CHAPTER 5

TECHNOLOGIES OF POWER: THE RECONTEXTUALISING FIELD

Curriculum and the Conditions of Teachers' Work

5.1. INTRODUCTION

The conditions of students' learning are inextricably related to the conditions of teachers' work. In this chapter I draw upon the work of Basil Bernstein for further theoretical perspectives on the Australian case study presented in chapter 4. I then relate these to broader aspects of teachers' work in the Australian VET sector in terms of the institutional constraints placed upon their professionalism.

5.2. VOCATIONAL MATHEMATICS CURRICULUM

Thomas Popkewitz (1997) argues that curriculum is a practice of social regulation, historically formed, inscribing systems of reasoning which are the effects of power, shaping and fashioning interpretation and action. Curricula not only regulate what content is selected, but also the construction of the student's 'self,' particularly in relation to labour market training (Farrell, 1999, 2000; O'Connor, 1994). Drawing on Foucault and feminist theories, he claims that the concept of an 'educated person' has shifted according to social and political conditions: teachers and students are re-visioned "as objects that are systematically classified, legislated, standardized and normalized" (Popkewitz, 1997, p. 148). Thus, curriculum and other policy documents should be read as expressions of classification of social problems and practices deployed to overcome them. How has vocational mathematics served to reproduce social relationships?

In Australia, since the late 1980s there has been a shift in control over school and VET curricula towards meeting the perceived needs of the economy (Marginson, 1997). Over a decade ago, Fitzclarence and Kemmis (1989) made the observation that there had been changes in the social relationships of education, not confined to the new communication technologies but also appearing in the technologies of social and educational administration. They argued that this might undermine the very possibility of critical thought. Although the focus of their concern was distance education for Masters students, which they asserted should be able to "offer a theoretical alternative to narrow, consensualist, bureaucratic and technicist approaches to thinking about education" (p. 174), their critique applies equally to the Australian VET sector.

5.2.1. Mathematics Curriculum in the Australian VET Sector

What do TAFE practitioners believe about current mathematics curricula?

> The curriculum is wide open now & students, especially those from industry, prefer to select non-math related subjects & not the hard-core engineering subjects. . . . It is not easy to impress on people the value of mathematics in a technical environment when other soft options are readily available in similar environments. [Male, >5 years TAFE experience]

> Mathematics is not considered important by those responsible for TAFE course design and mathematics testing is a mere formality — a pass means nothing. . . .Mathematics teaching is declining. Electronic mathematics, I-IV was 72 hours each module. Now there is a 40 hour total. [Male, >10 years TAFE experience]

> But it amazes me, here, like I used to work in the Centre for Computing and Information Technology, and there's no maths in their courses. Now they need to know about binary number systems, and so on. They need to know a little bit of Boolean algebra; when they're doing spreadsheets they need to know how to use formulas. [Female, >10 years TAFE experience]

Vocational mathematics content is apparently considered by powerful stakeholders in Australia to be of diminishing importance. Why? How is it that the teaching of vocational mathematics is virtually disappearing from even the most technological courses, such as Electronics, Engineering, and Applied Science? And that which remains becomes 'watered down' to "numeracy" — a subject intended to be taught generically (if at all) with literacy, as and when needed?

Clearly vocational courses are supposed to reflect the needs of the relevant industries as determined by their representative educational advisory bodies, so that certain branches of mathematics are more likely than others to appear in accreditation documents (e.g., calculations for trade areas, Boolean algebra for electronics technicians). Applied mathematical work in the academy and in industry appears to have had minimal effect on the actual content of the majority of Australian VET mathematics subjects which almost inevitably focus on a small subsection of teachable material from the discipline of mathematics, generally located in developments made well before the 20th century. Why did the curricula which were accredited until the last few years of the last century, free from the overwhelming influence that the universities had and continue to have on year 12 (final year), remain so dominated in form by the traditional mathematics education of earlier eras? Why does there appear to be an unquestioning acceptance of the tenet — not supported in the literature — of a fixed hierarchy of mathematical concepts and order in which they are supposed to be learned?

Why have certain generic content areas such as algebra (including concepts of rates of change, maximisation and minimisation) or statistics, even quantitative literacy, which are arguably of universal importance in industry — highlighted in chapter 2 as being of critical importance to workplaces of the future — been precluded for certain occupational groups? Does this reflect a failure to comprehend that many occupations require a broad spectrum of unrecognised — or unrecognisable to the layperson, and indeed some mathematics educators —

mathematical knowledges? Where are the visible signs of the influence of rapidly changing industrial and information technologies burgeoning in the last two or three decades?

Why are students enrolled in personal service industry and creative arts courses, for example, deemed not to need *any* mathematics? Is the diminishing mathematical content, even in technician courses, merely a pragmatic attempt at improving the completion rates? Above all, what consideration is given to the personal, social and civic development of vocational students as people who inhabit a mathematised, increasingly technological world, premised largely on economic goals and characterised by information saturation? Whose views actually inform decisions as to which mathematical content is worth knowing?

The introduction of the National Training Framework and its so-called Training Packages has seen a shift in control mechanisms from accredited curricula (as with the NVMCP framework topic packages) to assessment of outcomes according to sets of industry competency standards. In contrast to other sectors of education, curriculum no longer plays a central role in the VET sector, concomitant with a diminishing role for teachers, as all learning may now, in theory at least, take place on-the-job. With this non-endorsed model of curriculum the locus of power and control has shifted from the teacher — embodying the institution of education — to the 'user' — student or, most likely, employer — thereby making it more difficult to evaluate or to challenge. The question arises: What might be possible reasons for the elision and in whose interests are these changes? Chapter 6 will take up these questions from more theoretical perspectives.

Nerida Ellerton and Ken Clements (1994) have documented evidence of recent struggles over control of school curricula in Australia, especially mathematics. Yet over the last decade, there has been no visible evidence of any contestation by mathematics teachers in the Australian VET sector over mandated CBT curriculum and assessment regimes. One reason for this may be the widely engendered belief, accepted by TAFE teachers, that the curricula represent "what industry wants" (see, for example, Johnstone, 1993).

5.2.2. Goals for Vocational Mathematics Curricula

In the formation of curricula many goals need to be taken into account (Bishop, 1993; Niss, 1996; Stevenson, 1995a); it is not simply a matter of matching the curricula to the perceived needs of the employer which would serve neither the interests of individual students nor society at large (Ernest, 1991; FitzSimons, 1997b). Anna Sierpinska and Stephen Lerman (1996), building on Sal Restivo's case for a strong sociology of mathematics, argue that communities validate themselves, establish and retain power through their justification of socially valued knowledge. They claim that this applies to the investment that mathematicians have in the status of mathematics in society, "and it is certainly the case for mathematics educators and the status given to [school] mathematics curricula all over the world"

(p. 840). What effect might the support of mathematicians have on the public image of vocational mathematics, and with what consequences?

As noted in chapter 1, goals for school mathematics are based on the presuppositions of mathematics being able to make a contribution to the technological and socio-economic development of society at large, to its political, ideological and cultural maintenance, and to individual development (Niss, 1996). I contend that these foundational reasons should not be confined to the needs of school students if one follows the tenets of lifelong education, espoused by many governments, and assumes that adults are continuing to develop throughout their mature years. In any case, there are overlaps in age between Australian VET sector students with senior school and undergraduate students, so that there can be no justification for an abandonment of goals other than industrial ones (Stevenson, 1996, 1997).

