Professionalisation and Change in Secondary Mathematics

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Secondary education in Victoria began in the 1850s, and the struggle for control of the mathematics curriculum dates back to this time. However this struggle was intensified with the emergence of public secondary education this century. By the 1960s University control was under attack, principally due to two main factors - the attempt to modify course content on the basis of a new mathematical paradigm, and the professionalisation of mathematics. The critical role that the "New Maths" played in these processes is examined.

It is difficult to realise that the first white settlement in Victoria only occurred in 1835. By 1853 the University of Melbourne had been founded thus signifying that education was to play a major role in the new colony. A challenge was immediately issued to the British traditions of University entrance - in 1855 attempts were made by two of the newly appointed professors, Hearn (History and Political Economy) and Wilson (Mathematics), to liberalise the entrance requirements. An air of utilitarianism spiced their comments. They pointed out that the compulsory study of the Classics or higher Mathematics was regarded by many prospective students as both a waste of time and a distraction from more 'practicable and profitable pursuits' (Clements, Grimison & Ellerton, 1989). Their objections also highlighted the consequent decline in standards occasioned by such mandatory requirements.

Their proposed reforms were rejected. A major area of concern was the maintenance of standards on a par with British institutions; but in seeking to allay this concern one of the consequences of the new University's first actions was to exercise an immediate influence on pre-university schooling. This may not have appeared a major concern at that time. In 1857 the role of the Universities with regard to schooling was outlined by the Vice-Chancellor of the University of Sydney.

> It is the privilege and the duty of the University ... to determine what previously acquired knowledge shall be demanded from those who seek admission to its teaching; and thus it virtually determines what shall be the general system in preparatory schools, private as well as public (quoted in Clements et al, 1989, 60).

The die had been cast. Despite the attempts by the Professor of Mathematics, and others, to loosen the constraints placed by Universities on preparatory schooling, and in so doing to broaden the appeal of university study to a larger cross-section of the community, the University of Melbourne introduced the requirement of a pass in Greek, Latin, Euclid, Algebra, Arithmetic, and English in order to gain admittance to the University (Ellerton & Clements, 1988). Even as questions were beginning to be asked of the central role of Euclid in mathematical education (Siddons, 1956), Euclid was firmly established as a topic in Victorian schools.

Indeed the events surrounding the questions of University entrance clearly illustrate that all professors, and not just those concerned with mathematics, were instrumental in influencing the type of mathematics taught at secondary level. In the period to 1900 Euclid was to feature in a number of other challenges to the nature of the content demanded of university matriculants. Two of these challenges, instigated by mathematicians, had mixed success, while the third, which the University was quick to accede to, was a request by the Faculty of Medicine for a change to the matriculation examination in geometry. The Faculty of Medicine was concerned that the examination with respect to Euclid was not rigorous enough to satisfy the British General Medical Council (Clements, 1989).

Throughout the 19th Century the government addressed the problems of primary education and left the provision of secondary education to the private sector.

This sector emerged in the eighteen-fifties to prepare students for the University of Melbourne, and consequently principals and staff were recruited from the English 'public' school sector. Not surprisingly they brought with them traditions and practices with which they were familiar, and so the formative developments in secondary education were influenced by English traditions. However, the unique social conditions of Australia necessitated many modifications to these traditions and more relevant courses were soon to emerge (Connell, 1962), but the demands by the professions to maintain international status exerted considerable conservative influences.

The mathematics taught in the schools was determined in part by the university but also in part by what was happening in Britain. In England the Revised Code of 1862 and the Taunton Commission of 1868 had argued for mathematics in secondary schools to be determined by student origins. The differentiation that this entailed meant that English school mathematics courses were built around arithmetic (Cooper, 1994). In 1873 Victoria also made arithmetic a compulsory subject at both primary and secondary level (Kamens & Benavot, 1991).

With courses strongly biased towards arithmetic, and with Euclid as essential for university entrance, Victorian education entered the twentieth century. The content of courses was entirely a selection from Classical mathematics. The Classical emphasis was on number as measurement (Spengler, 1926), and such an emphasis was particularly appropriate to a community grappling with the hardship of living in a land bereft of any of the traces of the civilisation that they had left behind. Measurement, primarily in the form of arithmetic, provided the technology to buttress commerce and ownership and not surprisingly was seen as an essential subject for all children to master.

