<td>63.8</td>
<td>70.8</td>
<td>82.6</td>
<td>67.6</td>
<td>1.2</td>
</tr>
<tr>
<td>A2 av</td>
<td>90.5</td>
<td>66.4</td>
<td>55.8</td>
<td>63.4</td>
<td>57.3</td>
<td>68.0</td>
<td>90.5</td>
<td>62.2</td>
<td>1.5</td>
</tr>
<tr>
<td>A3 av</td>
<td>93.2</td>
<td>60.7</td>
<td>63.8</td>
<td>64.4</td>
<td>63.5</td>
<td>73.5</td>
<td>93.2</td>
<td>65.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

The index (last column) shows that students at the women’s campus were awarded a larger proportion of their marks for the coursework than those they scored in the tests.

While teachers from the women’s campus argued that their clients / students were far more dedicated than their male counterparts they were at a loss to explain why this did not translate to better test marks and a reduction in the index accordingly. Comparison of some teacher’s Homework checklists also contradicted this viewpoint because it was shown that one extremely competent and motivated women’s group (A1) had significantly outperformed yet had a lower index than another less favorably described group (A2).

Further it was shown that section Z1 from the men’s camps had performed more credibly than section A2, had met all of its homework / coursework requirements, but had a lower index than A2.

Ensuing discussion led to the belief that grades for coursework were skewed by teacher expectation which was in turn influenced by student expectation in the form of negotiation and lobbying (anecdotally, something the female students were also very good at).
During the discussion some teachers agreed they may have been too generous in the face of student expectations, other teachers said they may have been too strict.

2. **Individual student samples are analyzed**, comparisons are made and further conclusions are drawn by individual teachers.

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Coursework %</th>
<th>Tests %</th>
<th>Mid-Semester %</th>
<th>Project %</th>
<th>Final Exam %</th>
<th>Course %</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>92001261</td>
<td>64.8</td>
<td>64.6</td>
<td>74.3</td>
<td>48.7</td>
<td>64.2</td>
<td>64.4</td>
<td>D</td>
</tr>
<tr>
<td>92001286</td>
<td>72.4</td>
<td>73.8</td>
<td>61.4</td>
<td>71.8</td>
<td>62.1</td>
<td>67.9</td>
<td>D</td>
</tr>
<tr>
<td>92001233</td>
<td>75.0</td>
<td>86.3</td>
<td>61.4</td>
<td>59.2</td>
<td>53.7</td>
<td>67.2</td>
<td>D</td>
</tr>
<tr>
<td>92001225</td>
<td>64.5</td>
<td>67.1</td>
<td>62.9</td>
<td>55.3</td>
<td>66.3</td>
<td>64.4</td>
<td>D</td>
</tr>
<tr>
<td>92001310</td>
<td>85.8</td>
<td>65.9</td>
<td>54.3</td>
<td>74.2</td>
<td>53.7</td>
<td>66.3</td>
<td>D</td>
</tr>
<tr>
<td>92001311</td>
<td>81.2</td>
<td>74.0</td>
<td>62.9</td>
<td>39.2</td>
<td>54.7</td>
<td>64.9</td>
<td>D</td>
</tr>
<tr>
<td>92001206</td>
<td>80.9</td>
<td>69.3</td>
<td>42.9</td>
<td>52.9</td>
<td>58.9</td>
<td>63.5</td>
<td>D</td>
</tr>
<tr>
<td>92001259</td>
<td>81.3</td>
<td>74.1</td>
<td>71.4</td>
<td>59.5</td>
<td>58.9</td>
<td>69.5</td>
<td>D</td>
</tr>
<tr>
<td>92001245</td>
<td>100.0</td>
<td>73.6</td>
<td>52.9</td>
<td>62.6</td>
<td>50.5</td>
<td>69.9</td>
<td>C</td>
</tr>
<tr>
<td>92001259</td>
<td>100.0</td>
<td>74.7</td>
<td>52.9</td>
<td>49.5</td>
<td>56.0</td>
<td>69.8</td>
<td>C</td>
</tr>
<tr>
<td>92001291</td>
<td>80.0</td>
<td>69.0</td>
<td>74.3</td>
<td>77.6</td>
<td>57.9</td>
<td>70.1</td>
<td>C</td>
</tr>
<tr>
<td>92001291</td>
<td>98.0</td>
<td>80.7</td>
<td>47.1</td>
<td>56.1</td>
<td>56.8</td>
<td>70.4</td>
<td>C</td>
</tr>
</tbody>
</table>

What the analysis of a few individual student samples showed teachers was the impact upon individual students of this variation (based upon) in teacher interpretations.

An outstanding example is the comparison of students

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Coursework %</th>
<th>Tests %</th>
<th>Mid-Semester %</th>
<th>Project %</th>
<th>Final Exam %</th>
<th>Course %</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>920012338</td>
<td>75.0</td>
<td>86.3</td>
<td>61.4</td>
<td>59.2</td>
<td>53.7</td>
<td>67.2</td>
<td>D</td>
</tr>
<tr>
<td>920012451</td>
<td>100.0</td>
<td>73.6</td>
<td>52.9</td>
<td>62.6</td>
<td>50.5</td>
<td>69.9</td>
<td>C</td>
</tr>
</tbody>
</table>

In this comparison it is clear that student 2338 outperforms 2451 in almost all areas but that a significant difference in the allocated coursework grade sees 2451 get the
required C grade for promotion to the next course while 2338 was expected to repeat the Precalculus 2 course.

To most teachers involved in the discussion this did not seem an acceptably fair and equitable outcome. Further discussion by the two teachers of these students revealed both were working strongly and the difference in coursework scores not an accurate indication of these student’s abilities and performance.

By means of the discussion it became clear to the teachers involved that there were serious discrepancies in the grading process and that changes needed to be made in and to the system.
### Teaching Mathematically Research Questionnaire
#### Version 2: Non-Mathematics teachers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program / Faculty</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wael El-Sokkary</td>
<td>Foundation English</td>
<td>M.A. TESOL/Bilingual Education</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you choose teaching as a career?</td>
<td>Comments:</td>
<td>I find it very rewarding.</td>
</tr>
<tr>
<td>2. What are your preferred teaching styles?</td>
<td>I like to motivate students first. Once they get started, I tend to move around them as they work.</td>
<td></td>
</tr>
<tr>
<td>3. Do you include mathematical / problem solving/critical thinking activities in your lessons?</td>
<td>Yes, on a daily basis. We do a lot of graphs, tables, and charts. The students are asked to draw conclusions, predict trends, and write English compositions based on the numerical information provided.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. How regularly?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Give examples</td>
<td></td>
</tr>
<tr>
<td>4. What benefits do you see from incorporating math activities in your lessons</td>
<td>I think this adds a lot of thinking to language acquisition. The language becomes more real and useful.</td>
<td></td>
</tr>
<tr>
<td>5. What do you consider to be the benefits to your students of learning mathematics as a part of another subject?</td>
<td>Our students are bound to be engineers and I believe mathematics to be an integral part of their careers.</td>
<td></td>
</tr>
<tr>
<td>6. How do you define the term 'competent' in regard to students</td>
<td>I would say a student is competent if he/she is able to handle authentic language texts/scripts. (i.e. language that has not been modified to suit their limited linguistic abilities)</td>
<td></td>
</tr>
<tr>
<td>your subject area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>7. How do you decide a student is mathematically competent with regard to our learning activities?</td>
<td>I’m not sure of how advanced they should be. (For example when comparing countries, they should at least be able to tell that it is useless to consider a country’s GNP without looking at other factors such as the income per capita)</td>
<td></td>
</tr>
</tbody>
</table>
| 8. In what ways could you identify or measure the mathematical competence of students in your lessons? | Graphs  
Charts  
Tables  
Fun: [www.mathsisfun.com](http://www.mathsisfun.com) |
| 9. In general what techniques / strategies do you employ to empower your students as learners? | Time to brag 😊  
I always tell my students to get to know their strengths. I strongly believe that we cannot ‘make’ any person a successful teacher. They have to like it, enjoy it and above all find it a very gratifying career. That is probably what helps me earn the confidence and respect of my students. Once they realize the teacher wants to help and is capable of doing so, they give this teacher their best. My students know that I expect nothing less from them. I think I sometimes push my students beyond their own expectations, yet they try to do a decent job just to avoid disappointing me. They know I believe in them, and this pushes them to reach higher every time I raise the bar. This belief means so much to our young students. One of my students wrote in his evaluation that he improved because I believed in him. It simply showed me I was on the right path. |

**General Comments:**
### Appendix 9.1.2 – Questionnaire / Profile – English Teacher

**David Thomson**

Teaching Mathematically Research Questionnaire  
Version 2 : Non-Mathematics teachers

<table>
<thead>
<tr>
<th><strong>Name</strong></th>
<th><strong>Program / Faculty</strong></th>
<th><strong>Teaching Qualification(s)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>...David Thomson.....</td>
<td>...Foundation English.</td>
<td>...MA Teaching English..</td>
</tr>
</tbody>
</table>

1. Why did you choose teaching as a career?

*Comments:* Teaching is a second career for me. While working in my first career, I volunteered to teach English to refugees and immigrants in my home town. Through this experience I found that teaching was much more rewarding to me personally because of the direct contact I had with learners, and because I had the sense that I was doing something positive to help individuals.