Sue Willis (1996), developing the idea of cultural conflict identified, from a social justice perspective, four approaches to curriculum with consequent (re)solutions:

1. The curriculum is taken as more or less given. Students who are not adequately prepared are treated as *remedial*, or regarded as having *skill deficits*, and the solution is to provide assistance for that which is lacking.
2. The curriculum is also assumed as fixed, but pedagogical and assessment practices favour or relate to the experiences, interests, and cultural practices of some social groupings more than others. The proposed solution is to develop *non-discriminatory* practices so that the experiences of all students are recognised in a supportive learning environment with more valid and fair assessment practices.
3. The curriculum is viewed as a selection, neither given nor unchangeable, which reflects the values, priorities, and lifestyles of the more powerful members of the dominant culture, and which acts to produce relative advantage. The solution is to provide curricula which acknowledge, accommodate, value, and reflect the experience of the diversity of social groups, adopting an *inclusive* perspective.
4. A *socially critical* perspective considers the problem to lie with the way the curriculum positions, classifies, and selects students, in the interests of reproducing the status quo. The solution is to challenge the hegemony in a way that is recognised by all participants. This means helping students to understand and exploit the explicit uses of mathematics in their own interests and in the interests of social justice, as well as the problematic uses of mathematics curriculum.

Following Willis's analysis, the first perspective could describe TAFE vocational mathematics since the inception of the TAFE sector, at least, in its provision of remedial tuition and access programs. The second perspective could be related to the history of technical education in Australia which has traditionally favoured masculine interests, as have mathematics curricula — especially in view of their close connection to the trades and technologies. Encouraging the use of vocational applications probably renders an appearance of non-discrimination and

hence gender neutrality since the curriculum is supposed to reflect the students' perceived vocational interests. However no other social interests are seriously addressed — as is the case in some other subjects such as basic computing (e.g., Australian Committee on Training Curriculum [ACTRAC], 1994) — and vocations themselves may be inherently gendered, racist, ageist, and so forth.

The third perspective could be related to the past as well as recent vocational curriculum selection which reflects the dominance of powerful industry representatives who sit on advisory bodies, and the consequent privileging of industrial values over all others. In terms of mathematics it means privileging the traditional school mathematics experienced by predominantly male industry spokespersons (Willis & Kenway, 1996). ("It was good for me, so . . ."). There has been a failure in Australia to problematise either the relevance to current industry practices or the unequal distribution of access to rewards in the form of mathematics-linked credentials. On the other hand, the proposed solution of inclusivity has long been espoused by the ACFE sector (see FitzSimons, 1997a, 2000d) and some TAFE preparatory courses with few or no externally imposed restrictions on content, assessment, and/or pedagogy. Notably, the latter, unregulated courses have all but disappeared in the current political and economic climate of accountability.

The fourth, socially critical, perspective appears antithetical to the thrust of the training reform agenda which, as illustrated in chapter 4, appears to desire a compliant, self-regulating workforce.

The question may be asked: "What are the goals and purposes of vocational mathematics instruction and whose are they?" In senior secondary school, where mathematics becomes an optional subject, the focus would appear to be on achieving a credential as a prerequisite to further study, sometimes employment, and as a general tool for other areas of study. In this environment the emphasis is on the discipline of mathematics itself, with applications usually included to provide some motivation. By contrast, mathematics in the vocational education sector, when identified as such, is usually compulsory; therefore it is essential for completion of the desired course of study and hence achievement of the credential. Its inclusion in a course of study is ostensibly on the grounds that it will be useful as a tool on the job if not in other subject areas (ACTRAC, 1993). However, Corinne Hahn's (2000) study of jewellery apprentices problematises this assumption. Similarly there appears to be a belief that learning mathematics (any mathematics) will enhance higher order thinking skills — this is not necessarily a valid assumption either. Certainly worker/students have strong opinions (often expressed in graphical language!) as to the usefulness or otherwise of the content and processes of vocational mathematics subjects in actual practice. Although the intended emphasis is on the utility of mathematical applications, it is not uncommon to find an ambiguity of purpose between mathematics as a means to an end and mathematics as an end in itself. Personal experience suggests that, contrary to popular belief, it is

INTRODUCTION

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THEORY AND PRACTICE OF MATHEMATICS EDUCATION FOR ADULTS

Our world is dominated by technological developments: The philosopher Heinz Hülsmann wrote that "Atom, Gen and Bit" are the three basic principles now (see Hülsmann, 1985). Each of the so-called new technologies is based upon mathematics: The first computer was built as a part of the Manhattan Project to calculate models of the atomic bomb. The human genome project uses computers very often to find out the structure of the genome. And computers are mathematical machines, materialised mathematics.

Social organisations, companies, and not least governments use computers to process information. A precondition for this is to formalise the social or economical structure which "produces" the information. This formalisation is a type of mathematisation, too. The social and economical models of organisations or companies are a part of the process of mathematising the world.

Last, but not least, mathematics is a part of everyday life and work. People handle money, buy things, do handywork at home (measure areas to paint, and so on). All together, mathematics is not only the basis for technology, economy, work and everyday life, but a part of our culture.

It seems clear that everyone in our society should know more about this. Learning mathematics in the traditional way is not enough. But the tendency in school (enforced by many governments) is not to learn more and different aspects of mathematics (for example, modelling or statistics) but to learn less. Research in many countries shows that people forget most of the algorithms they learned at school. They are left with the feeling that mathematics is useless. And they do not like mathematics because they remember a lot of bad situations at school.

Mathematics education for adults is very important in this situation. Mature people have to learn what they did not learn at school or what they need to get a (better) job. Younger people would like to reach higher formal qualification levels in order to have better chances in life. And all people (as citizens) should know much more about mathematics in our society. This is not only helpful to get more money or a better job but also to have more chance of taking part in political discussions. Democracy depends upon understanding the world we live in.

Mathematics education for adults should not repeat the past mistakes of school teaching. Adult learners have different knowledges and different abilities. In most mathematics courses or open learning situations adults should primarily get the feeling that this is not a repeat of the typical school situation that served them badly in many cases. New and better ways of teaching are necessary.

It is a very important task for all teachers to find such new ways. Good mathematic educators find such ways. But only a very few of these good teachers start to communicate about their ways of teaching. There is very little literature about good ways of teaching mathematics for adults.

We think that there are several reasons for this:

- In many countries teaching mathematics for adults is not a primary occupation but an additional job for people with other formal positions such as engineer, teacher at school, university students or even literacy teachers.
- Only a very few teachers reflect on their work as researchers and then document it for the sake of others. This would be additional and unpaid work for them.
- Only a very few university mathematics educators are working in the area of mathematics education for adults. Most of them are only concerned with teaching at school.

Dr. Gail FitzSimons is a very positive example of a teacher who has started to reflect on this situation. She has published many papers on its different aspects, and this book gives a very good overview. It shows the actual status of international discussion, giving a detailed analysis of the situation in Australia as an example of the (potential) situation in other countries with similar political orientations. In short: Everyone who starts working in and thinking about the field of adults learning mathematics should read this book.

REFERENCE

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CHAPTER 1

WHAT COUNTS AS MATHEMATICS? INSTITUTIONS AND IMAGES

1.1. INTRODUCTION

In considering what counts as mathematics, in this chapter I consider understandings from a variety of perspectives, necessarily partial, with respect to mathematics and to mathematics education. I frame these within the concept of institution, attending to patterns of social conduct and value, norms and rules, embodied within everyday activities. In so doing I am attempting to elucidate what it means to think and work mathematically — with particular reference to the workplaces of the technologically-developed world. In this context, I also explore the somewhat contentious issue of mathematics and its relation to numeracy.

Morris Kline (1979a, p. v) asserts that there are many facets to the discipline of mathematics, which he claims is "limitless in extent and depth, vital for science and technology, and rich in cultural import." He recognises that in compulsory education at least that it may be presented in a dull manner, limited in the range of mathematical values presented. Instrumentally, the subject of mathematics is likely to be perceived by many students and teachers as a series of techniques illustrating *what* can be done and *how* this might be done rather than as a subject calling for reflection (Bishop, 1988).