Although the Western conception of mathematics had started to emerge from the mid-seventeenth Century little of its impact was to be felt within Victoria at the turn of this century. The Western paradigm emerged from the work of Descartes, Leibniz and others from the 17th Century onwards (Restivo, 1992). Its major achievement was the liberation of mathematical thought from the boundedness of sensory perceptions. Number, and shape, was abstracted from reality and new conceptions of number - complex numbers, quaternions, matrices - emerged. The infinite, banned from Classical thought, underpinned the calculus, and analysis, and the notion of function, became central to the comprehension of this paradigm. It was not until 1930 that calculus made its appearance upon the educational scene. In the ensuing years the secondary schools were at odds with the University over the purposes of schooling. To some extent this antipathy represented attempts by the Education Department to assert control over the secondary system, but it also represented the feeling within the private school sector that responsibility for determination of curriculum was the preserve of the schools (Phillips, 1962). This situation was resolved in 1945 by transferring responsibility for examinations to the Professorial Board. A sixth year of secondary schooling was introduced and three mathematics subjects were proposed, Pure Mathematics, Calculus and Applied Mathematics, and General Mathematics. Pure Mathematics, like its predecessor, was seen as defining the essential nature of school mathematics, and in this subject the emphasis remained the Classical mathematics paradigm. A prominent textbook of the time, that was used in classrooms from the nineteen twenties through the nineteen sixties, gave notional assent to the idea of function. Apart from a two-line definition and one and half pages of examples neither the word function nor the functional notation was used again in the remaining 500 pages of the book (Baker & Bourne, 1925).

A paradigm shift was yet to emerge. In fact, in the development of mathematics curriculum, major formative influences with an Australian bias were also lacking. In a country with an underdeveloped community infrastructure, with a passion from the mid-eighteen fifties for the quest for gold, and with vast rural expanses demanding proficient navigational expertise one might have expected a curriculum that at least gave some semblance of recognition to these conditions. Courses that included work on

probability, on astronomy and other navigational aids, on surveying, or the like might have been expected to be found. But sadly such courses were lacking. The original subject matter, and most of the later changes effected in mathematics courses up to this stage, came as a result of overseas trends or in response to overseas trends. What was very clear is that the teacher as educator had little impact on the nature of the content of courses. Why was this so?

Other influences on courses and their control were beginning to be felt. The emergence of a public secondary system might have been expected to introduce new influences onto the educational scene. After all Tate, the first Director-General of Education, ranked teachers very highly, and his ascendancy to the premier administrative position in education in this State might have been expected to elevate the role of the classroom teacher to curriculum developer (Selleck, 1982). And in the early stages new courses were introduced, but from the top down. One such course was a new arithmetic course that was introduced into the primary school in order to lay a good foundation for secondary education (Clements, 1989).

However, the initial fervour and support soon yielded to the demands of institutional control as the centralised system and growing bureaucracy within the Education Department marginalised the classroom teacher. The use of inspectors for both curriculum innovation and teacher assessment inevitably led to conflict in their role and subsequent diminishment of their effectiveness (Cramer, 1967). As many commentators were to note, the public secondary system by the early nineteen fifties was in a state of low morale and despondent malaise (Butts, 1955; McLaren, 1968). Neither in its secondary teachers nor within the ranks of the inspectors were the sources of innovation and reform, so desperately needed within the mathematics education fraternity, to be found.

Clearly the creation of the institutional infrastructure necessary to maintain secondary education had effects. But these effects were not all that might have been envisaged. The combination of factors arising from British influence, uniformity and centralisation had led to a situation wherein public educators, whether they be teachers or officials such as inspectors and administrators, had only minimal control over the determination of content within the education system. Other forces resistant to this aim were obviously in place. These forces related to the University professoriate and the Examination Boards.

Melbourne University saw the determination of syllabi in the preparatory years to university entrance, and as a consequence in all the years of secondary schooling, as within its mandate. As a consequence the responsibility for determining the nature of the education that students received rested with university professionals - the Council and members of the university professoriate. In 1912 the Government institutionalised this responsibility through the creation of the Melbourne University Schools Board as a sub-committee of the University Council. The Schools Board was the Examination Board responsible for the conduct of Junior and Senior, later to be called Intermediate and Leaving, examinations. Passes in these examinations were required for government employment. These examinations were also important for students wishing to matriculate.

