

Mathematics Educators: Shaping the Curriculum?

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Two major developments in mathematics curricula have been the 'New Maths' of the 1960s and the recent changes of the 1990s. A framework developed by Howson (1979) is used to compare and contrast these two periods of mathematics curriculum change. What are the influences which shape curriculum development and to what extent are these changes under the influence of anything or anyone? It is suggested that mathematics educators have made a difference in curriculum development through placing constructivism on the curriculum agenda, countering the effects of current reforms in education. From this comparison, further research agendas are proposed.

Significant shifts in the emphases of mathematics curriculum documents occurred in the 1960s and the 1990s, with consequences for the teaching and learning of mathematics. This paper focuses on curriculum change and development at the national level and does not address the working out of curriculum at the level of the school or the individual teacher.

Curriculum change in mathematics in the 1960s and 1990s occurred in a number of nations. Of particular relevance to the New Zealand context are developments in the United Kingdom and the United States of America. The focus in this paper is the New Zealand context, although it is necessary to acknowledge how this is informed/influenced by international pressures. Kline (1973) accounting for why different nations came up with similar documents in the 1960s, suggests that it was partly imitation, but more to do with the emphasis and direction which mathematicians were favouring. He thus treats them as a single movement characterised by common features and content.

It is useful in a comparison of influences in the two periods to have some understanding of the nature of the curricula and how they are different. The 'New Maths' of the 1960s had its origins in the structure of mathematics itself and was concerned with children learning the laws of mathematics from its axiomatic base. Content was organised around algebraic structure and there was little concern for pedagogical matters (Neyland, 1991). Emphasis was placed on rules and the one way of solving a mathematical problem. The curricula which came out of this were 'teacher proof' and textbook driven (Apple, 1992a).

In contrast to this, changes in mathematics curricula in the 1990s focus on the teaching and learning of mathematics with an emphasis on problem solving and multiple ways of 'doing mathematics'. The curriculum aims to "help students to develop a variety of approaches to solving problems involving mathematics, and to develop the ability to think and reason logically" (Ministry of Education, 1992, p8). It is stated that "mathematics is best taught by helping students to solve problems drawn from their own experience... real-life problems are not always closed, nor do they necessarily have only one solution" (Ministry of Education, 1992, p11). Students construct new knowledge and refine their existing knowledge and ideas (Ministry of Education, 1992). The use of technology is encouraged as a tool for learning. Mathematics is perceived as a human activity, culturally produced and socially constructed (Walshaw, 1994).

A Curriculum Development Framework

Placing curricula within their complex contexts, there are a significant number of influences which have the potential to shape curriculum development. These can be discussed in terms of specific contributors to the writing of the document, or as broader pressures that influence curriculum change.

Dealing specifically with mathematics curriculum development, Begg (1994) acknowledges not only the crucial role of curriculum writers, but also that their thinking is influenced by other groups, who have in turn been influenced by their own experiences,

their professional reading, international trends and concerns, and political views. These groups include teachers, mathematicians and statisticians (academic and professional), mathematics educators, the community (parents and employers), resource producers, politicians and students. These groups could either be seen as influencing curriculum writers, or as potential writers themselves.

Taking a broader view than this, Howson (1979) identifies four types of pressures that can serve to initiate curriculum development. These are societal and political, for example, the demand for mathematicians to enhance national prosperity and economic growth; educational, pressure from, for example, teachers; mathematical, changes in the discipline of mathematics and the influence of university based mathematicians; and change itself, the international factor with nations desiring to 'keep up' with neighbours. Using this as a framework for analysis, curriculum change in mathematics in the 1960s and 1990s will be compared.

'New Maths'

Societal and political influences

In the 1960s, societal and political pressures on curriculum development were strong. Price identifies the importance of three events in the American context. The first of these was World War Two and the role played in it by scientists and mathematicians. The second event was the launching of Sputnik I and Sputnik II by the Russians in October and November 1957, and thirdly there was the race to be first on the moon (Price, 1989).

The assumption made was that for America to 'lead the world' there was a need for scientists and mathematicians and that the curriculum needed to be changed to produce these. The School Mathematics Study Group (SMSG) had its origins in a committee requested by the National Science Foundation to "devise a practical programme which will improve the general level of instruction in mathematics in elementary and secondary schools" (Price, 1989, p391). By 1960 sample texts had been written for each of grades 7-12 and there were also at least seven other curriculum study groups which had written texts or issued reports with recommendations for improved programmes (Price, 1989). This growing political demand for science and mathematics has also been attributed to change in New Zealand; "mathematical achievement and national prosperity were coming to be regarded as directly linked" (Openshaw, 1992b, p142).