The formal activity of learning mathematics at any stage of life is intimately bound up with the identity of the learner. Yet, public opinion is generated on a wide variety of issues not necessarily experienced, or even thoughtfully considered, by individuals (Vanderburg, 1988). As a consequence the public image of mathematics itself has many facets. Decisions concerning mathematics in adult and vocational education are made by a variety of stakeholders, coloured by personal and public opinions which may be quite distant from those of academic mathematicians or professional mathematics educators — and even these may not be in accord one another (Sierpinska & Kilpatrick, 1998). So, how is mathematics to be understood?

1.2. THE INSTITUTION OF MATHEMATICS

Every person of school age or over, in communities with so-called universal education, has come into formal contact with mathematics and formed opinions, consciously or unconsciously, about the nature of mathematics. Opinions are not only formed in the cognitive domain but also, often very powerfully, in the affective domain (FitzSimons, 1994; McLeod, 1992), interacting at the meta-level (Hannula,

2000; Schlöglmann, 2001). I will utilise the concept of institution in order to explore understandings of the discipline of mathematics from a variety of perspectives.

According to John Abraham and Neil Bibby (1988, p. 4) the discipline of mathematics "cannot be completely understood without some understanding of the social institution of mathematics." The concept of *institution* attends to patterns of social conduct and value; rules and procedures provide coherence and meaning to everyday activities and are embodied in regularised patterns of behaviour, specific vocabularies and particular roles (Popkewitz, 1988). Also recognised is the importance of human actions and commitments which have given rise to major developments in mathematics, as well as the role mathematics plays in the social structuring of thoughts and actions. In what follows I will be considering: (a) the social structuring roles, (b) the practices of mathematics, and (c) the relationships between knowledge and power and the discourse of mathematics.

Mogens Niss (1994) outlines four perspectives on the concept of mathematics as a discipline. As a *science*, in an epistemological sense, it may be oriented towards the domains of mathematical entities (pure mathematics) or towards extra-mathematical areas (applied mathematics). The difference between the two is in the focus rather than the content matter. As a system of *instruments*, in products as well as processes, it can assist in decision-making and actions, thus providing *tools* for a wide range of social practices and techniques. As a field of *aesthetics* it is capable of giving experiences of beauty, joy and excitement to many. Finally it is also a *teaching subject* in the educational systems of societies. Teaching in the vocational education sector demands an interrogation of instrumental uses of applications, yet cannot overlook its aesthetic side. (Simone Weil, sister of mathematician André Weil, argues that work itself should have an aesthetic dimension, according to Gary Lewis, 1988; see also Richard Bagnall, 1997.) Within the academic purview at least, the instrumental uses are founded upon the epistemological science of mathematics. By contrast, as will be discussed in chapter 2, in the workplace and the community a more pragmatic approach to 'what works here under these circumstances' may be adopted.

Jean-Pierre Kahane (1998, p. 83) observes that, unlike other sciences, mathematics is not defined by its subjects in nature or society. ". . . mathematics acts on notions coming from different fields, generalizes, simplifies, purifies, makes a theory out of them, with mathematical definitions and deductions. Then and only then are these notions available to the unexpected." This is particularly pertinent to the workplace in dealing with the non-routine problems which arise continually over time and space.

Kline (1979a) asserts that, historically, the prime value of mathematics has been that it has enabled the answering of questions about the physical world, the comprehension of the operations of nature and the dissipation of much of the mystery of life. In his opinion the supreme value is the revelation of order and law from apparent chaos; although he later acknowledges (1987) the fallibility of human construction of rational designs based upon increasing factual knowledge of the physical world. Kline (1979a) also makes reference to the concept of aesthetics, including the mathematical branches of number theory and projective geometry —

the former may be linked to information technology; the latter is illustrated in subsequent readings to be of direct relevance to the vocational area of art and design.

Other mathematicians are even less modest about their discipline, as evidenced by an Australian discipline review (National Board of Employment, Education and Training [NBEET], 1995b) which proclaims:

> Mathematics is the study of measurement, forms, patterns, variability and change. It evolved from our efforts to understand the natural world. . . . Modern mathematical science is a supreme creation of the human intellect; it is also critical for economic competitiveness, and a basis for investigations in many fields. (p. ix)

This 'supreme creation' nevertheless had humble and pragmatic beginnings.

1.2.1. Historical Aspects of Mathematics

From archaeological studies of Egypt and Mesopotamia, James Ritter (1989) asserts a close, symbiotic relationship between mathematics and writing, based on the need to measure, divide and distribute the material wealth of societies. Without writing, the limitations of human memory limited the degree of numerical sophistication. Conversely, material needs, particularly the need for record keeping, were central to the development of writing. Ritter observes that no word for "mathematician" existed in these ancient languages. Rather, there were scribes who could become mathematics teachers or work as accountants — to calculate work, rations, land and grain.

George Joseph (1990) traced the spread of mathematical ideas through the ages across the Asian and African continents in an attempt to overcome the legacy of Eurocentrism — the dominance of Europe and its cultural dependencies — over the last 400 years as manifested in the historiographically biased accounts of mathematical activity. In a similar manner, Mary Harris (2000), Valerie Walkerdine (1994), and Margaret Wertheim (1997), among others, have highlighted some of the barriers erected to suppress, even prohibit, women's participation in mathematics in European cultures, together with the ongoing resistance to recognition of their achievements — only somewhat ameliorated in recent decades. This will be discussed further below under the section on the institution of mathematics education.

There is not one single mathematic, absolute and infallible (Davis & Hersh, 1980/1983; Ernest, 1991; Kline, 1980, 1987) but rather a plurality of mathematics which operate on a pragmatic basis, linked to time and place. The discipline of (abstract) mathematics emerged from a codification of sets of arithmetic and geometric problems. A more important step was the ability to state general rules for solving problems of a particular type, and a further step was to arrange these problems so that they could be treated in more general and abstract terms (Restivo, 1992). Thus Sal Restivo claims that academic mathematics as we know it evolved through the confluence of certain socio-cultural conditions, such as the rise of commerce, the need for time-saving devices such as algorithms, as well as the spread of printed material — all underpinned by ceaseless competition among

mathematicians, but with a generational continuity. As Restivo observes: "The nature and availability of organizational and material resources can change the organizational structure of mathematics" (p. 87). The work of Otto Spengler (1926) provides further support for Restivo's (Durkheimian) argument concerning the relationship between ideas and contemporary social conditions, and thus against the notion of context-free formulations and applications. Spengler argued that, rather than progressing through a staged sequence of development, a certain type of mathematical thought is associated with each culture. The two major cultures in Spengler's scheme are Classical and Western. The Classical mathematics of Ancient Greece dealt with number as magnitude, as the essence of visible, tangible units; the Western paradigm of modern Europe, from the 17th century onwards, dealt with number as an object of pure thought, focusing on the concept of function, and thereby liberating mathematics from the boundedness of sensory perceptions.

The history of mathematics used in the work environment indicates that 'Applied' Mathematics has generally been regarded as inferior to its more detached academic counterpart nowadays known as 'Pure' Mathematics (e.g., Jahnke, 1994; Kline, 1980). In many cases its worth was and still is disparaged or ignored, even to the point of being invisible to its users, especially when it comes under the categorisation of numeracy (see, for example, Coben, 2000a). However, as Gibbons et al. (1994) argue, the adequacy of traditional knowledge-producing institutions is being called into question with the emergence of a new mode of knowledge production (see chapter 6).

These brief historical accounts illustrate the dependence of the social construction of mathematics on the social and cultural milieu of the times (see also Davis & Hersh, 1986/1988; Harding, 1998). This complex inter-relationship is particularly relevant to the workplace context where mathematical problems and solutions are continually being generated at all levels of operation, from manufacturing production operator or service worker to management, across all sectors of industry. This is not to say that they are necessarily recognised as mathematical by those involved.