What the Schools Board inherited was a tradition of university determination of the content of secondary schooling. This content was essentially derived from the conditions that prevailed in Britain. The Schools Board was so constituted that this tradition was not going to change. But derived courses tend to lack relevance and immediacy. Not surprisingly the form tended to dominate the substance - increasingly the education system came to be dominated by examinations. Education in Australia was seen by one prominent Mathematician in the following terms:

> The success or failure of their pupils in the examination has been regarded as the chief test of the value of the school. They have so dominated secondary education in Australia that even at the present time the most satisfactory way of describing the extent of school work in mathematics, or in any other

> subject, would be to give copious extracts from the handbooks for these examinations where the details of the subjects of study are to be found (Carslaw, 1914, p.11).

Examinations very early on began to dominate educational discussion. The combination of a developing public secondary system with minimal demand among its pupils for university education, combined with a registered school sector with a high regard for university status, and with special relationships and privileges with the university resulted in little or no resistance. But the situation was changing.

The era of the university as guardian of preparatory educational responsibility was coming to an end. The wider social and ideological stage had been set for a challenge to the hegemony of university mathematicians and teachers in the schools were only too happy to join the fray. The charisma of the university, its acceptance and respect within society, had provided the basis of its unchallengeable right to control secondary education. By the nineteen sixties, a new professional grouping within society was claiming secondary education as their concern. The professional educator had emerged as a major participant in the struggle for control of secondary curriculum. Their role was enhanced by changed social circumstances which witnessed an increasing demand for mass secondary education. The university responded by shifting its focus from wider educational concerns to the more narrow concerns of the career academic.

But it was not only the wider educational concerns that motivated the impending challenge. Mathematics itself had changed. While the developers of school courses were struggling to come to grips with the transition from a Classical paradigm to a Western paradigm, another paradigm was emerging. The name Bourbaki began to resonate in education corridors. The Structural paradigm had arrived. From number as measurement of the Classical to number as function of the Western had been added number as structure.

The "New Maths" provided one last opportunity for University mathematicians to retain their ascendancy in the area of curriculum formation. The motivation of Bourbaki, the systematisation and unification of mathematics using a set of fundamental underlying concepts - in part, operators, functions, topology, logic, sets and structures - struck a chord with those mathematicians looking for a renewal of the curriculum. The "New Maths" also reflected the desire of educators to teach a curriculum relevant to the practice of modern mathematicians. The curriculum was prepared by a group of experts and reinforced elitist notions of mathematics. In short, the "New Maths" offered a solution to the ever-increasing demands for a renewal of the mathematics curriculum in mathematical terms. The changes ran counter to the changing educational environment.

However, the "New Maths" was a significant attempt to bring about a paradigmatic change in the mathematics curriculum. It represented the embodiment of the Structural paradigm and offered the unification and codification of mathematics in terms of underlying structural concepts. It was at one and the same time seen as a simplification of the complexity and diversity of current mathematics research and the embracing of a new, and modern, paradigm. The attempt was an abysmal failure. The structural concept represented the work of mathematicians. It was unsuccessful because it failed to resonate with the concerns of the students and of the majority of teachers (Cribb, 1986). But one of its consequences was the transformation of the secondary curriculum. An unsuccessful attempt had been made to go forward but there was no turning back (Elkins, 1977). The Classical paradigm was also a victim of the failure of the Structural. Secondary mathematics curriculum moved on to embrace the Western paradigm. Loosely, we can now view the primary curriculum as being essentially underpinned by the Classical paradigm, the secondary by the Western, and the tertiary by the Structural. This attempt at reform represents the last *major* attempt to change content within the mathematics curriculum in Victoria. Looked at in terms of the underlying paradigms, we can see why. There is essentially nowhere else to go.

"New Maths" is symbolic of the end of one era and the start of another. The era from colonialism until the nineteen sixties is characterised by its emphasis on subject matter - viz mathematics, by the emergence of secondary education, and by the fact that the major intellectual influences are to be found in the form of the University professoriate and of University mathematicians. The educational ideology of the era centred on education as training of the mind and the development of a cultural elite. The educational emphasis was on content and memorisation (Connell, 1962). To the extent that psychology was invented to socialise people to their society's views and values it is interesting to note that the major psychological theories that gained ready acceptance and dominated educational thought throughout this era, the connectionism theories of Thorndike and the rote learning theories of the radical behaviourist Skinner, reflected this emphasis on the mastery of content and character training through memorisation. Thorndike offered a classic formulation of his theory in the

> law of effect, which held that any act that produced satisfaction became associated with the circumstances under which it arose and was more likely to recur if those circumstances recurred. In other words, purposive behaviour was a compounding of learned reactions. Habits took the part in the mind formerly reserved for will, and character-training became a question of habituation" (Hale, 1980, 82).