Political/societal pressures influence curriculum development not only at this level of larger agendas, but also in terms of the curriculum reform process in place. In New Zealand, curriculum development at this time was centralised through the Department of Education but occurred on a 'piecemeal' basis with different subject areas being reformed at different times. In the case of 'New Maths' initial change came from teacher innovators but state approval was required to disseminate the changes in a wider, nationally organised way.

New mathematics innovators initially required Departmental legitimation to prepare an alternative examination syllabus. It is interesting to note here that in negotiations with the Department, reforms were labelled 'modern' rather than 'new' to facilitate "the most crucial test of successful curriculum innovation in New Zealand ... [which] remains its translation from a limited regional experiment into a national curriculum reform movement" (Openshaw, 1991a, p15). The relative success of the second pilot scheme was certainly dependent on Departmental backing and nominal Departmental leadership; "to the extent that central support was vital for both resource allocation and access to curriculum making on a national basis, the Department can be regarded as a bureaucratic gate-keeper" (Openshaw, 1992a, p206). Although the role of the Department is not seen as being large, through the conferences and inservice courses which enabled dissemination of the changes, they did play a role as selective interpreters of innovation (Openshaw, 1991a).

Educational influences

"Dissatisfaction with the existing secondary mathematics curriculum among some mathematics teachers was of long standing in New Zealand" (Openshaw, 1992b, p140); the

impetus for change came from a group of teachers. McCausland (1974) identifies the focus for change as a group of Christchurch secondary teachers who met to consider ways of introducing new ideas into the mathematics syllabus. Meeting to write texts, and trialing material in the classroom, this Christchurch Mathematics Group was given official recognition and set up and marked its own School Certificate paper called Pilot Mathematics (McCausland, 1974). All members of this group were Heads of Department and were given by their schools an afternoon per week to meet.

Thus change stemmed from a localised group of teachers but required Departmental approval and funding to be implemented on a national scale. It is also important that change occurred in assessment. A limited pilot scheme for School Certificate began in September 1961; this became more comprehensive in January 1964 after a teacher refresher course. An alternative School Certificate Paper was introduced in 1965 and by 1969 twenty per cent of School Certificate mathematics candidates from seventy secondary schools sat the new mathematics option (Openshaw, 1992b). Change in assessment meant there was also change in curriculum at junior secondary and primary levels. The move towards general acceptance is illustrated by the Alternative Mathematics School Certificate paper being renamed Mathematics in 1973 (McCausland, 1974). Teacher Refresher Course Committee courses were run, booklets put out and texts written.

Openshaw identifies two significant points from his interviews with those involved with the development of 'New Maths'. These are the importance of small groups of teachers in initiating and in sustaining curriculum reform, and the need for innovators to be in step with the times they are living in and the dominant rhetoric of those times (Openshaw, 1991a). This latter point is significant, as the teacher innovators did conform to the dominant rhetoric of the time. 'New Maths' changes were occurring internationally, and were seen as a way of improving the nation through the development of 'better' mathematicians.

Mathematical influences

Mathematical influences are changes occurring in the body of knowledge which is defined as mathematics, and the influence of mathematicians. There is a sense in which all who engage in 'mathematics' are mathematicians; the emphasis here is on university based academics. Internationally, there has been considerable focus on university based pure mathematicians and the part they played in the development of 'New Maths'. In America, they were requested by the state to assist in the programme of mathematical curriculum change. A criticism made by Kline (1973) is that the college professors leading curriculum reform lacked pedagogical skill, and were generally not interested in the connections of mathematics with the real world. Education professors were not utilised as they did not have a mathematical background.

In New Zealand, mathematicians in universities have not been identified as significant leaders in curriculum change. The universities did, however have a role, and changes were occurring there even though they didn't directly influence what was happening at the secondary school level.

As students at the University of Canterbury, McDowell, Goldsmith, Parr and Strange had first met, each having been '...exposed in our last Degree years to some of the interesting unifying concepts in mathematics' and in consequence coming to ask 'Why [weren't] these in the school programme?' (Openshaw, 1992b, p145).

However, "the absence of any large scale new mathematics curriculum projects closely associated with prestigious secondary schools and controlled by University interests undoubtedly was a factor in contributing to a situation which, in this respect at least, was at variance with developments in Britain and elsewhere" (Openshaw, 1992b, p145).