2. What are your preferred teaching styles?

*As a teacher who believes in the notion of 'principled pragmatism' I try to first determine the needs and levels of the learners and their purpose for learning, and then use one of my 'styles' to fit the situation I am involved in. My styles range from drill-and-kill to go-away-and-figure-it-out-by-yourself and all points in between - whatever is appropriate for the learning situation. I use a variation of the Socratic method fairly routinely. I think Richard Feynman said it well: First figure out why you want the students to learn the subject and what you want them to know, and the method will result by common sense.*

3. Do you include mathematical / problem solving/critical thinking activities in your lessons?  
   If yes –  
   1. How regularly?  
   2. Give examples

*Yes, I use each. I try to do several every week. (I teach the same class five days a week, 15 contact hours.)  
Re math(s): I have students ‘estimate’ numbers and try to figure percent mentally. The course book for my program(me) has math (physics related) activities. I have my students track oil prices and find averages. I have students create tables to show numeric information. I ‘test’ students on reading ‘big’ numbers.  
Re thinking activities, I have several books with ‘critical thinking’ activities that I have my students use. For example:*

   *When can these answers be correct?*

   
   10 + 7 = 5  
   9 + 6 = 3  
   11 + 5 = 4  
   8 + 11 = 7

4. What benefits do you see from incorporating math activities in your lessons

*I believe very strongly in the notion of learning for a purpose. By incorporating math activities into English lessons I hope to have students see that the assignment they're working on pertains to their other studies, too, that the purpose of the activity is multi-fold. I believe that learning should be integrated as much as practical, that in ‘real life’ (if there is such a thing) language, math and science are not separate entities.*

5. What do you consider to be the benefits to your students of learning mathematics as a part of another subject?

*Similar to #4. above, I think the more subjects and lessons are integrated with each other, the more effective the lesson and learning. I know my students have to study math and if I can help them on something as narrowly focused as pronunciation then there is a possibility that that could be beneficial to them in both math and English.*
<table>
<thead>
<tr>
<th>6. How do you define the term 'competent' in regard to students your subject area</th>
<th>My institution defines 'competent' as students averaging $\geq 60%$ so I go along with that. To me this means that the student has the ability to get basic meaning from texts given at her/his current language level, and can adequately express his/her understanding orally or in writing. At the level I'm currently teaching, 'competency' really comes down to the students having sufficient vocabulary to handle the tasks they've been assigned.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. How do you decide a student is mathematically competent with regard to our learning activities?</td>
<td>Deciding a student's mathematical competence is not part of my job, but when I do activities that incorporate math I get a gut feel for the student's math ability. I believe that a student's skill in estimating is one way to see how able he/she is in that aspect of math.</td>
</tr>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td>I do quiz my students on their abilities to use (hear, spell, say) big numbers and give them marks (miniscule) for this.</td>
</tr>
<tr>
<td>9. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>I don't believe that one human being can empower another, instead that people empower themselves. However, I do try various motivation techniques, which range from carrot to stick. I've found that by using Newton's 1st law (inertia) as a metaphor I can have some common vocabulary that I can use to try to communicate with them and hopefully motivate them. I also think that it's imperative for me to work one on one with my students, to get them to see that I value them as individuals.</td>
</tr>
<tr>
<td>General Comments:</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 9.1.3 – Questionnaire / Profile – English Teacher – Jamie Baird

Teaching Mathematically Research Questionnaire

Version 2 : Non-Mathematics teachers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program / Faculty</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamie Baird.</td>
<td>…English.</td>
<td></td>
</tr>
</tbody>
</table>

1. Why did you choose teaching as a career?  

Comments:  

I fell into it. I liked it, I decided to continue.

2. What are your preferred teaching styles?  

Experiential, getting the students to do all the work, learning through doing.

3. Do you include mathematical / problem solving/critical thinking activities in your lessons?  

If yes –  

1. How regularly?  

2. Give examples  

As much as possible. Perhaps once every 2 weeks, more with a disciplined class. Less with a class that takes more time on regular English work. Whenever it's possible to make the lesson meaningful with real life examples (math examples).

4. What benefits do you see from incorporating math activities in your lessons  

The more the disciplines overlap, the greater their general comprehension. Students who want to be engineers are generally interested in math and sciences and less so in English, so if we can do the English in a context that they enjoy, they learn the English sort of peripherally and use it meaningfully.

5. What do you consider to be the benefits to your students of learning mathematics as a part of another subject?  

As above, if it's interesting to them, they lose the burden of English while doing the math (or sciences), so their focus changes but their learning of both subjects is enhanced.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. How do you define the term ‘competent' in regard to students your subject area</td>
<td>In English, able to communicate appropriate ideas effectively through writing and speaking, and able to comprehend appropriate passages through listening and reading, i.e. grasping main ideas and responding meaningfully.</td>
</tr>
<tr>
<td>7. How do you decide a student is mathematically competent with regard to our learning activities?</td>
<td>If they can do the activity and arrive at a reasonable outcome using English as the medium, they are competent in that task.</td>
</tr>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td>Most of the tasks involve comprehension questions alongside, so if they can perform the task (e.g. take reasonably accurate measurements and calculate PI as well as answer the questions with the text, they are competent in the math).</td>
</tr>
<tr>
<td>9. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>Give them tasks, let them figure them out with as much guidance as required. As the semester progresses they should require less and less guidance. I can’t guide them on math, I can only help them understand the English to do the math.</td>
</tr>
</tbody>
</table>

General Comments:
### Appendix 9.1.4 – Questionnaire / Profile – English Teacher
#### Daniel Mangrum

Teaching Mathematically Research Questionnaire  
Version 2 : Non-Mathematics teachers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program / Faculty</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniel Mangrum</td>
<td>Foundation English</td>
<td>MA English (TESOL)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you choose teaching as a career?</td>
<td>I chose teaching English language because I wanted to live in different places in the world.</td>
</tr>
<tr>
<td></td>
<td>I chose teaching because I enjoy helping people reach their personal goals.</td>
</tr>
<tr>
<td>2. What are your preferred teaching styles?</td>
<td>I think that my preferred style is Q and A. Much of what I do is asking (mis)leading questions in order to draw out either what a student already knows or get that person to make the mental connections on his own.</td>
</tr>
<tr>
<td>3. Do you include math thinking / activities in your lessons?</td>
<td>No</td>
</tr>
<tr>
<td>If yes –</td>
<td>1. How regularly?</td>
</tr>
<tr>
<td></td>
<td>2. Give examples</td>
</tr>
<tr>
<td>4. What benefits do you see from incorporating math activities in your lessons</td>
<td>From a language learning perspective, I don’t immediately see any benefits. From a wider perspective, I would say that repetition of concepts, regardless of context, is necessary for long-term retention.</td>
</tr>
<tr>
<td>5. What do you consider to be the benefits to your students of learning mathematics as a part of another subject?</td>
<td>Again, repetition.</td>
</tr>
</tbody>
</table>
6. How would you describe the concept of mathematical competence within the bounds of your subject area?

7. In what ways if any do you measure mathematical competence in your lessons?

8. In general what techniques / strategies do you employ to empower your students as learners?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>How would you describe the concept of mathematical competence within the bounds of your subject area?</td>
</tr>
<tr>
<td>7.</td>
<td>In what ways if any do you measure mathematical competence in your lessons?</td>
</tr>
<tr>
<td>8.</td>
<td>In general what techniques / strategies do you employ to empower your students as learners?</td>
</tr>
</tbody>
</table>

General Comments:
Appendices

Appendix 9.2  
Reading Dates in English: *Months* and *Days of the month*

<table>
<thead>
<tr>
<th>Months</th>
<th>Days of the month (ordinal numbers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 January</td>
<td>1(^{st}) first</td>
</tr>
<tr>
<td>2 February</td>
<td>2(^{nd}) second</td>
</tr>
<tr>
<td>3 March</td>
<td>3(^{rd}) third</td>
</tr>
<tr>
<td>4 April</td>
<td>4(^{th}) fourth</td>
</tr>
<tr>
<td>5 May</td>
<td>5(^{th}) fifth</td>
</tr>
<tr>
<td>6 June</td>
<td>6(^{th}) sixth</td>
</tr>
<tr>
<td>7 July</td>
<td>7(^{th}) seventh</td>
</tr>
<tr>
<td>8 August</td>
<td>8(^{th}) eighth</td>
</tr>
<tr>
<td>9 September</td>
<td>9(^{th}) ninth</td>
</tr>
<tr>
<td>10 October</td>
<td>10(^{th}) tenth</td>
</tr>
<tr>
<td>11 November</td>
<td>11(^{th}) eleventh</td>
</tr>
<tr>
<td>12 December</td>
<td>12(^{th}) twelfth</td>
</tr>
<tr>
<td></td>
<td>13(^{th}) thirteenth</td>
</tr>
<tr>
<td></td>
<td>14(^{th}) fourteenth</td>
</tr>
<tr>
<td></td>
<td>15(^{th}) fifteenth</td>
</tr>
<tr>
<td></td>
<td>16(^{th}) sixteenth</td>
</tr>
<tr>
<td></td>
<td>17(^{th}) seventeenth</td>
</tr>
<tr>
<td></td>
<td>18(^{th}) eighteenth</td>
</tr>
<tr>
<td></td>
<td>19(^{th}) nineteenth</td>
</tr>
<tr>
<td></td>
<td>20(^{th}) twentieth</td>
</tr>
<tr>
<td></td>
<td>21(^{st}) twenty-first</td>
</tr>
<tr>
<td></td>
<td>22(^{nd}) twenty-second</td>
</tr>
<tr>
<td></td>
<td>23(^{rd}) twenty-third</td>
</tr>
<tr>
<td></td>
<td>24(^{th}) twenty-fourth</td>
</tr>
<tr>
<td></td>
<td>25(^{th}) twenty-fifth</td>
</tr>
<tr>
<td></td>
<td>26(^{th}) twenty-sixth</td>
</tr>
<tr>
<td></td>
<td>27(^{th}) twenty-seventh</td>
</tr>
<tr>
<td></td>
<td>28(^{th}) twenty-eighth</td>
</tr>
<tr>
<td></td>
<td>29(^{th}) twenty-ninth</td>
</tr>
<tr>
<td></td>
<td>30(^{th}) thirtieth</td>
</tr>
<tr>
<td></td>
<td>31(^{st}) thirty-first</td>
</tr>
</tbody>
</table>

‘Reading’ dates: Look at the calendar at the top of the page. On it, ‘Today’ is 1/10/2005. This is written and read *January tenth two thousand five*.