Other psychological theories, although available, were not taken up (McQualter, 1974).

The underlying "cognitive base" of this era was mathematical and education was discussed in terms of mastery of content. This era represented a period of control of the secondary curriculum by the University. The institutional structures in place throughout this era seek to confirm this analysis. Firstly the Schools Board, legally gazetted as responsible for curriculum determination, sought to involve, under University guidance and co-operation, the participation of practising teachers and other bodies vitally concerned with the consequences of schooling. But when the concerns of teachers began to place demands on the secondary curriculum that were unacceptable to the University professoriate, control shifted quite forcibly to the Professorial Board. A strict hierarchical structure, together with a regime of examinations ensured that University mathematicians were firmly in control of the content of secondary mathematics curriculum well into the nineteen sixties.

In the nineteen sixties a new examination board was put into place. This examination board reflected the shift in emphasis to a system with professional education as its core. The era of control of the University Professoriate had begun to wane. Why did the influence of University mathematicians wane? Many explanations are possible - for one a new "cognitive base" was emerging. However there were also conditions that saw the University mathematicians contributing to their own decline.

Professionalism emerges from the institutionalisation of expertise by modern societies (Larson, 1977). Among the many characteristics that identify professionalism are the professional association, cognitive base, institutionalised training, as well as work autonomy and colleague 'control'. Are University mathematicians professionals? And, if so, what are the consequences of this answer for their interest and involvement in the definition of secondary school mathematics curriculum?

Professionalisation of mathematicians is essentially a consequence of events of the second half of the nineteenth century which culminated in the twentieth century (Schubring, 1981). University mathematicians, by the nature of their employment, obviously enjoy work autonomy and colleague 'control'. In 1947 the first PhD candidate graduated from an Australian University. In effect a well-recognised credential had become available to provide the category of institutionalised training.

The concept of "cognitive base" delineates the problems a profession must address, and thus enables a profession to assert supremacy over these problems. Such a cognitive base was essentially lacking from the conception of mathematics in terms of the Classical paradigm (Restivo, 1992). By its general nature and its pervasiveness of all tertiary educational courses this conception of mathematics did not provide the

exclusiveness needed to provide a unique jurisdiction to the mathematician. Many mathematical problems were solved by gifted amateurs (Davis & Hersh, 1981). However the Western paradigm provided the basis for a unique, and exclusive, cognitive base and thus created the conditions for the emergence of the professional mathematician (Schneider, 1981). With the advent of the Structural paradigm, which allowed for greater specialisation and hence greater abstraction, the conditions for the spawning of a profession within Australia were present.

All that was now needed was a professional association. This was provided with the formation in 1956 of the Australian Mathematics Society. Australian mathematicians could now be recognised as professionals in their own right. Professional mathematicians applied themselves to the domain of their own expertise - a domain that was becoming increasingly distanced from other disciplines and from secondary teachers. Kline (1980) observed that the work of mathematicians turned from applications to a preoccupation with mathematics itself. In Kline's terms, mathematics had become inward looking. But in terms of the professional phenomenon mathematicians were seeking intellectual opportunities that would enable them to make a research contribution. With professionalism comes increasing specialisation. Secondary school mathematics now only interested a few mathematicians who chose to specialise in that area. It was no longer viewed as an essential concern of the University in general.

To some extent the episode of the "New Maths" highlights one of the social changes that saw the universities lose control of the curriculum. For the focus of university academics had shifted from broader educational concerns to concern with the demands of the professional. The characteristic of professionalism, the institutionalisation of expertise, was also to lead to the alienation of the teaching fraternity. As the cognitive base of the academic professional became more abstract, so did the distance between the academic and the teachers. And with this distancing the gulf between what Universities were demanding at matriculation and what teachers were expecting from their students was widening. This loss of confidence in the University, allied with other social factors in evidence, effectively undermined the University's legitimacy in the field of curriculum determination.

Mathematicians had developed new passions, and consequently their grasp on secondary education curricula was weakened. Other groups with other educational philosophies would emerge to claim this responsibility. Prominent among these groups would be mathematics educators, teachers and others.

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