I now focus more particularly on the discipline of mathematics as expressed in the viewpoints of sociologists and others concerned with the interrelationship between mathematics and particular societies and cultures in which it is embedded. This is in order to contribute towards accounting for the immanent, somewhat paradoxical, duality of beliefs and attitudes towards mathematics among members of the public, including vocational students and other relevant political and industrial decision-makers — elaborated later in this chapter.

1.2.2. Sociological Aspects of Mathematics

Sal Restivo (1993) argues that the foundations of mathematics are located in social life, not in logic or systems of axioms; Spengler's theory of mathematics yields a weak and a strong sociology of mathematics. In the weak form attention is drawn to the variety of mathematical traditions across and within cultures, for example ethnomathematics (see D'Ambrosio, 1985/1991). The strong form, in Restivo's

words, "implies the sociological imperative — the idea that mathematical objects are constitutively social" (p. 251): "mathematics are reflections of and themselves worldviews" (p. 253). Restivo makes the further point that it is not mathematicians who manufacture mathematics but it is that mathematical forms or objects, containing the social history of their construction, are produced "*in* and *by* math worlds" (p. 250).

With increasing specialisation and levels of abstraction, the origins of mathematical work and its products become increasingly obscure. In fact, Philip Davis and Reuben Hersh (1986/1988) argue that:

> Each attempt to view mathematics as existing outside of time and human society strips away a layer of meaning and exposes a desiccated kernel. The way in which detemporalization is carried out is precisely by such a stripping process. Detemporalization leads to a naive faith that formal manipulation may be productively and authoritatively invoked in any situation. (p. 200)

They argue further that "abstraction is extraction, reduction, simplification, elimination. Such operations must entail some degree of falsification" (p. 281). They note that in the compression of meaning "one of the reasons why probability and statistics did not flourish until the 17th century was precisely the refusal of people to suffer the loss of the individual" (p. 282). And yet, in the dehumanising effects of the mathematising and computerising of policies and actions which affect individuals: "*What is often not pointed out is that this dehumanisation is intrinsic to the fundamental intellectual processes that are inherent in mathematics*" (p. 283).

As will be discussed in chapter 3, Max Weber observed that the emergence of formal rationality or 'calculability' in social action fostered the development of the rational state; in fact it was one major condition for the rise of modern capitalism (Giddens, 1972). In a striking parallel, Restivo (1993) notes that specialisation, professionalisation, and bureaucratisation are aspects of the organisational and institutional history of mathematics as a discipline. Their effect on the system is to generate closure in the system, which Restivo asserts may be helpful to some degree in facilitating innovation but is ultimately inhibiting of progressive change. The effect on the larger population tends to provoke feelings of exclusion and alienation.

Roland Fischer (1993) provides an explanation for the apparent alienation of people from mathematics on a personal level when he outlines the duality of mathematics as a means and a system:

> mathematics provides a *means* for individuals to explain and control complex situations of the natural and of the artificial environment and to communicate about those situations. On the other hand, mathematics is a *system* of concepts, algorithms and rules, *embodied in us*, in our thinking and doing; we are subject to this system, it determines parts of our identity. This system runs from everyday quantifications to elaborated patterns of natural phenomena to complex mechanisms of the modern economy. (pp. 113-114)

In this duality humans are both subjects and objects of mathematics; the means so created build into a system which then in turn reacts on the person — the relationship between mathematics and computerisation is an example. However, according to Fischer, most people are unaware of the subjective, systemic side of mathematics inherent in humans, thereby allowing the domination of the objective,

CHAPTER 2

TECHNOLOGY, MATHEMATICS, AND INDUSTRY

Mathematics In and For the Workplace

2.1. INTRODUCTION

This chapter will focus on primarily on the role of mathematics in the workplace. Firstly from the perspective of industrial needs it will elaborate on conceptions of the workplace and workplace competence. It will then address technology as it applies to changing notions of the workplace in a knowledge economy. Following this there will be a review of a selection from the literature on the dialogical relationship between mathematics and the workplace. Finally it will address recommendations made by various authors concerning mathematics education which might be applicable to the workplace to meet the needs of adult learners as they participate in, or prepare for, employment — whether it be aiming for an initial qualification, continuing professional development towards advancement or promotion, or even a change of employment.

In a world which is increasingly dependent upon technology there is debate about the roles of explicit and implicit mathematics (as discussed in chapter 1) and the implications for what mathematics may be actually required in the workplace. Analyses reported in this section will suggest that the workplace is characterised by its own discourses which interact with dominant (including mathematical) discourses in different ways. An important aspect is the role of decision-making allied to a need for democratic competence (Skovsmose, 1994). A large majority of adult and vocational students are accorded full rights of citizenship in the broader society, and their democratic participation at work, study-site, community, and home is likely to be enhanced by appropriate mathematics education of the kind described in chapter 1 as *mathemacy*.

2.2. GLOBALISATION

At the start of the new millennium the most salient contextual issue appears to be that of globalisation. In asserting the need to review and analyse the wide-ranging changes resulting from globalisation Keith Forrester (1998, p. 426) quotes Korsgaard's (1997) characterisation of globalisation as "qualitative change towards a system in which distinct national economies are subsumed and re-articulated into the system by international processes and transactions." Yet, although the term

globalisation is frequently used to describe a major influence on our personal, political, and 'professional' lives, it is not something imposed from on high in the Platonic sense. John Wiseman (1998, quoted in Butler, 1998b, p. 5) asserts that choices have been made, within certain restrictions of bounded freedoms, by governments, corporations, communities and individuals to participate in the processes of history-making, at each level up to the transnational.

Globalisation, according to Wiseman, "is the most slippery, dangerous and important buzzword of the late twentieth century." Australia's ready acceptance of globalisation has been supported and informed by ideological shifts towards neoliberalism. In its wake, as will be discussed in chapter 6, education has come to be regarded as a commodified, positional good, subject to an increasingly deregulated quasi training market (Marginson, 1997); it has come to be regarded as a tradeable, personal good rather than a public service. Yet education is imbricated in discourses of global competitiveness — as evidenced in the recent strategic push for lifelong learning in Australia (ANTA, 2000; n.d.-b), the UK and the European Union (DfEE, 1998a, 1998b; EU, 2000).

Forrester (1998, p. 426) claims that understandings of the role and implications of this issue "shape the very nature of the problems and possible solutions available." Accordingly there are calls for new educational designs, new systems of learning, and new ways of thinking about learning. While traditional social and economic problems remain, Forrester asserts that their character, implications, and hence solutions have changed drastically. At the same time the social transformation implied by Ulrich Beck's (1992) notion of the *risk society* — where risks are no longer limited by time or space, but distributed unequally with greater burden on those at the bottom — supports calls for changes in the agenda of adult educators (Jansen & Van der Veen, 1992, cited in Forrester).

In pragmatic terms lifelong learning, especially for young adults but also for other groups regarded as 'at risk,' is proposed by local and global policy makers as a means for them to accumulate social (valued relations), cultural (primarily legitimate knowledge), and economic capital (Bourdieu, 1991). These are deemed necessary for survival in times of rapid change, where high skills approaches to economic development are associated with income equity, and low-skill, low-income jobs tend to migrate to economies with lower labour costs (Kirby, 2000; McKenzie, 1998). But the problem remains to achieve an equitable distribution of scarce educational resources, especially when those more privileged inherently have greater access.

2.3. THEORISATIONS OF THE WORKPLACE

In any discussion of 'the workplace' it must be acknowledged that there is no generic workplace — the term is used for ease of communication and analysis. In the same way there is no generic 'worker' or 'workplace competence.' Each conception of worker, workplace, and workplace competence must be situated, located in time and space, within a specific community of practice with its multiple relationships across social and cultural settings. In this section I wish to

problematise the notions of workplace and globalisation. In the following subsection I will attempt to tease out some of the complexities of workplace competence. Most of the literature appears to be premised on conceptions of full-time paid work but this is not to deny its possible relevance to other categories of labour.