1. How do you write 1/19/2005?

____________________________________________

2. How do you write 3/31/2005?

____________________________________________

3. How do you write 6/17/2005?

____________________________________________

4. How do you write 10/30/2005?

____________________________________________
NB In the examples above, the month is listed first and the day of the month second. However, often the month is written first and the day of the month second.

<table>
<thead>
<tr>
<th>Cardinal numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 one</td>
</tr>
<tr>
<td>2 two</td>
</tr>
<tr>
<td>3 three</td>
</tr>
<tr>
<td>4 four</td>
</tr>
<tr>
<td>5 five</td>
</tr>
<tr>
<td>6 six</td>
</tr>
<tr>
<td>100 one hundred</td>
</tr>
<tr>
<td>200 two hundred</td>
</tr>
<tr>
<td>300 three hundred</td>
</tr>
<tr>
<td>400 four hundred</td>
</tr>
<tr>
<td>500 five hundred</td>
</tr>
</tbody>
</table>

* ‘and’ is said usually in British English, often in American English

Reading Dates in English: Years

This is the year 2006. It is written and generally read two thousand six (though many say two thousand and six). Next year will be 2007, or two thousand seven. One of the Foundation teachers was born in 1967, which is written and read nineteen sixty-seven. One of the students was born in 1986, or nineteen eighty-six. Ras Al Khaimah joined with the six other emirates to finally form the UAE in 1972, or nineteen seventy-two. The Suez Canal was completed in 1869, or eighteen sixty-nine. The French Revolution started in 1789, or seventeen eighty-nine. The Mongols invaded Syria in 1400, or fourteen hundred. Oxford University was founded in 1168, or eleven sixty-eight. The Tower of London was constructed in 1066, or ten sixty-six.

NB Commas are never used in years. The number 1,842 is read one thousand eight hundred forty-two, but the year 1842 is read eighteen forty-two.

1. Write the year 1314 in words. __________________________________________

2. Write the year 1490 in words. __________________________________________

3. Write the year 1756 in words. __________________________________________

4. Write the year 2001 in words. __________________________________________

5. Write the date 3/17/2006 in words. ______________________________________
Reading Numbers

**BIG Numbers**

<table>
<thead>
<tr>
<th>billion,</th>
<th>million,</th>
<th>thousand,</th>
<th>hundred.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>3,</td>
<td>4</td>
</tr>
<tr>
<td>hundred billions</td>
<td>ten billions</td>
<td>billions*</td>
<td>hundred millions</td>
</tr>
<tr>
<td></td>
<td>9,</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>millions</td>
<td>ten thousands</td>
<td>thousands</td>
<td>hundreds</td>
</tr>
<tr>
<td>2,</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>tens</td>
<td>units</td>
<td></td>
</tr>
</tbody>
</table>

* In British English ‘thousand millions’

The number written above is read:

one hundred eighty-three billion,
four hundred sixty-nine million,
seven hundred fifty-two thousand,
one hundred thirty-eight.

**Directions:** Express the following in numbers.

1. twenty eight billion, thirty million, twenty-eight thousand, fourteen.
   _______________________________

2. one million, six
   _______________________________

**Directions:** Express the following in words.

1. 27,349,001,008
   _______________________________

2. 107,280,161,399
   _______________________________
‘Reading’ Fractions

The example on the left can be read several ways, including 1.) five over six, 2.) five divided by six, OR 3.) five sixths.

In 3.) the numerator (also called dividend) is read as a cardinal number (i.e. one, two, three, etc.), and the denominator (also called divisor) is usually read as an ordinal number (i.e. third, fourth, fifth, etc.) . NB

Exceptions to the general rule of 3.) are when either 1 or 2 is the denominator. For example, \( \frac{3}{1} \) can be read three over one or three divided by one, however the ordinal number is not used when 1 is the denominator. \( \frac{1}{2} \) can be read one over two or one divided by two or, more commonly, one half. The ordinal number is not used when two is the denominator.

**Directions:** Express the following using **numbers**.

1. four thirds ______ 2. two thirteenths _______ 3. nine eighths _________

4. three halves ______ 5. one eleventh _______ 6. sixteen thirty-seconds ______

**Directions:** Express the following using **words**.

1. \( \frac{2}{7} \) ____________________ 2. \( \frac{3}{4} \) ________________ 3. \( \frac{1}{5} \) ____________________
### Appendix 9.3 – English Rubric for Evaluating the Calculators Project

**ID#: __________ ASSIGNMENT: CALCULATOR PRESENTATION**

<table>
<thead>
<tr>
<th>Score</th>
<th>Excellent (A) 90 — 100</th>
<th>Acceptable (C) 70 — 79</th>
<th>Very Poor (F) 40 — 59</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description/Explanation</strong></td>
<td>description/explanation is successful and fully developed</td>
<td>description/explanation is adequate</td>
<td>description/explanation not adequate</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>well-organized</td>
<td>organization supports communication</td>
<td>unorganized</td>
</tr>
<tr>
<td><strong>Detail</strong></td>
<td>few if any details missing</td>
<td>some detail missing</td>
<td>lacking detail</td>
</tr>
<tr>
<td><strong>Promption Required</strong></td>
<td>no prompting required</td>
<td>some prompting required</td>
<td>communicates little, even with prompting</td>
</tr>
<tr>
<td><strong>Listener Confusion</strong></td>
<td>fluent</td>
<td>fairly fluid</td>
<td>high degree of listener confusion</td>
</tr>
<tr>
<td><strong>Listener Intervene</strong></td>
<td>listener can easily understand</td>
<td>little listener confusion or need for clarification</td>
<td>listener needs to intervene frequently for clarification</td>
</tr>
<tr>
<td><strong>Pronunciation</strong></td>
<td>only a few pronunciation errors</td>
<td>some L1 influence in pronunciation</td>
<td>high L1 influence in pronunciation</td>
</tr>
<tr>
<td><strong>Errors of Syntax, Word Form, Tense and Reference</strong></td>
<td>minimal errors of syntax, word form, tense and reference errors that do not impair understanding</td>
<td>errors of syntax, word form, tense and reference errors are clearly noticeable but seldom impair understanding</td>
<td>frequency of syntax, word form, tense and reference errors impairs understanding</td>
</tr>
<tr>
<td><strong>Errors Memorization</strong></td>
<td></td>
<td></td>
<td>OR appears to have been memorized</td>
</tr>
</tbody>
</table>
Appendix 9.4   STEPS 201 – Graphics Lab
Fall 2008
Geometric Construction Exercise - Metal Gasket

In this exercise you will build a metal gasket part as shown in Figure 1. You will then make a drawing of the metal gasket and save the drawing file.

![Figure 1. Metal Gasket](image)

I. Make the Part

Use the part template you created to start the part file:

1. Open the ANSI-METRIC part template
2. Immediately save the file as a solid part (.sldprt), name the part Metal Gasket.sldprt
3. Study the geometry of the part as shown in Figure 1. Determine geometric entities and geometric relationships.
   (Note: R = radius dimension, $\phi$ = diameter dimension).
4. Start an Extrude Boss/Base operation
5. Sketch the part in the Front plane using geometric construction techniques
   a. Use the Circle tool to sketch two concentric circles centered at the origin.
      i. Click the Circle tool
      ii. Bring the cursor to the origin (if the origin is not shown, click View | Origin)
      iii. When the origin becomes a red dot, click to start sketching the circle
   b. Use the Smart Dimension tool to dimension the two circles to radii of 24 and 48 mm
   c. Use the Circle tool to sketch two more concentric circles with their center aligned horizontally with the origin
      i. Click the Circle tool
      ii. Bring the cursor to the origin, then move it horizontally to the right. A dashed line appears, indicating horizontal alignment with the origin
      iii. Move a sufficient distance to the right
      iv. Click to start sketching the small circle
      v. Move the cursor to the center of the small circle
      vi. When it becomes red, click and start sketching the second larger circle
      vii. The circles should be Concentric. But if they appear not to be concentric, select both circles.
      viii. On the property manager that appears on the left pane select the Concentric constraint
   d. Use the Smart Dimension tool to dimension the circles to radii of 12 and 24 mm
      i. Click the Circle tool
      ii. Bring the cursor to the origin, then move it horizontally to the right. A dashed line appears, indicating horizontal alignment with the origin
      iii. Move a sufficient distance to the right
      iv. Click to start sketching the small circle
      v. Move the cursor to the center of the small circle
      vi. When it becomes red, click and start sketching the second larger circle
      vii. The circles should be Concentric. But if they appear not to be concentric, select both circles.
      viii. On the property manager that appears on the left pane select the Concentric constraint
   e. Now connect the two sets of circles with tangent lines. The result should look like Figure 3.
      i. Select the Line tool and sketch a line that connects the two outer circles
      ii. Note the yellow tag that appears when you sketch the line. If you are careful enough, you may sketch the line tangentially
      iii. If the line is not tangent, then you need to set the tangent constraint.
      iv. Select the line and the circle
      v. Select Tangent from the Property Manager on the left pane
      vi. Repeat for the other circle connected to the line
f. Trim unwanted lines using the Trim tool, using Trim to Closest option. The result should look like Figure 4.

