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 17^{th} 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,

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