2.3.1. Problematic Representations of Workplaces

Elaine Butler (1998a) observes that the literature on workplaces overwhelmingly represents work as primarily full-time, paid work in the 'official' labour market. Marilyn Frankenstein (1996) outlines several other categories of the labour force which may or may not be included in official statistics (e.g., people already employed but wishing to change their work status, or people discouraged from looking for work). Such omissions in official statistics in addition to the non-market labour in the private or domestic sphere, both productive and reproductive, have ongoing and contested equity implications, according to Butler. At the same time formal categorisations assume a compartmentalisation of (and by?) workers of their knowledges and identities — a notion Butler claims is challenged by poststructuralist and feminist theories as well as discourses of practical politics. Distinctions between public and private spheres are further complicated by considerations of voluntary work, outworkers and home-based employees. In short, she notes that the representation of work, workplaces and workers is multi-layered and deeply problematic; there is no single construct of 'work' or 'workers,' and yet these are treated unproblematically in the discourses of workplace-based learning, and lifelong learning as they are harnessed in support of the economy.

Butler (1998a) observes that workplace learning takes place both in association with, and despite, formal training.

> Workplace learning is not a neutral, a-political activity. Rather, it is about the production, ownership, valuing (or otherwise) and use (or abuse) of knowledges produced by workers and others in the materiality of workplaces, and in their day to day practices of living and working. (p. 90)

In recognising that issues of power and knowledge are central, she concludes with a plea for the voices of the workers/learners themselves be heard in order to temper the unproblematic representation of 'worker' and 'learner' in texts on workplace learning. Similarly, Lesley Farrell's (1996) study of textile workers, menders whose competence was rendered 'invisible' in their workplace, notes that the 'competency' approach which stresses outcomes is in conflict with 'quality' approach which stresses processes; in this case the process was to document and eliminate faults. Elizabeth Buckingham (1997) also draws attention to workers learning when *not* to speak. Much of mathematical competence is also rendered invisible, but in this case under the guise of 'common sense' (e.g., Coben, 2000; Cockcroft, 1982).

Thus, there can be no universal conception of workplace competence, particularly in times of rapid social and economic change. However the term is central to current discourses of vocational education and training. In what follows I will elaborate on general conceptions to be adopted in this monograph, with applicability to manufacturing, service, and symbolic-analytic sectors as they pertain

to vocational education and training in Australia. Although I draw from both European and USA sources, the former predominate because I believe that Australia's population size and economic situation are closer in many respects to some European countries than to the USA.

2.3.2. Workplace Competence

The concept of workplace competence is often taken for granted, but is in fact understood in complex and sometimes contested ways. Per-Erik Ellström (1998) explicates three views encompassing five meanings of the notion of competence. Firstly, *as an attribute of the individual* it may be: (a) formal competence — measured, for example, by years of schooling completed or by credentials received; or (b) actual competence — as the potential capacity of an individual to successfully handle a certain situation or to complete a certain task. This approach approximates human capital theory, but ignores qualitative differences in education and the fact that actual competence also includes "outcomes of work [as well as] a wide range of different, informal, everyday activities" (p. 42). Secondly, *as a job requirement* it may be: (c) officially demanded competence, for example as a basis for recruitment or the setting of wages; or (d) the competence actually required by the job. Official demands may be influenced by demand and supply of qualified people, also professional interests; actual requirements may be unknown due to difficulties and costs associated with job analysis. Both views are actually socially constructed arising from a complex interplay of external (macro) factors (e.g., economic, technological, political) and internal (micro) factors at the level of the company or enterprise (see also Achtenhagen, 1994a). A third, *interactive view* is: (e) of competence in use, as "a dynamic factor mediating between the potential capacity of the individual and the requirements of the job" (p. 43). Whereas previous experience and self-confidence are likely to be important individual factors, the competence that an individual actually uses to perform his/her job is likely to be strongly impacted by "the formal and informal organisation of the workplace with respect to worker autonomy, participation, task characteristics, and feed-back" (p. 43). This last notion of workplace competence is complex and multi-layered. Discussion in this monograph will be premised on the third, interactive understanding of the term competence, and the development of an individual's capacity in relation to mathematics.

In terms of the work an individual performs, Paul Blackmore (1999) differentiates between the terms *role*, *function*, and *skill*, which he asserts collectively contain all formal approaches to occupational analysis. Role analysis is likely to contain a structural and an interactive aspect; to be illuminative rather than seeking an exhaustive description of all aspects. Role is "characterised by a tendency to select ways of working in accordance with circumstances, flexibly and with a willingness to change" (p. 63). It is contrasted with functional analysis which breaks job roles into distinct parts for investigation. Its products are standardised competences, "which would describe the knowledge, skills and understanding necessary for competence in an occupational area" (p. 64). However, Blackmore

doubts whether these can be brought into a single framework; in fact he claims that it is this universality which provokes frequent criticism.

Blackmore (1999) makes several criticisms of the notion of elements of competence as incorporated into the British National Vocational Qualifications (NVQs) — arguably these also apply to competency-based education and training (CBT) in Australia. These are: (a) difficulties in representing excellence — in describing how these qualities will be manifested, and in describing the performance of interlinked activities; (b) the under-representation of underpinning knowledge and understanding — based on positivistic analyses, implying that knowledge is a generalisable and an objective truth; (c) the lack of a developed model of interrelationships between competencies, which also ignores context; (d) the neglect of reflectiveness; and (e) the superficial, if any, attention given to values and principles. "Functional analysis is an attractive tool to anyone who wishes to see social and political relationships, in the workplace and beyond, as unproblematic, ordered and without tensions" (p. 66). It has clearly been an attractive tool in the Australian vocational education and training context (e.g., Johnstone, 1993) both as a technology of management over worker/students and their teachers, also in its contribution to 'rational' curriculum construction.

"Whereas the term 'task' or 'function' refers to the job to be done, 'skills' refers to the human capacities that are required for successful performance" (Blackmore, 1999, p. 67). These are often termed 'generic competenc(i)es,' although Blackmore warns against simplistic approaches to the modelling of human expertise. Transferable skills (and skills of transferring) are a major issue, related to context. Blackmore continues that, in contrast to the functional analysis approach, the skills focus is on process, as individuals develop and access task-specific local knowledge bases; psychological aspects include reflectiveness and reflexiveness. He concludes that the existence of recognised generic skills admits that people do draw on a central repertoire of skills in dealing with a wide range of contexts including novel situations. However, the challenge is to codify the expertise of an occupational area. Importantly, the skill of using mathematical ideas and techniques is included in the Australian key competencies, although its realisation in the current codification practices of CBT mathematics (and other) curricula continues to be problematic. As noted by Gibbons et al. (1994), the requirements for tacit and codified knowledge vary according to the contextual situation, but this is not to deny the importance of a sufficiently strong body of codified knowledge for each worker. However, the content of that codified knowledge is (or should be) an issue for debate in relation to changing work practices, and will be developed further.

Many definitions of competence implicitly presuppose a functionalist, adaptation perspective, defined and evaluated in terms of successful performance of certain given or predetermined tasks. Ellström (1998) claims that this perspective

> fails to recognise the active modification and subjective redefinition of the work task that occurs continuously and with necessity during the performance of a job. . . . In fact, as argued by Norros (1991), operators in many complex production systems are in a certain sense involved in a continuous process of redesigning and improving the system. In contrast to an adaptation view, the developmental perspective strongly emphasises

CHAPTER 3

INTERLUDE

Theoretical Frameworks

3.1. TECHNOLOGIES OF POWER

How are technology and power related? In this section I begin to tease out some theorisations of the term *technology* and its complex interrelationships with *power*. From the *Prelude*, Barnes (1988) comments that, strictly speaking, power should be taken as referring to distributions of capacity, potential, or capability. Technologies of power impact multifariously upon all stakeholders involved in activities of teaching and learning of adult and vocational mathematics: as citizens participate in their social, cultural, and civic activities; as workers and employers labour in the workplace; as students and teachers located in various educational settings teach and learn together; as teachers and their managers as employees of educational (and other) workplaces perform managerial tasks; academics as researchers and teacher educators carry out intellectual and pedagogical work; and as government policy makers, bureaucrats, and educational planning officers legislate for and enact political imperatives.