Figure 4. Trim unwanted lines

- Sketch a vertical Centerline passing through the origin
- Mirror the sketch to get the left side (Figure 5)
  - Click on the Entities to mirror window, then click on the lines you want to mirror
  - Click on the Mirror about window, then click on the Centerline
  - Click the green checkmark when done
- Trim unwanted lines
Appendices

Appendix 9.5  Press Release for METSMaC 2007

In helping to support constant renewal and development in teachers and educators across the country and beyond the METSMaC Organising Committee wishes to announce its Third Annual Conference for Middle East Teachers of Science, Mathematics and Computing (METSMaC 2007). The event is to be held at the Beach Rotana Hotel & Towers, Abu Dhabi, between 17–19 March 2007.

The three day event is being hosted by The Petroleum Institute in association with the National Bank of Abu Dhabi (NBAD). Other major sponsors of the conference include Edutech and ADNOC.

The conference, now in its third year, seeks to improve the teaching of mathematics, the sciences, and computing at the upper secondary and tertiary levels in the United Arab Emirates and across the region. METSMaC offers a professional development forum wherein teachers and educators can learn from each other so that the level of student achievement in schools, colleges and universities is continuously improved. The METSMaC 2007 conference theme, Active Teaching, Active Learning, reflects this aim.

Apart from Science, Mathematics and Computing Tracks, the conference has added a new track devoted to undergraduate Engineering Education. This track will explore the evolving needs of engineering education over the next decade to counteract the perceived skills deficiency of today’s graduate engineers. How engineering education can be furthered through enhancing teaching methods and curriculum will also be explored.

The conference program has attracted wide interest from both within the UAE and across the region and will include over 90 presentations. Oral sessions are organised into ten sessions chosen to showcase a representative range of talks across various levels and subject areas. A feature of the conference, not typical to most educational conferences, is the open poster session which allows presenters and delegates to network and interact with each other one-on-one in a relaxed and less formal setting.

In addition the conference will feature five invited talks from outstanding international speakers who are leading educational experts in each of their respective fields:

Mr Douglas Butler: ICT Training Centre, Oundle School, UK – Plenary Speaker
Dr David Tall: University of Warwick, UK – Mathematics Keynote Speaker
Dr Norman Reid: University of Glasgow, UK – Science Keynote Speaker
Dr Stephen Heppell: Heppell.net - ICT Policy, Research and Practice Consultancy, UK – Computing Keynote Speaker
Dr Linda Schmidt: University of Maryland, United States of America – Engineering Keynote Speaker

Teachers and educators are invited to attend and registration can be made through the conference website: www.metsmac.org

For further information please visit the conference website or contact:
Mr Michael Giblin (Tel: +971 2 5085180, e-mail: mgiblin@pi.ac.ae)
Appendix 9.5.1

METSMaC 2007 Press Conference
Held on 14 March 2007 at ADNOC Headquarters at 9.45 am

METSMaC 2007 is a conference dedicated to the teaching and learning of mathematics, the sciences, computing, and engineering education at the upper secondary and tertiary levels. The Middle East Teachers of Science, Mathematics and Computing Conference offers a professional development forum wherein teachers, lecturers and educators throughout the region and beyond can come together to share and exchange experiences, hear and learn about new and innovative ideas, and discuss current pedagogical best practices. Now in its third year, the conference endeavours to promote the continual renewal and improvement of student learning and achievement in schools, colleges and universities. This aim is reflected in the METSMaC 2007 theme of Active Teaching, Active Learning.

The three-day event offers a programme which consists of five technical tracks – Mathematics; Science, which comprises physics, chemistry and biology; Computing; Engineering; and General Education, a track embracing topics of concern and interest to all educators, regardless of specialisation. The engineering track is a new addition to the conference in 2007. This significant and highly relevant track will explore the evolving needs of engineering education over the coming decade to counteract the perceived skills deficiency of today’s graduate engineers. Included within the programme are a number of invited and contributed oral sessions. Each of the six invited speakers for the conference is internationally renowned and is a leading educational expert within their field.

The technical programme of METSMaC 2007 offers conference delegates a wide variety of topics of interest ranging from the effective integration and use of technology in the classroom, to learning content in a second-language environment, to current assessment methodologies. The programme consists of sixty-six contributed talks from speakers from across the United Arab Emirates, the wider Gulf region and beyond, divided into ten parallel sessions which are interspersed between the six invited-speaker sessions. Each parallel session has speaker representation from one of the five technical track issues with each particular presentation being of interest to an audience teaching at either the upper secondary, pre-university foundation, or tertiary level. Each of the invited speaker’s presentations addresses current topics and areas of broad concern and are meant to have wide-ranging general appeal. In contrast, the dialogue with the contributed speakers tends to focus more on topics and areas of particular concern to the teacher as classroom practitioner.

A unique feature of the conference programme is the Open Poster Session on Sunday, 18 March. This session allows presenters and delegates to network and interact with each other on a one-to-one basis in a relaxed and less formal setting. This year’s conference features a total of seventeen such posters.

Appendix 9.5.3
Founding of METSMaC, it’s Vision and Contribution to ADNOC

The concept of a regional-based conference for teachers of science, mathematics and computing was developed in early 2004. Dr. Jim Leanderson of the Petroleum Institute recognized that there were no teaching conferences in the Gulf region for interested teachers, lecturers and professors in these fields. It is widely known that students benefit when teachers participate in professional forums and bring new ideas back to the classroom. A conference held annually in the area would benefit the teachers at the Petroleum Institute and would improve the quality of its graduates, thereby improving the quality of new engineers employed by ADNOC.

With the support of the Petroleum Institute and ADNOC, a task force of Foundation, Core and the Chemical Engineering faculty was assembled who created an annual teachers’ conference that would not only provide an opportunity to improve education in science, mathematics and computing at the Petroleum Institute but at other educational institutions both in the UAE and the region. It was recognized early in the organizational process that one of the target audiences should be secondary school teachers from all private and national schools throughout the UAE and the Gulf region. This was in recognition that better educated secondary school graduates improve the quality of incoming students not only at the PI but at colleges and universities throughout the UAE and the region.

The first annual Middle East Teachers of Science, Mathematics and Computing (METSMaC) Conference was held in April of 2005. Approximately 250 educators attended whose contributions made the Conference a stimulating and excellent forum where professional contacts were established and teaching ideas exchanged. Most of these educators returned the following year who, together with new attendees made the second annual conference another success. In an effort to expand the outreach effort to teachers in the National schools, translators were provided at the second Conference for the Keynote presentations and will be also be provided at the third annual Conference. The third Conference, which will be held between 17-19 March this year, has expanded to include the engineering disciplines and will bring the total attendance at the Conferences over the past three years to about 1000 participants.

Jim Leanderson, PhD
Petroleum Institute
Foundation Science Coordinator
## Teaching Mathematically Research Questionnaire

### Mathematics teachers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neville Martin</td>
<td>Foundations</td>
<td>Post Graduate Certificate in Education</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you choose teaching as a career?</td>
<td>Comments: Challenging with good holidays</td>
</tr>
<tr>
<td>2. What are your preferred teaching styles?</td>
<td>Try to incorporate as many teaching styles as I see fit depending upon the situation</td>
</tr>
<tr>
<td>3. Do you regularly include problem solving /critical thinking activities in your lessons?</td>
<td>It’s part of the course</td>
</tr>
<tr>
<td>If yes – 1. How regularly? 2. Give examples</td>
<td>Most of the time</td>
</tr>
<tr>
<td>4. What advantages or disadvantages arise from incorporating the above types of activities in your lessons?</td>
<td>Word problems</td>
</tr>
<tr>
<td>5. What benefits or costs do you see in your students learning some mathematics in another subject?</td>
<td>Obvious benefits if it was done properly</td>
</tr>
<tr>
<td>6. What benefits or costs do you</td>
<td>Not a believer in project based learning……</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>see in your students learning some maths by doing collaborative projects?</td>
<td>Projects as a small part of a Maths course with independent learning is a good thing</td>
</tr>
<tr>
<td>7. How do you define the term 'mathematically competent' in the context of your teaching activities?</td>
<td>?</td>
</tr>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td>Observe, test, ….</td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the students)? Explain</td>
<td>Me</td>
</tr>
<tr>
<td>10. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>Time makes this difficult with the constraints we have</td>
</tr>
</tbody>
</table>

General Comments:
Appendix 10.1.2– Questionnaire/Profile – Maths Teacher – Mick Giblin

Teaching Mathematically Research Questionnaire
Mathematics teachers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mick Giblin</td>
<td>Foundation</td>
<td>Higher Diploma in Education and B.Sc.</td>
</tr>
</tbody>
</table>

1. Why did you choose teaching as a career?
   - **Comments:**
     I would refer to the movie “Goodbye Mr Chips”. I was drawn to the profession because of the impact he had on his students and wanted to make a similar contribution.