Change itself

From the 1959 Royaumont Conference in France, which eighteen countries attended under the umbrella of the Organisation for European Economic Cooperation, a number of projects were developed internationally. At this international meeting the abandonment of virtually all the familiar courses in high school mathematics (including Euclidean geometry) had been urged (Kline, 1973). There is a sense in which the change occurring had its own impetus, not directed by any single nation, group or individual. "By the mid 1960s well over one hundred curriculum projects aimed at introducing radical changes to secondary school mathematics and science programmes had been initiated" (Openshaw, 1992b, p140).

Although the teacher innovators do not speak much of the international nature of the change itself and how much this had an effect, they were aware of projects developing in other countries. McDowell remembers that Max Riske came back to New Zealand "waxing eloquent on the new emphasis on mathematics in the United States.... he provided the catalyst and it really set us off" (cited in Openshaw, 1991b: 32).

The 1990s

Societal and political influences

As the first curriculum statement to be developed as part of the Achievement Initiatives policy under the umbrella of the *New Zealand Curriculum Framework*, the document is embedded in the broader social and political milieu of an era characterised by the most extensive restructuring and policy reformulation in education for more than a century (Walshaw, 1994, pi).

Privatisation has occurred across social systems; in education, school administration and management has been decentralised with Boards of Trustees responsible for the running of schools. However the 1989 Education Act dismantled the Curriculum Development Unit of the Department of Education and curriculum came under Ministerial control with greater centralisation than at any point in the past (Peters, forthcoming). By May 1991 the Minister of Education had published his plans for comprehensive reform of the school curriculum to "bring our schooling system into line with the needs of the 90s and the 21st century and the imperatives of the modern competitive international economy" (Smith cited in Peters, forthcoming, p10). The discussion document for the National Curriculum Framework was launched in a speech at the Post Primary Teachers' Association Curriculum Conference, with frequent reference to labour market needs and a narrow and functionalist core curriculum (Peters, forthcoming). This rationale has seen the development of a National Curriculum with an instrumental emphasis on essential, generic skills.

Within this context, mathematics curriculum change was initiated in 1991. Curriculum change has occurred within

... a context increasingly defined by the right. Its agenda includes the marketisation and privatisation of education, the slashing of budgets, the standardisation of pedagogy and content through the development of national testing and national curricula, the defining of the needs of business and industry as the primary goals of schooling, the return to a romanticised 'common culture' based on the 'western tradition', and a schooling system that is much more highly stratified in terms of student outcomes than before (Apple, 1992b, p439)

Educational influences

Political demands and the overall agenda of the state have therefore been dominant in this period of curriculum change. What educational influence was there on the curriculum in this period? The rhetoric of the government has been the involvement of teachers in the writing groups of curriculum documents.

The national curriculum statements are developed by the Ministry of Education following widespread consultations with teachers, other educators, boards of trustees, and the wider community, including the business community.... Drafts are sent to schools for comment and

trialing before final statements are published for implementation (Ministry of Education, 1993, p22).

With the closure of the Curriculum Development Unit, curriculum development is contracted by the Ministry of Education. In the case of mathematics, the contract was awarded to the Wellington College of Education, under the name of an individual. There was a team of writers, a policy advisory group, and a review group. The original writing group was disbanded, with the rationale that it was dominated by mathematics educators and that more teachers were needed on it. However, the second group was also dominated by mathematics educators.

Another educational influence, which is crucial, is constructivist theory, which is currently prominent in many areas of education. Briefly, constructivists hold the belief that knowledge is actively constructed by the learner, and that learners are not discovering an independent pre-existing world (von Glaserfeld cited in Neyland, 1991). With regard to mathematics, there is an "emphasis on the process of mathematising; problem solving strategies, investigative approaches, communication and modelling" (Neyland, 1991, p41).

Mathematical influences ... mathematics educators?

Mathematical influences, defined earlier as those occurring within mathematics at university level, have not been explicit in the curriculum of the 1990s. Here the limitations of Howson's framework are evident in analysing mathematics curriculum development of the 1990s. Where are mathematics educators?

The first International Congress on Mathematical Education (ICME) was held in France in 1968, followed by another in 1972. Although under the name of mathematics education, these two conferences were attended by mathematicians. It was not until the 1976 conference in Germany that there began to be talk of an academic discipline called 'mathematics education'. With regard to New Zealand involvement, one New Zealander attended in 1976, six in 1980 when the conference was held in the United States, and more in 1984 when it was in Australia. Mathematics education developed in the 1980s as a discipline for those with both educational and mathematical backgrounds, working in the field of the teaching and learning of mathematics. Before this, there had been teachers or mathematicians. Britt, (cited in Openshaw, 1992c, p53) states that

the mathematics educators I still feel are getting off the ground in New Zealand. They are I think to a very great extent associated with the Teachers' Colleges. There are many teachers' colleges that now see themselves as Mathematics Education Departments and as mathematics educators.