3.1.1. The Concept of Technology

The concept of *technology* is central to this monograph. Firstly, from an industrial perspective it is integrally linked with mathematics in production in the manufacturing, service, and symbolic-analytic sectors. Secondly, it is utilised as a tool of management, both in industrial settings and throughout the Australian VET sector — although, as will be argued in chapter 6, the education sector itself is being transformed from a public good to a competitive industry. Following the work of Jacques Ellul, George Grant understands technique as "the systematic utilization of the most efficient methods of producing and distributing desired goods" (Andrew, 1988, p. 303); technology is seen as the bringing together of *techne* and *logos* (our making and our knowing). Grant asserts that technology is not a set of instruments, nor a world of things, but rather is a worldview, present in attitudes to things and people, embodied in an integrated system of procedures, languages, and purposes. Minds and bodies are exploited by and attuned to the systematic control of nature. He claims that just as the subject-object split in technological research submerges subjectivity, so values are denied cognitive status in a technological world

predicated upon facts, but return as products of autonomous human will — as standardised and 'ready-made.' These theses resonate with those raised in earlier chapters.

The primary meaning and the publicly accepted interpretation of the Australian post-compulsory vocational education acronym *TAFE* was, and remains, Technical and Further Education — despite numerous attempts to replace it with more politically expedient alternatives. However, in recent years derivatives of the term *technology* have become more prevalent (e.g., Universities of Technology), various adjectivally qualified department and School (faculty) titles (e.g., Engineering Technology), and subject titles (e.g., Biotechnology). There has been a slippage of terminology in the progression from the low-status technical skills and knowledges to technological know-how — reflecting at one and the same time changes to industry sectors in modern society and the perceived need by the education industry for astute marketing of its products.

Andrew Feenberg (1995) argues that technology is one of the major sources of power in modern societies; the power wielded by masters of technical systems largely overshadows political democracy in the control they exert over, inter alia, experiences of employees and consumers. However, rather than accepting a thesis of technological determinism, Feenberg asserts that technology is but one important social variable. He claims that technological determinism draws its force from an attitude that the essence of technical objects lies in their explainable functions. Instead, he suggests that there are two hermeneutic dimensions: their social meaning and their cultural horizon. The first extends beyond the concept of 'goal' which strips technology of its social contexts; the second holds that technological development is constrained by cultural norms — for example, the assembly-line technology of production was specific to a certain form of capitalist economics and social context. According to Feenberg, "social meaning and functional rationality are inextricably intertwined dimensions . . . not ontologically distinct" (p. 12), as 'double aspects' of the same underlying technical object. Functional rationality isolates objects from their original contexts, contributing in an apparently neutral way to what he calls the 'bias' of technology in support of a hegemony. Feenberg continues that modern technology can only be understood against the background of the traditional technical world from which it developed. However, rather than a generic shift, he claims that there has been a significant shift in emphasis of features such as the use of precise measurements and plans, and the technical control over some people by others. Bureaucracy is one example.

3.1.2. Bureaucracy and Rationalisation: The Contribution of Max Weber

The work of Weber relating to the development of rationalisation in Western civilisation offers an insight into the processes of bureaucratisation prevalent in the institution of vocational education and training, in Australia at least. The sector derives its primary political and social importance from the initial preparation and continuing education and (re)training of actual and potential members of the workforce. A secondary but not insignificant role is to provide an alternative,

politically pertinent in statistical terms, activity to the personal void and the public liability of unemployment. In other words, a major but generally tacit goal of governments internationally is to be seen to be minimising unemployment figures. The management of the public funding and educational outcomes for 1.7 million Australian students (approximately 10% of the population), whilst being seen to be responsive to the electorate in general and to industry in particular, requires an efficient and effective bureaucracy.

Anthony Giddens (1972, p. 32) notes that contrary to liberalism and Marxism, a key theme in Weber's writings is "his emphasis upon the independent influence of the 'political' as opposed to the 'economic'." According to Weber, the relationship between democracy and bureaucracy in the modern social order creates a profound source of tension. While the development of democratic government necessarily depends upon the further advancement of bureaucratic organisation, the reverse is not true. The essential character of capitalism is in the rational orientation of productive activity. This process, such as the separation of workers from their means of production which gives rise to bureaucratic specialisation, is irreversible. Bureaucratic specialisation of tasks is, in Weber's opinion, first and foremost the characteristic of the legal-rational state; this affinity between capitalist production and rational law derives from the factor of 'calculability' intrinsic to both.

As will be elaborated in chapter 6, bureaucratic specialisation is reflected in the shifts that have taken place in ultimate responsibility for the Australian VET sector, particularly over the last two decades. Under the influence of political ideologies of neoliberalism (or economic rationalism) there has been a transition from departments headed by experienced professional educators to ministries headed by bureaucrats — in the newly legitimated structures. Calculability is of the essence, together with accountability. The influence of bureaucracy has been so pervasive in the adoption by many Australian educational institutions of the International Standards Organisation (ISO) quality assurance model — a model designed not for educational institutions but for commerce.

In contrast to the contestation over, and eventual transfer of, responsibility for secondary mathematics curriculum from the profession to the bureaucracy of the state (Horwood, 1997), mathematics teachers in the Australian VET sector have, historically, operated under different conditions of professionalism. They have never received the support of powerful universities and at best a tokenistic support from industry, and appear to have ceded their responsibilities without any sign of a struggle. It could be surmised that one explanation lies in the massive nature of bureaucratic changes which have overwhelmed teachers during the last two decades and which met with little, if any, organised resistance. In fact, the bureaucratic task was made easier in the 1980s by the actions of mathematics teachers associated with the TAFE Mathematics Common Interest Group, in the state of Victoria, who proposed and received state funding for an audit of the plethora of extant courses. (This will be further discussed in chapter 4.)

According to Giddens (1972, p. 13), "Weber recognised an absolute dichotomy between the validation of 'factual' or 'scientific' knowledge on the one hand, and of 'normative' or 'value' judgements on the other." Hence politicians' factual

knowledge can never validate their value-laden goals. The correlate to Weber's epistemological proposition that rational analysis cannot validate or disprove judgements of value is the sociological approach that "rationalised systems of social organisation do not create values, but instead only function as a *means* to furtherance of existing values" (Giddens, 1972, p. 52). The assessment of rationality takes moral objectives or ends as givens; the rational cannot evaluate competing ethical standards.

Education, through its contribution to rationalised human conduct as exemplified in the manifestation of the bureaucratised division of labour, cannot avoid specialisation. Thus, seeing intellectualism as bound up with the rationalisation of human conduct, Weber concludes that professional education has come to replace humanism (Giddens, 1972). Here Weber's theorisation helps to explain the shift towards instrumentalism in vocational mathematics education, as will be illustrated in chapter 4, and the apparent lethargy by politicians and bureaucrats towards engagement with issues such as those raised by John Stevenson (1996, 1997) and others concerning the worthwhileness of vocational curricula in general for individual students, not to mention current and future industrial and societal needs.