2. What are your preferred teaching styles?
   - **I like to have an interactive class as much as possible although the fetters of a fixed syllabus can make this difficult.**

3. Do you regularly include problem solving /critical thinking activities in your lessons?
   - **Yes**
   - **3 to 5 times a week**
   - Collaborative word problems, science and finance applications of particular concepts

4. What advantages or disadvantages arise from incorporating the above types of activities in your lessons?
   - **Collaboration often leads to gossip and lost time as a result**

5. What benefits or costs do you see in your students learning some mathematics in another subject?
   - **While it may take from the pure academics of the other subject it serves to reinforce mathematics as a multifunction tool rather than as a set of arithmetic tables and a bunch of rigid rules**

6. What benefits or costs do you see in your students learning some maths by doing collaborative projects?
   - **Teamwork, debate, social skills, infectious enthusiasm given the right subject matter, reinforcement through teaching each other; “teach something, learn it twice”**
   - **Costs: if the members are unmotivated they will socialize more rather than using their social skills to produce something constructive**
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. How do you define the term ‘mathematically competent’ in the context of your teaching activities?</td>
<td>For me it means that the students have the ability to use mathematics to solve a new problem; the ability to recognize their mistakes and have the willingness to rectify those mistakes.</td>
</tr>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td>Mainly through assessment, both academic and project based and also by discussion.</td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the students)? Explain</td>
<td>It has been a 50-50 effort typically. Following up on old work and teaching new concepts and then getting the class involved in the practicing new skills and assimilate the new concepts into their existing conceptual framework.</td>
</tr>
<tr>
<td>10. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>Recognizing student effort at every turn, give positive feedback, give advice on how to improve performance rather than telling students that they are not working effectively. Encourage effectiveness rather than efficiency in their learning.</td>
</tr>
</tbody>
</table>

General Comments:

SPAMMING BASTARD!!
### Appendix 10.1.3– Questionnaire/Profile – Maths Teacher – Dom Munster

#### Teaching Mathematically Research Questionnaire

**Mathematics teachers**

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dom Munster</td>
<td>Comments: It’s a social profession where one can interact with people and impart knowledge.</td>
<td>Cert Ed (PGCE)</td>
</tr>
</tbody>
</table>

1. **Why did you choose teaching as a career?**

   - It’s a social profession where one can interact with people and impart knowledge.

2. **What are your preferred teaching styles?**

   - Generally, worksheet driven lessons

3. **Do you regularly include problem solving /critical thinking activities in your lessons?**

   - Yes. PS & CT are an integral part of Mathematics
     
     - Try to incorporate every lesson

4. **What advantages or disadvantages arise from incorporating the above types of activities in your lessons?**

   - Lessons can sometimes go slower than the ideal lesson plan

5. **What benefits or costs do you see in your students learning some mathematics in another subject?**

   - Big Benefit: Students can become more familiar with the vocab used if they get exposure to the language if incorporated in other courses such as English

6. **What benefits or costs do you see in your students learning some maths by doing collaborative projects?**

   - Weaker students can get help/understanding from peers, especially if they feel uncomfortable asking teachers knowing/feeling they are weak.

7. **How do you define the term ‘mathematically competent’ in the context of your teaching activities?**

   - Is when they can apply the knowledge they have obtained to real world problems
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td>Quizzes and Tests</td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the students)? Explain</td>
<td>Sometimes myself. Depends on the focus of the lesson</td>
</tr>
<tr>
<td>10. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>Like to get students to start solving new worksheets on their own or in small groups if suitable. Then follow up solving with the students as a class.</td>
</tr>
</tbody>
</table>

General Comments:
### Appendix 10.1.4– Questionnaire/Profile – Maths Teacher – Jane Neilson

#### Teaching Mathematically Research Questionnaire

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane Neilson</td>
<td>Foundation - Maths</td>
<td>MSc (Maths Education)</td>
</tr>
</tbody>
</table>

1. **Why did you choose teaching as a career?**
   Comments: I like my subject and enjoy teaching. However, I did fall into this vocation accidentally – I’ll tell you all about it some time.

2. **What are your preferred teaching styles?**
   I’ve gotten used to lecturing, but prefer to have more time to allow the students to teach each other (in small groups, or as one large one).

3. **Do you regularly include problem solving/critical thinking activities in your lessons?**
   | Quizzes (sometimes), HW assignments, and “questions for experts” sometimes contain a component to be taught in a future lesson, or maybe a future course. Students might see a question like this once or twice a week. GM’s “backsides” are good examples. |
   If yes –  
   1. How regularly?  
   2. Give examples

4. **What advantages or disadvantages arise from incorporating the above types of activities in your lessons?**
   A disadvantage is that weak students who have trouble understanding the core of the subject may be put off or stressed out by a question that is clearly beyond their scope of understanding. Good students might find it challenging.

5. **What benefits or costs do you see in your students learning some mathematics in another subject?**
   Previous exposure to Mathematics in another subject gives relevance to Mathematics being applicable. Problems arise when certain given equations (as in Physics) are not “allowed” to be used in the current Mathematics course.

6. **What benefits or costs do you see in your students learning some maths by doing collaborative projects?**
   Collaborative projects teach students to work together cooperatively, as they will have to do in the workplace. They learn that not everyone learns the same way, or even the same “thing”, from a given lesson.

7. **How do you define the term ‘mathematically competent’ in the context of your**
   A student should have a working knowledge of material taught in all previous Maths courses.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td>A student should be able to apply the lesson to a “real life” situation.</td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the students)? Explain</td>
<td>The teacher, of course! To the student it may not look like I do much because they are the ones answering questions orally or on the board, but I have to select the students that I ask, and the questions that I ask, with some idea of the most likely outcomes. A timely delivery of the material takes practice!</td>
</tr>
<tr>
<td>10. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>I try to get the students excited about the subject by defining a lesson’s application to real life, and by explaining what I find interesting about a topic. This is not very successful with students who suffer Math Anxiety, or who have learned to hate the subject (something that is rare in the PI environment, since these girls will be engineers).</td>
</tr>
<tr>
<td>General Comments:</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 10.1.5– Questionnaire/Profile – Maths Teacher – **Dr Gary Miller**

Teaching Mathematically Research Questionnaire  
Mathematics teachers

<table>
<thead>
<tr>
<th><strong>Name</strong></th>
<th><strong>Program</strong></th>
<th><strong>Teaching Qualification(s)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller</td>
<td>math</td>
<td>Ph.D. (math), tertiary diploma in ed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Why did you choose teaching as a career?</strong></td>
<td><strong>Comments:</strong> The enormous respect and high salaries</td>
</tr>
<tr>
<td><strong>2. What are your preferred teaching styles?</strong></td>
<td>Small groups of students with equal abilities</td>
</tr>
<tr>
<td><strong>3. Do you regularly include problem solving /critical thinking activities in your lessons?</strong></td>
<td>Yes, every day but almost always only one such question</td>
</tr>
<tr>
<td><strong>If yes – 1. How regularly? 2. Give examples</strong></td>
<td></td>
</tr>
<tr>
<td><strong>4. What advantages or disadvantages arise from incorporating the above types of activities in your lessons?</strong></td>
<td>Motivating students can be difficult. They would prefer the formula which will answer the exam questions.</td>
</tr>
<tr>
<td><strong>5. What benefits or costs do you see in your students learning some mathematics in another subject?</strong></td>
<td>I think that I would rather that they did not. The slightest change in notation or method seen elsewhere seems to upset them.</td>
</tr>
<tr>
<td><strong>6. What benefits or costs do you see in your students learning some maths by doing collaborative projects?</strong></td>
<td>Cost: the lazy ones get by Benefit: they have a chance to learn at their own pace, and they may even discover time management skills.</td>
</tr>
<tr>
<td><strong>7. How do you define the term ‘mathematically competent’ in the context of your</strong></td>
<td>A mathematically competent instructor knows the origin and the further application of each item. A mathematically competent student is able to connect new material with old.</td>
</tr>
<tr>
<td>Question</td>
<td>Response</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8. In what ways could you identify or measure the mathematical</td>
<td>I invariably pause in writing out steps on the board to suggest a false step, saying &quot;right?&quot; Again and again the students have been reminded that when I say &quot;right?&quot; I mean that there is something wrong. And they are invited to point out the mistake.</td>
</tr>
<tr>
<td>competence of students in your lessons?</td>
<td></td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the students)? Explain</td>
<td>I am working at least as hard as the hardest-working student. This can be demonstrated.</td>
</tr>
<tr>
<td>10. In general what techniques / strategies do you employ to empower</td>
<td>I encourage them to explain what they understand to a classmate.</td>
</tr>
<tr>
<td>your students as learners?</td>
<td></td>
</tr>
<tr>
<td>General Comments:</td>
<td>I can't be serious about question one.</td>
</tr>
</tbody>
</table>
Appendices

Appendix 10.1.6– Questionnaire/Profile – Maths Teacher

Mariam Al Hanai

Teaching Mathematically Research Questionnaire
Mathematics teachers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M Al Hanai</td>
<td>Found Maths</td>
<td>M. Sc (App Maths)</td>
</tr>
</tbody>
</table>

1. Why did you choose teaching as a career

Comments:
Because I think that the most valuable thing one can do is to enlighten people through knowledge.

2. What are your preferred teaching styles?

With Precalculus students, “Personal Model” modeling skills and processes and then coaching the students to apply the knowledge. With more mature students I tend towards a facilitator style.

3. Do you regularly include problem solving/critical thinking activities in your lessons?

I like word problems that require them first, to understand the pieces of information and then, translate them into math.

I cannot say precisely the regularity because depends on the topic and time constraints.

4. What advantages or disadvantages arise from incorporating the above types of activities in your lessons?

Advantage: The above average students respond with enthusiasm to such activities, they enjoy the extra work.
Disadvantage: The below average students fill like outsiders.

5. What benefits or costs do you see in your students learning some mathematics in another subject?

To me the benefit is to learn that mathematics has a place in daily life and it is not a mere abstract subject that one has to study to get a degree.

6. What benefits or costs do you see in your students learning some maths?

The benefit is to instill in them independent learner skills because life is a continuous learning path.
The cost that I see in this collaborative projects is that
| by doing collaborative projects? | there are some students that do not collaborate and only seek a mark the easy way. |
| 7. How do you define the term 'mathematically competent' in the context of your teaching activities? | Mathematically competent is a student that can find patterns and relationships. |
| 8. In what ways could you identify or measure the mathematical competence of students in your lessons? | Sometimes from the questions they ask during the lessons, sometimes from the questions that I make during the lessons, sometimes from questions in the quizzes. |
| 9. Who works the hardest in your lessons (you or the students)? Explain | I think the students: they are studying the subject in a foreign language and the pace is different from that of High School. |
| 10. In general what techniques / strategies do you employ to empower your students as learners? | I tried to activate background knowledge. I use humor. Use technology to enhance the learning process. |

**General Comments:**
### Appendix 10.1.7– Questionnaire/Profile – Maths Teacher

#### Turlough O’Brien

#### Teaching Mathematically Research Questionnaire

**Mathematics teachers**

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Teaching Qualification(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Why did you choose teaching as a career?</strong></td>
<td>Comments: I felt that I had communication skills that could enable me to pass on knowledge in an effective and interesting way to students. I also felt that I was adaptable enough to use new and different methods to pass on this knowledge. It is a profession that enables me to keep abreast of new developments and learning in my own subject areas.</td>
<td></td>
</tr>
<tr>
<td><strong>2. What are your preferred teaching styles?</strong></td>
<td>It depends on the subject but generally an introduction of the new concept including examples and using different presentation methods followed by exercises for the students to attempt and further individually worked exercises for practice purpose.</td>
<td></td>
</tr>
<tr>
<td><strong>3. Do you regularly include problem solving /critical thinking activities in your lessons?</strong> If yes – 1. How regularly? 2. Give examples</td>
<td>Yes 1. Depends on topic and where most effective, usually as part of introduction of a new concept. 2. a) Most recently during an intro of dry ice. The question posed was what are the bubbles given off when dry ice is dropped into a beaker of water. What is the difference between these bubbles and the bubbles formed when water is heated to boiling point. b) In introducing the set of irrational numbers; why is the number π not rational despite normally being substituted with the rational 3.14 or the rational 22/7.</td>
<td></td>
</tr>
<tr>
<td><strong>4. What advantages or disadvantages arise from incorporating the above types of activities in your lessons?</strong></td>
<td>It causes a conflict in the students existing knowledge which they must resolve thus forcing a restructuring of that knowledge and hence hopefully ‘learning’. A conflict should also become more of a memorable event rather than passively accepting a given fact.</td>
<td></td>
</tr>
<tr>
<td><strong>5. What benefits or costs do you see in your students learning some mathematics in another subject?</strong></td>
<td>The benefits are a reinforcement of and more exposure to topic areas. The costs are the forming of misconceptions arising from different outcome requirements for a particular piece of knowledge and the different emphases put on it’s uses.</td>
<td></td>
</tr>
<tr>
<td><strong>6. What benefits or costs do you see in your students</strong></td>
<td>Benefits are team building, use of their own language and learning from their peers.</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Response</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>learning some maths by doing collaborative projects?</td>
<td>Costs are free-riders not getting the benefit of 'finding out' but simply allowing others to 'discover' and being told.</td>
<td></td>
</tr>
<tr>
<td>7. How do you define the term 'mathematically competent' in the context of your teaching activities?</td>
<td>One who has the basics fully understood and the desire to build on them.</td>
<td></td>
</tr>
<tr>
<td>8. In what ways could you identify or measure the mathematical competence of students in your lessons?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the students)? Explain</td>
<td>Me.</td>
<td></td>
</tr>
<tr>
<td>10. In general what techniques / strategies do you employ to empower your students as learners?</td>
<td>Giving them 'extra' work to do to practice techniques and use learned methods to apply to new or differently presented problems.</td>
<td></td>
</tr>
</tbody>
</table>

**General Comments:**
# Appendix 10.2 – Questionnaire/Profile – Male Student # 1

## Teaching Mathematically Research Questionnaire

**Mathematics Students**

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Electrical</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you choose engineering as a career? Comments:</td>
<td>Because it needs hard work and I like to be a hard working person and it bases on math and physics and I like them</td>
</tr>
<tr>
<td>2. What are your preferred subjects?</td>
<td>Math and physics</td>
</tr>
<tr>
<td>3. What do you like and or dislike about studying mathematics?</td>
<td>I like math and I like solving problem but I don’t like complicated problem</td>
</tr>
<tr>
<td>4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.</td>
<td>I like to do them both, because the teacher examples may not contain all the ideas so I solve new problems to make sure I got the whole idea.</td>
</tr>
<tr>
<td>5. Do you do much maths and or problem solving in other subject areas?</td>
<td>Sometimes</td>
</tr>
<tr>
<td>6. Did you learn much maths by doing research projects?</td>
<td>Yes, it is very useful</td>
</tr>
<tr>
<td>7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain.</td>
<td>I like to do it in groups because I think it is important to share our opinion with other students</td>
</tr>
<tr>
<td>8. Do you think your teacher is competent? Are all the students in your class competent?</td>
<td>Yes, the teacher is competent but not all the students are competent</td>
</tr>
<tr>
<td>Question</td>
<td>Response</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>The teacher gives us examples then we do a lot of works and homework</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson?</td>
<td>Yes, when the teacher gives us classwork he chases two student for each question so I think it is a good way to do the classwork. Also he has good way to run the class.</td>
</tr>
</tbody>
</table>

General Comments:
Appendix 10.2.2– Questionnaire/Profile – Male Student # 2

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Not given</td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?
   Comments:
   1 - Money
   2 - Nice job
   3 - vacations

2. What are your preferred subjects?
   Math, English

3. What do you like and or dislike about studying mathematics?
   I like to do homework after that do small quiz because that let you do your job

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.
   Yes, because I want to understand first

5. Do you do much maths and or problem solving in other subject areas?
   Not much only Physics

6. Did you learn much maths by doing research projects?
   Yes.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain
   Part, because I want to be sure of my methods or answers

8. Do you think your teacher is competent? Are all the students in your class competent?
   Yes, yes
9. Who works the hardest in your lessons (you or the teacher)? Explain

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Both, because he asks and we both have to think then he has to explain. Then we do the h/w</td>
<td></td>
</tr>
</tbody>
</table>

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes.</td>
<td></td>
</tr>
</tbody>
</table>

**General Comments:**

It was a very good course and I want to thank you a lot for everything
## Appendix 10.2.3– Questionnaire/Profile – Male Student # 3

### Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Not given</td>
</tr>
</tbody>
</table>

1. **Why did you choose engineering as a career?**
   
   **Comments:**
   
   It’s a satisfying career after having too much trouble getting through school.

2. **What are your preferred subjects?**
   
   Math, Physics

3. **What do you like and or dislike about studying mathematics?**
   
   Nothing as long as I am being taught by a good teacher.

4. **Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.**
   
   Solving new Q’s are better for me cause I can remember the lesson and not forget it easily

5. **Do you do much maths and or problem solving in other subject areas?**
   
   Sometimes in Physics, rarely in chemistry

6. **Did you learn much maths by doing research projects?**
   
   Not really much, but new information.

7. **Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain**
   
   First alone then if I give up on a few questions then I can ask other students to help me

8. **Do you think your teacher is competent? Are all the students in your class**
   
   The teacher is ..but some students aren’t, not because they are mentally weak, but because of skipping class.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>Both!!</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?</td>
<td>Yes, I enjoy it…</td>
</tr>
</tbody>
</table>

**General Comments:**

Good luck = D
**Appendix 10.2.4– Questionnaire/Profile – Male Student # 4**

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Not given</td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?
   - **Comments:**
   - Because I like that career and I make me to think and depend on mind to solve problem.

2. What are your preferred subjects?
   - **Math** because it depend on understanding

3. What do you like and or dislike about studying mathematics?
   - I like too much and I can be understood easily. No disliking.

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.
   - Two to copy but with explaining it before then I solve in front of my teacher

5. Do you do much maths and or problem solving in other subject areas?
   - Yes in Physics and chemistry

6. Did you learn much maths by doing research projects?
   - No nothing, they don’t really help me at all.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain
   - I use two ways sometimes alone and sometimes with group.

8. Do you think your teacher is competent? Are all the students in your class competent?
   - Yes.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>Teacher because he is great and prepare before he come to lesson, so I think he do a lot of works same like student</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he / she runs the class?</td>
<td>Yes, he ask questions and allow us to solve and show him the answer. I love that way and that makes me to be good in Math</td>
</tr>
</tbody>
</table>

General Comments:
Thanks Grame ☺️
Appendices

Appendix 10.2.5– Questionnaire/Profile – Male Student # 5

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Not given</td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?  
Comments: 
Because I like that career.