Although Claus Offe (1972) was writing about a late capitalist welfare state, contrasting it with the liberal capitalist society where the economic system was institutionalised as a domain beyond the authority of the state, his observations may yet be pertinent to neoliberal political regimes. He notes that social processes, almost without exception, no longer take place beyond politics. Following his argument, an alternative explanation may be found for the apparent lack of political interest in day-to-day educational practice as compared to the managerial aspects of the Australian VET sector. Considering the need by ruling parties to maintain mass loyalty, state intervention would only be justified if there appeared to be consequences arising from the current situation that would jeopardise the immediate stability of the system as a whole. In any case, teachers in the Australian VET sector have now been placed in a severely weakened political situation — as evidenced by their replaceability by trainers with minimal qualifications or (potential) technologies of education — discussed in chapter 5. Their students, with reduced powers of student unions and few financial resources to back them, have not the collective voice that employers have (Anderson & Hoare, 1996). Yet, Australian employers like their British counterparts (Stuart, 1999, 2000), traditionally reluctant to countenance the funding of initial vocational education and training have, through representatives of big business and industry, still managed to influence government policy in the direction of deregulation. Collectively, they show little evidence of concern to ameliorate the declining quality and quantity of vocational mathematics education (as evidenced in the following chapters) — in fact, just the opposite.

The growth of what Weber termed *technical rationality*, as evinced in social relationships in the form of bureaucratisation, is closely tied to the development of legal-rational norms (Giddens, 1972). From Offe's (1972) discussion of a *technocratic* concept of politics, with decision-making processes designed to maintain stability with the political focus away from the *status quo*, I now turn to the

work of Jürgen Habermas, a member of the Frankfurt School of critical sociologists along with Offe, to develop further the discussion of technology and values.

3.1.3. Technical Rationality: The Contribution of Jürgen Habermas

According to Paul Connerton (1976), the idea of critique is a product of the Enlightenment, extended and reformulated by the Frankfurt School. He describes the methodology of Critical Theory as being related to "the idea of critique as reflection on the conditions of knowledge in the social world" (p. 37). Its proponents argue that no system of basic concepts, such as those found in the natural sciences, is in principle possible for the study of society; reality can only be perceived through certain a priori categories embedded in the human subject. From a political perspective Critical Theory "is related to the idea of critique as an analysis of constraints imposed by the historically variable structures of the social world" (p. 38). The argument here is that our world is increasingly dependent upon science and technology, but then scientific criteria are used to determine whether or not the social world is rationally ordered. Habermas addressed several human interests: the technical, the practical, and the emancipatory (linked respectively to empirical-analytic, hermeneutic, and critical paradigms). However, Connerton notes that in the case of the interest in possible technical control this is not an empirical, demonstrable interest, but an interest in the *condition of the possibility* of natural science. In other words, not only its emergence and continued existence need to be explained, but also its procedures and methodological structure.

Habermas (1963/1974) argues that science, technology, industry, and administration are interlocked in the continual expansion of technical control over nature and concomitant refinement of administration over human beings. The social potential of science is reduced to technical control, and "emancipation by means of enlightenment is replaced by instruction in control over objective or objectified processes" (pp. 254-255). Industrialised societies are now unable to distinguish between practical (hermeneutic or interpretive) and technical power. Rather than attempt a rational consensus on the part of the community, technical control is attempted through ever-improving administration. There is a paradox in that people are externally bound to the functionally interdependent technological systems in the social order while personally being denied knowledge and, even more so, the ability to reflect on them. Rather than improved systems of manipulation, Habermas suggests a possible solution in a persistent critique.

Distinguishing between the exercise of *technique* in its former sense of guiding artisans and the modern use of the term *technology*, Habermas (1963/1974) relates the function of modern science to the social division of labour. In addition to its monopolisation powers of technical control, the other critical achievement of positivist science has been to reject all competing claims to a scientific orientation other than purposive-rational action. These are blocked out through slogans of ethical neutrality or value-freedom, according to Habermas. In fact, even this sole admissible 'value' of economy of means in the form of technical recommendations is not seen explicitly as a value because of its coincidence with rationality as such.

CHAPTER 4

TECHNOLOGIES OF POWER: RECONTEXTUALISING TEXTS

An Australian Case Study

4.1. INTRODUCTION

In order to better appreciate and understand the current situation of mathematics curriculum and assessment, teaching and learning within vocational education in Australia, this chapter will briefly situate the monograph in its broad institutional setting. It will begin in the narrative mode with discussion of historical aspects of the development of the sector and the images which it conveys to the public and the education sector as a whole. This will be followed by an example of recontextualising texts (Bernstein, 1996). Here the analysis will focus on the reproduction and acquisition of mathematical knowledge, with consequent implications for students' and teachers' identities.

4.2. THE INSTITUTION OF VOCATIONAL EDUCATION AND TRAINING

In chapter 1, I discussed the institutions of mathematics and of mathematics education. Now I wish to shift the focus onto vocational education as a sector within the broader institution of education, as set in the Australian context. Discussing institutions such as education, Seddon, Angus, Brown, and Rushbrook (1998) assert that they are effects or outcomes of particular practices of organising which constitute contextual settings that shape behaviour and other social action — their regulatory norms constitute the social infrastructure as a social, discursive, and organisational medium. The impact of these regulatory norms will be in evidence throughout this chapter and the two which follow. Seddon et al. elaborate on the socialisation roles played by institution of education for the young and the (relatively) inexperienced in the transmission of the cultural heritage of society (see also Beach, 1999). They also draw on the work of William Connell in relation to the development of a collective capacity for learning and dealing with change. Vocational education, no less than school education, has a role to play in these developments. Seddon et al. also note the work of Claus Offe who observed that the outcomes generated by institutions both create and depend upon meanings, norms, and values in their production. In other words, cultural change cannot be brought

about by administrative fiat alone; it may be resisted or contested by institutional actors. In the Australian VET sector it is the practitioners and their students who are the ultimate, albeit relatively powerless, decision-makers as they carry out their day-to-day tasks within the constraints and parameters set by their local managers, interpreted from conditions set by state and national bodies who are charged with operationalising policy deliberations of government. However, as Seddon et al. suggest, the efficacy of policy interventions is limited by their reduction of complexity and ignorance of significant social and cultural dimensions in economic discourse and rational actor theories.

In the Australian post-compulsory education sector (which includes both VET and higher education or university) the trajectories of change include the following trends: the growing role of government; the collapse of the youth labour market contributing to an increase in post-compulsory education participation rates by school leavers together with an associated rise of credentialism; and significant changes to work organisation in general. In the particular case of the VET sector, there have been changes to teachers' work and employment conditions associated in part with the declining status of teachers as professionals (see chapter 5) and in part with pervasive industrial reform agendas (see chapter 6). These trajectories shape and are shaped by changes to education and work embedded within changing social life, according to Seddon and Angus (1995), who observe that education is subjected to intensified pressures for change as it becomes repositioned globally and nationally. They claim that traditional arrangements are being problematised and the purposes of education redefined. For example, under the influence of neoliberal philosophies of government the cultural values associated with education are being reconceived in economic and vocational terms; self-management of the institution and the individual is being sought, and the investment in human capital has been reoriented from a social investment to self-investment. Government policies and interventions have been strategic to bringing about change.

4.2.1. A Brief History of Adult and Vocational Education

Vocational education and training has existed for as long as the novice, or newcomer, has sought to appropriate and even surpass the skills of the old-timer, to use Lave and Wenger's (1991) terminology. The practice of observation and imitation, often of an older family member, was formalised in concept of apprenticeship which has existed in Europe since the Middle Ages (Deissinger, 1994). Formalised institutional provision for adults originated in the 19th century with Mechanics Institutes in England. However, Copa and Bentley (1992) describe the institutional history of vocational education in the USA dating back to 1630. The 20th century saw the burgeoning of organised vocational education and training, in part because of rapidly changing skill requirements which could not be adequately met by the traditional apprenticeship system (Copa & Bentley, 1992; Williams & Raggatt, 1998). The purposes of vocational education for school children and adult learners alike appear to have been contested over its history (e.g., Copa & Bentley, 1992; Kangan, 1974/1979; Rushbrook, 1995; Stevenson, 1997). In addition there has

been territorial contestation among sectors of education (discussed below), and within the Australian VET sector. In the following I will trace briefly the histories of the further education and vocational components; although the prime focus is on the latter. In policy terms there appears to be a convergence in both purpose and target population.