2. What are your preferred subjects?  
Math.

3. What do you like and or dislike about studying mathematics?  
Basic math I like it.

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.  
Yes

5. Do you do much maths and or problem solving in other subject areas?  
No I dont

6. Did you learn much maths by doing research projects?  
No I didnt.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain  
Group. Because it help each other.

8. Do you think your teacher is competent? Are all the students in your class competent?  
Yes.
9. Who works the hardest in your lessons (you or the teacher)? Explain

| Of course me |

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

| 1. Yes, he does.  
2. Yes I do |

General Comments:
Appendix 10.2.6– Questionnaire/Profile – Male Student # 6

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Not given</td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?  
   Comments:  
   Because I like the job of engineers.

2. What are your preferred subjects?  
   Chemical subjects

3. What do you like and or dislike about studying mathematics?  
   I like basics.  
   I dislike the calculus course

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.  
   Solve new problem in math lessons because I can learn more

5. Do you do much maths and or problem solving in other subject areas?  

6. Did you learn much maths by doing research projects?  
   No.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain  
   Group because we can learn more.

8. Do you think your teacher is competent? Are all the students in your class competent?  
   Our teacher is competent.  
   Also we.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>The teacher.</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you</td>
<td>Yes.</td>
</tr>
<tr>
<td>like the way he/she runs the class?</td>
<td>Yes we like the way he taught</td>
</tr>
</tbody>
</table>

General Comments:
Appendices

Appendix 10.2.7– Questionnaire/Profile – Male Student # 7

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td>Not given</td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?

**Comments:**

Because it's a wonderful and challenging career.

2. What are your preferred subjects?

English, Math, Computer and Chemistry

3. What do you like and or dislike about studying mathematics?

The precalculus but I like the calculus

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.

Yes because the teacher gives us examples which are more easier than the book and we can learn from this experience

5. Do you do much maths and or problem solving in other subject areas?

No.

6. Did you learn much maths by doing research projects?

Yes.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain

HW sheets alone because it helps me to depend on myself and any question that I don't know how to solve I will ask the teacher next day.

8. Do you think your teacher is competent? Are all the students in your class competent?

Yes, all of them. Also we.
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>Teacher, because the teacher try his best for us to understand the lesson and he wants us to pass the course.</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?</td>
<td>Yes.</td>
</tr>
<tr>
<td>General Comments:</td>
<td>No comments</td>
</tr>
</tbody>
</table>
## Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anon</td>
<td>Precalculus 1</td>
<td></td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?
   **Comments:**
   I chose it because it's the best job in my mind its good from benefits and salary. I liked it because I can help others and moves and work not a desk job.

2. What are your preferred subjects?
   Maths & physics

3. What do you like and or dislike about studying mathematics?
   I like solving problems and equations the contain graphs

4. Do you prefer to copy teacher examples or solve new problems in math lessons?
   Yes, because it will help me in the exam or the quiz

5. Do you do much maths and or problem solving in other subject areas?
   No

6. Did you learn much maths by doing research projects?
   No.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group?
   Alone, makes me independent, besides taking responsibility alone, not to blame anyone but myself.

8. Do you think your teacher is competent?
   Students are hopeless in class.
9. Who works the hardest in your lessons (you or the teacher)? Explain

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>I work harder because I have to learn new things. The teacher is</td>
<td>repeating what he already knows.</td>
</tr>
</tbody>
</table>

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, he allow everybody to have a share in the lesson. He definitely runs the class perfectly</td>
<td></td>
</tr>
</tbody>
</table>

**General Comments:**
Mr. Graeme is an outstanding teacher! He has a real strong feedback of the subject. I like the way he teaches besides he is so fair to us. I wish every maths teacher is the same as Mr Graeme. In honest words he is the best maths teacher of all, he made me like the subject!
### Teaching Mathematically Research Questionnaire
#### Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>No need 😊</td>
<td>Foundation 2</td>
<td>Not yet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
</table>
| 1. Why did you choose engineering as a career? | Comments:  
- makes good money!  
- have the best jobs |
| 2. What are your preferred subjects? | English, maths, biology |
| 3. What do you like and or dislike about studying mathematics? | Mathematics makes my brain work properly, besides it makes me alert. I dislike Mr. Ward’s homeworks. |
Usually the teacher explains every dialect in the subject, so why bother solving new problems while you got enough examples. |
| 5. Do you do much maths and or problem solving in other subject areas? | Yes, in Physics.  
I hate it. |
| 6. Did you learn much maths by doing research projects? | Not really.  
I learn mostly from teacher's examples |
| 7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain | Of course with group because working with group we will have less mistake. |
| 8. Do you think your teacher is competent? Are all the students in your class competent? | I strongly think is the teacher competent.  
Not all of them. |
9. Who works the hardest in your lessons (you or the teacher)? Explain

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>Teacher -</td>
</tr>
</tbody>
</table>

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?</td>
<td>He allow all of the students and his way is really fine and nice.</td>
</tr>
</tbody>
</table>

General Comments:
# Appendix 10.2.10 – Questionnaire/Profile – Male Student # 10

## Teaching Mathematically Research Questionnaire Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ali Obaid</td>
<td>Foundation 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you choose engineering as a career?</td>
<td>Comments: Because I like creating machines</td>
</tr>
<tr>
<td>2. What are your preferred subjects?</td>
<td>Mathematics</td>
</tr>
<tr>
<td>3. What do you like and or dislike about studying mathematics?</td>
<td>I like calculating numbers and graphing formulas.</td>
</tr>
<tr>
<td>4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.</td>
<td>Yes, because as an engineer I have to improve my skills</td>
</tr>
<tr>
<td>5. Do you do much maths and or problem solving in other subject areas?</td>
<td>Yes, I do.</td>
</tr>
<tr>
<td>6. Did you learn much maths by doing research projects?</td>
<td>Yes, I do.</td>
</tr>
<tr>
<td>7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain</td>
<td>I prefer to do it in group because working in numbers is more difficult than words. So there are a lot of mistakes.</td>
</tr>
<tr>
<td>8. Do you think your teacher is competent? Are all the students in your class competent?</td>
<td>Yes, I think my teacher is competent. No, I think not all student are competent.</td>
</tr>
</tbody>
</table>
9. Who works the hardest in your lessons (you or the teacher)? Explain

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think the teacher is hardest because he solve as many as he can.</td>
<td></td>
</tr>
</tbody>
</table>

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, he do.</td>
<td></td>
</tr>
<tr>
<td>Yes, I do.</td>
<td></td>
</tr>
</tbody>
</table>

**General Comments:**
Appendix 10.2.11– Questionnaire/Profile – Male Student # 11

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>anon</td>
<td>Foundation 2</td>
<td></td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?  
   **Comments:** Because it’s the only career that I have a basic information, and because I study engineering in the last three years.

2. What are your preferred subjects?  
   I like Math and sometimes chemistry

3. What do you like and or dislike about studying mathematics?  
   I like solving equations when I know the main information. I didn’t like when I solve a equation with unknown formula.

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.  
   Yes I like to copy what the teacher wrote on the board because it make the studying easier for me more than study in the book.

5. Do you do much maths and or problem solving in other subject areas?  
   Of course we use the math equation in physics but I use it also at home for solve a few problems.

6. Did you learn much maths by doing research projects?  
   Yes in my last few years I did a lot of projects of math and I didn’t forget the information because I remember the projects.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain.  
   I like doing a group work because we can help each other and discuss questions together.

8. Do you think your teacher is competent? Are all the students in your class competent?  
   The teacher makes the students compete together by making a question sheet with time and …..
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>The teacher because he solve a lot of questions and more than one time.</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he / she runs the class?</td>
<td>Yes.</td>
</tr>
</tbody>
</table>

**General Comments:**
### Appendix 10.2.12– Questionnaire/Profile – Male Student # 12

**Teaching Mathematically Research Questionnaire**  
**Mathematics Students**

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>anon</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you choose engineering as a career?</td>
<td>Comments: Actually since 1997 and am in love with electricity. And also once I was playing football in the house and I broked a light, I try to fix it and finally I did and I said to myself I will be an engineer.</td>
</tr>
<tr>
<td>2. What are your preferred subjects?</td>
<td>Mathematics</td>
</tr>
</tbody>
</table>
| 3. What do you like and or dislike about studying mathematics?           | Like – 1. Its subjects are clear and easy  
                                                                   2. I have to think clearly and deeply about an equation or something like that  
                                                                   3. Using a calculator all the time approximately.  
Dislike – 1. The book’s weight, I have a lot of Subjects.  
                                                                   2. Sometimes the questions are complicated |
<p>| 4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain. | In fact, copying teacher examples is good, but solving new problems is the best way to open your mind and have great ideas. |
| 5. Do you do much maths and or problem solving in other subject areas?   | Actually, No. Because there is no time to do it if you have another subjects                                                             |
| 6. Did you learn much maths by doing research projects?                  | No, in my opinion this is the worst way if you try to learn mathematics.                                                                     |
| 7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain | Projects and HW sheets. Its very helpful because I try to produce new ideas and I do my best                                               |
| 8. Do you think your teacher is competent?                               | No                                                                                                                                              |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are all the students in your class competent?</td>
<td></td>
</tr>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>The teacher of course. He give us a homework sheets and help us to solve it together.</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?</td>
<td>Yes, yes.</td>
</tr>
</tbody>
</table>

**General Comments:**
# Appendix 10.2.13 – Questionnaire/Profile – Male Student # 13

## Teaching Mathematically Research Questionnaire

**Mathematics Students**

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>anon</td>
<td>Foundation 2</td>
<td></td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?

   **Comments:**
   - Because engineering has a good salary.
   - Because I want to put my new idea to improve the company.

2. What are your preferred subjects?

   Geo science

3. What do you like and or dislike about studying mathematics?

   I like everything only the graph

4. Do you prefer to copy teacher examples or solve new problems in math lessons?

   I like to copy teacher example

5. Do you do much maths and or problem solving in other subject areas?

   No

6. Did you learn much maths by doing research projects?

   Yes.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group?

   I like to do projects and HW sheets with a group

8. Do you think your teacher is competent? Are all the students in your class competent?

   For the teacher yes
   For the student no
9. Who works the hardest in your lessons (you or the teacher)? Explain

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher.</td>
<td></td>
</tr>
</tbody>
</table>

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes.</td>
<td></td>
</tr>
</tbody>
</table>

**General Comments:**
Appendix 10.2.14—Questionnaire/Profile – Male Student #14

Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>anon</td>
<td>Foundation 2</td>
<td></td>
</tr>
</tbody>
</table>

1. Why did you choose engineering as a career?
   - Comments:
     - Because I think I can think like an engineer.
     - Some of my brothers are engineers.
     - It's my ream from the child.

2. What are your preferred subjects?
   - Math, Physics

3. What do you like and or dislike about studying mathematics?
   - I like the class work and I dislike the large amount of homework.

4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.
   - Both, I copy the teacher examples then I solve new problems in the same way the teacher did.

5. Do you do much maths and or problem solving in other subject areas?
   - Yes

6. Did you learn much maths by doing research projects?
   - No.

7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain
   - Part of a group, it makes the work easier and help the whole group to understand the HW

8. Do you think your teacher is competent? Are all the students in your class competent?
   - Yes.
9. Who works the hardest in your lessons (you or the teacher)? Explain

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Me.</td>
<td></td>
</tr>
</tbody>
</table>

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes I do.</td>
<td></td>
</tr>
</tbody>
</table>

General Comments:
## Appendix 10.2.15 – Questionnaire/Profile – Male Student # 15

### Teaching Mathematically Research Questionnaire
Mathematics Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>Engineering degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmed</td>
<td>Foundation 2</td>
<td>Petroleum</td>
</tr>
</tbody>
</table>

#### 1. Why did you choose engineering as a career?

**Comments:** Due to Engineering is currently one of the most well paid and respected professions.

#### 2. What are your preferred subjects?

Mathematics and Chemistry

#### 3. What do you like and or dislike about studying mathematics?

I like algebra as well as geometry ut with no graphing involved

#### 4. Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.

Copy teacher’s examples because you use his methods of solving to understand firmly and then implement them in other problems.

#### 5. Do you do much maths and or problem solving in other subject areas?

Yes.

#### 6. Did you learn much maths by doing research projects?

Not much.

#### 7. Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain

Alone, I concentrate more and makes me think because in a group I might depend on others when I am lazy.

#### 8. Do you think your teacher is competent? Are all the students in your class competent?

My teacher is competent as well as my classmates but some are lazy but still competent.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Who works the hardest in your lessons (you or the teacher)? Explain</td>
<td>Teacher, a he explains solves as well as he makes sure we understand and sometimes repeats lot to make sure we understand.</td>
</tr>
<tr>
<td>10. Does your teacher allow all students a share of the lesson? Do you like the way he / she runs the class?</td>
<td>Yes, and lets everybody work so no one comes lazy and gets the momentum of the class moving.</td>
</tr>
</tbody>
</table>

**General Comments:**


### Appendix 10.2.16– Questionnaire/Profile – Male Student # 16

#### Teaching Mathematically Research Questionnaire

<table>
<thead>
<tr>
<th>Mathematics Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
</tr>
<tr>
<td><strong>Program</strong></td>
</tr>
<tr>
<td><strong>Engineering degree</strong></td>
</tr>
</tbody>
</table>

1. **Why did you choose engineering as a career?**
   - Comments: Engineering is including in everything, beside they get high salaries.

2. **What are your preferred subjects?**
   - Physics and Math

3. **What do you like and or dislike about studying mathematics?**
   - I like the implement of math.
   - I dislike homeworks in weekend.

4. **Do you prefer to copy teacher examples or solve new problems in math lessons? Explain.**
   - Both because I can't solve new problems without referring to the teacher examples.

5. **Do you do much maths and or problem solving in other subject areas?**
   - If it is necessary, yes.

6. **Did you learn much maths by doing research projects?**
   - Sometimes, yes.

7. **Which do you prefer – doing projects and HW sheets alone or as part of a group? Explain.**
   - I like alone, because if I work with group I get a lot of time wasted.

8. **Do you think your teacher is competent? Are all the students in your class competent?**
   - The teacher is competent.
   - The students are no all competent.
9. Who works the hardest in your lessons (you or the teacher)? Explain

The teacher, because he is keeping to explain the lesson although we didn’t give attention.

10. Does your teacher allow all students a share of the lesson? Do you like the way he/she runs the class?

Yes, yes

General Comments:

I hope to work more in implementing of math.
Appendix 10.3– Student-Centered Contextual research project

Case # 1

You are part of the design team investigating ADOIL’s plan to connect its two newest wells - Offshore-93A and Onland-774 - to its main feeder pipeline.

The shortest distance from each well to the pipeline is Offshore-93A ..(a)..km and Onland-774 ..(b)..km, which gives a separation of ..(c)..km along the main feeder pipeline, but you have been instructed to minimize costs by connecting each new pipeline to the same point on the main feeder line.

Your team is to conduct its research from 3 perspectives.

1. Minimize the total size (length) of the new pipelines to be built from each well to the main feeder pipeline.

2. Minimize the cost of the new pipelines to be built from each well to the main feeder pipeline given that it costs ..(d)..<times as much to build a pipeline under water than it does over land.

3. Minimize the average time taken to pump oil from each well to the main feeder pipeline given that the offshore pipeline must run up hill and estimated average flow speed would be ..(e)..<m/s compared to ..(f)..<m/s in the over-land pipeline.

In addition to giving mathematical solutions to these three problems you are also instructed to explain your answers in detail, including any strengths or weaknesses you see in each solution.

Your discussion should include all logistical, cultural and environmental issues that come up in your discussions with other team members or members of the public.
Case # 2

You have just received the latest report from ADOIL’s geo-survey team on a new gas-oil field underlying the western desert at the edge of the main sea.

Geometric modeling using seismic data approximates the oil reservoir to be cylindrical in shape and situated in stone that is ..(a)% porous. This ‘cylinder’ has a radius of ...(b)… km and lies at a depth of ...(c) …m to a final depth of ...(d) …m.

The gas reservoir exactly caps the oil cylinder and is hemispherical in shape. It appears to be completely eroded and is a hollow dome - except for the gas it contains.

Directly below the oil reservoir in layers of stone that are ..(e)% ..porous, is a cone-shaped reservoir of fresh water. The water begins directly below the oil and extends down another ...(f)…m

Your team is to give an inventory of the gas, oil and water reserves in this field.

1. Calculate the approximate volume of oil in the reservoir.
2. Calculate the approximate volume of oil in the dome.
3. Calculate the amount of fresh water available below the oil.

Case # 3

You are part of the research team responsible for optimizing extraction of gas, oil and water from the above gas-oil field.

Initial plans are to drill directly down to tap the gas dome and to drill two angular wells from the same point to tap into the top and the bottom of the oil reservoir.

It is speculated that a fourth well could be drilled from the sea side of the field to later pump in sea-water when the field pressure drops or oil levels fall. This hasn’t been decided yet as many team members feel the fresh water should be extracted rather than wasted.

1. Calculate the length of pipe required to tap the gas dome.
2. Given the minimum angle of depression is ...(a)… for angle drilling calculate;
   (i) the closest position to the field that the drilling can take place.
   (ii) The total length of pipe needed to tap both ends of the oil reservoir.
Case # 4

Your team is to investigate the fresh water issue. Initial analysis indicates that the water is only ...(a)%... saline on average and could be used for drinking and irrigation of the local area.

One idea is to drill on an angle and tap the water reservoir ...(b)... m from its lowest point. This would avoid interfering with the gas and oil but would be expensive to drill. However, the natural weight of the oil and water reserves should generate enough pressure to provide a flow of water.

1. Given that pressure is directly proportional to depth, \( P = kd, \) approximate the pressure on the water at the lowest point given that probes indicate a pressure of ...(c)... at depth ...(d)... m.

2. List all the factors you can think of which would contribute to the proportionality constant \( k \).

3. List any problems you can foresee to the whole project by tapping this water.

If your colleagues decide to eventually flood this water supply with sea water to maintain internal pressure it would eventually change in composition. This creates two questions

a) How much sea water will make this ‘fresh’ water too salty to use?

b) How long will it take before the water is too salty?

4. Given this water is considered pure and sea water is ...(e)% saline how much sea water will it take to make this supply unusable ...(f)% saline?

5. Given the sea water will mix with the fresh water at a rate of ...(g)% ML per day, how long will it take for the two waters to be completely mixed?

Data Sheet:

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<th>Team # 2</th>
<th>Team # 3</th>
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Case # 3  Team # 1  Team # 2  Team # 3  Team # 4
(a)

Case # 4  Team # 1  Team # 2  Team # 3  Team # 4
(a)
(b)
(c)
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