4.2.1.1. *Adult and community education in Australia.*

According to Des Fooks (1994), drawing on the work of Stephen Murray-Smith, the first Mechanics Institutes were set up in Australia within a few years of their establishment in London in 1823. Although they were not scientifically oriented, they provided the basis of genuine educational work. However, their usefulness diminished as they were overtaken by other historical developments in education (Senate Standing Committee on Employment, Education & Training, 1991).

Terri Seddon (1994a) observes that in the late 1980s students in the Adult Basic Education sector (as it was then known) began to be perceived as an untapped resource to aid in economic recovery. Education was now conceived of as a productive industry, aimed at preparing workers for the labour market. This shift in political gaze has resulted in the growth of the sector and radical changes to classroom experiences; there is now considerable overlap between adult and vocational education course structures.

In the past it was possible for adults returning to study mathematics to determine: (a) which content they wished to study, and for what length of time; (b) the manner of assessment (if any); (c) their level of participation in class; and (d) the use to which their mathematical knowledge was put. With increasing political interest in the adult education sector this is no longer the case, as funding mechanisms are closely tied to documented and audited performance statistics, based on prescriptive curricula. (See FitzSimons, 1997a, 2000d for further description of the impact of changes wrought upon mathematics teaching in the Adult, Community, and Further Education [ACFE] sector.

In 1993 the Certificates in General Education for Adults (CGEA) were introduced in Victoria, and re-accredited after review (ACFEB, 1996), as adult and vocational education moved into the competency-based training (CBT) era. (CBT will be discussed further in chapter 7.) There were five broad areas of mathematics content organised according to purpose. These were specified at three different levels of performance, and assessment had to be verified at moderation meetings. Although it could be argued that moderation meetings provide good professional development for beginning teachers, Peter Waterhouse (1995) describes the tensions in this process. These include experienced teachers feeling under threat in the meetings, as well as the restrictions to teaching practice which result directly from the imposition of such a regulatory framework.

But what has been the cost of these reforms? Whose interests have they served? From the students' perspective, the increasing levels of fees are certainly a disincentive to women returning to study, particularly as they often already experience a sense of guilt in doing something for themselves (FitzSimons, 1994b), aside from financial hardships often associated with limited initial schooling. The

flow-on effect of lifelong education to children in such families cannot be quantified, and is therefore discounted by economic rationalists. Similar claims could be made for other groups identified as disadvantaged. (For further discussion of the issues associated with the technologising of equity through the identification of discrete target groups see Butler, 1998a.) Staff teaching in this sector remain less likely than others to have tenure, working as little as three- to six-month contracts for a few hours a week, year after year.

Increasing control and regulation of this sector of education have nevertheless brought some advantages. One is the recognition of qualifications gained by students; another is the serious attitude the sector has maintained towards professional development. In two states, Victoria and New South Wales, there has been extensive coverage for adult numeracy (Falk & Millar, 2001), especially necessary in view of the fact that many teachers of basic skills do not have strong mathematical backgrounds themselves. However, these are not mandatory, and uptake is patchy (D. Tout, personal communication, November, 2000).

4.2.1.2. *Technical education in Australia.*

Tracing the history of technical education in Australia, Gillian Goozee (1993) notes that

> although fulfilling a crucial role in providing post-secondary education and training for large numbers of people, [technical education] was consistently under-valued and under-resourced. The development of technical education has not been consistent but characterised by periods of rapid change followed by much longer periods of neglect. Thus, technical education has usually tended to prosper during times of national crises such as world wars and economic depressions. (p. 6)

According to Peter Kell (1994) the development of technical education has been shaped by working class ambitions for legitimation and institutionalisation of practices, demarcations and procedures, associated with political and economic struggles. It has experienced cycles of development in terms of financial support from governments and shifting educational emphases, from the narrowly instrumental to the broadly-based liberal (Kell, 1994; Rushbrook, 1995; Stevenson, 1995a; White, 1995). However there have been ongoing tensions between levels of government about jurisdiction. There have also been tensions between labour and capital over access to and responsibility for training, with evidence of restricted entry to trades along gender and race lines (Kell, 1994; Rushbrook, 1995).

The second half of the 19th century saw the beginning of a system of technical education for adults in Victoria: Abbott and Doucouliagos (1999) provide an historical review of the evolution of agricultural, mines, and 'Working Men's' colleges, as well as the establishment of junior technical schools. According to Kell (1994), prior to World War II the vocational education system across Australia was fragmented, and organised around awards and agreements with specific industries in an inconsistent and ad hoc manner. After 1945 the post-war shortage of labour was partly addressed by immigration policies, but it was not until the release of the Australian Committee on Technical and Further Education [ACOTAFE] (1974)

'Kangan' report that vocational education was established as an entity in its own right — coming to be known as the TAFE sector.

Over the last decade or so, the institutionally-oriented TAFE sector has been re-constructed — incorporated into the newly created VET sector (see chapter 6) — to accommodate formal learning which occurs at other sites (such as workplaces or community settings), often under the tutelage of private providers. The Australian Qualifications Framework (AQF) now encompasses occupational levels ranging from operators, through tradespersons and technicians, to paraprofessionals. Other terms for qualifications more familiar to European readers might be: *craft* (for trade and equivalent); *master-craft* (for post-trade supervisory type); and *technician* (for technicians and paraprofessionals) (Maglen & Hopkins, 1998).

There is a blurring of the boundaries at the upper levels where some vocational qualifications are recognised by universities. Even the term 'vocational education and training' is contested, as illustrated by one academic who included within its realm his university's provision "law, medicine, dentistry, optometry, veterinary science and pharmacy" (Maglen, 1996, p. 9) — an ironic touch given the highly prestigious nature of these professions and that particular university — thus signalling the trend towards de-differentiation of the two sectors (Nicoll & Chappell, 1998). This inclusion nevertheless reflects the history of universities as sites of professional preparation and underlines the sectoral contestation between the two sectors. Yet, Peter Rushbrook (1997) illustrates how fiercely the universities have opposed the introduction of competency-based education and training into their sector although, as Peter Raggatt (1998) recounts, it is now embedded in the UK system of teacher education. In the other direction, students in the final years of secondary school are now permitted to undertake certain accredited VET subjects.

The very concept of seamlessness across educational sectors, promoted in Australia, suggests that there should be some overlap or at least continuity in educational provision across sectors of education. Yet this is not generally the case — the debate over CBT is a prime example; the NBEET (1995b) report on mathematical sciences is another, highlighting the traditional pursuit of different purposes and orientations, especially with respect to mathematics, across sectors — the Australian VET sector was virtually ignored in the report.

In contrast to many universities, the VET sector historically has maintained a dual focus on both students and industry, albeit with fluctuating emphases. While students themselves have had very little voice (Anderson, 1999a; 1999b), from the mid-1980s the corporate sector has established an increasingly powerful presence in the determination of VET policy and practice, as did the trade unions until the election of a neoliberal federal government in 1996. However, it should be recognised that the voices of business and industry are not univocal, and that spokespersons can in no way represent the interests of the entire industry or vocation (Fisher, 1993; Hawke & Cornford, 1998). The trend towards globalisation of economies is also having diverse effects on industrial practices, including education and training programmes, although not in the deterministic manner suggested by some commentators (Butler, 1998b; McIntyre & Solomon, 1999) — impacting on the policy advice given in relation to vocational education and training.