This statement is made a year prior to the announcement of curriculum change in mathematics, which was dominated by mathematics educators. Mathematics educators predominantly work in Colleges of Education (as lecturers in pre-service education or advisors to teachers), and increasingly in universities. The first official mathematics education appointment was in 1992.

Change itself

Howson's recognition of change itself as a pressure on curriculum development is also relevant in analysis of New Zealand in the 1990s. Again there is a strong sense in which what is happening internationally informs the changes in New Zealand. *Mathematics in the New Zealand Curriculum* incorporates many features found in other publications, particularly in the United States and England (Howson, 1994). Constructivism, as an internationally prominent, or even dominant, philosophy of learning could almost be seen as having an impetus of its own, independent of specific agents of change. "The present change in perspective in mathematics education stems from the increasing acceptance of the constructivist view of learning" (Begg, 1993, p212). However, there have been challenges to constructivism and it will be interesting to see how these will inform future periods of curriculum development internationally.

Mathematics Educators: Shaping the Curriculum?

In both periods of curriculum change in mathematics there have been a range of influences. Figure 1 summarises the periods and enables similarities and differences to be identified. Particularly significant is the dominance of political demands as an overall agenda shaping the direction of change. International competitiveness and the role that it is believed education, and particularly mathematics can play in this is highlighted in both periods. This international competitiveness is also played out in the way that both periods of reform have been part of larger international change, with 'change itself' having its own impetus. A key difference, is the shift in 'expert' influence from mathematicians to mathematics educators. In the 1960s, mathematicians in universities were key figures in international change. By the 1990s the growth of mathematics education saw mathematics educators at the fore-front of curriculum writing.

Influences	1960s	1990s
<u>Societal/political</u>		
state education body	Centralised curriculum development but 'piecemeal'	Ministry of Education Education Act 1989 NZ Curriculum Framework- overall agenda
political demands	Demand for scientists and mathematicians 'Space Race' - international competitiveness	Skilled workforce and international competitiveness 'New Right' reforms
<u>Educational</u>		
teachers	Small group of teacher innovators - localised	Rhetoric of being on writing team and opportunities for all to comment on draft document
maths educators	<i>Did they exist as a community?</i>	<i>Prominent on writing group</i>
<u>Mathematical</u>		
mathematicians	University led reforms by pure mathematicians	What role did they play?
<u>Change itself</u>		
international	Influence of overseas projects	Constructivism

Figure 1. Summary of influences on curriculum development, 1960s and 1990s

The complex nature of curriculum development makes it difficult to pull from the contextual web key factors in curriculum change. It could be asked to what extent change is under the influence of any of these individual factors? Does change have its own momentum independent of specific actors or decisions? This rather rhetorical question has no simple answer. What it suggests however is that curriculum change cannot be attributed solely to any particular influence. However, although recognising this, it is argued here that mathematics educators have played a key role in shaping the curriculum document of the 1990s. It is not to suggest that other influences have not also been significant.

The growth of mathematics education as a recognised field has provided the setting for research into the teaching and learning of mathematics. Mathematics educators draw from mathematics *and* from educational theory, and interact with other disciplines, for example, psychology, sociology and philosophy.

Research into the teaching and learning of mathematics within constructivist theory has occurred internationally. Constructivism has been put on the agenda of mathematics curriculum writing by mathematics educators. Constructivism with its particular focus on children learning through discovery and investigation suggests particular ways of teaching. This has countered the direction the document might have taken under the influence of the National government, with its concern for privatising, measurable outcomes, testing and competition. The agenda of the government has been in some sense countered by constructivism, the influence of mathematics educators. This is evident in the words of Jim Neyland who led the writing team for the curriculum document. He states that "the task we set ourselves was easy to state: Marry the directives from the Government with the findings of the latest research and scholarship in mathematics education and with the very best of current teaching practice" (Neyland, 1993, p7).

Therefore, mathematics educators have shaped the direction of the document through the development of research and the theory of constructivism. Specific individuals may not have made the difference, but mathematics education as an academic discipline has shaped curriculum change in the 1990s.

Conclusion

This paper has analysed influences on curriculum development, comparing two significant periods of change in mathematics curricula. In these two periods, curriculum change was strongly influenced by societal and political factors, particularly concern about international competitiveness. However, the curricula developed were very different. It has been suggested here that the development of mathematics education and mathematics educators has shaped curriculum change through the placing of constructivism on the curriculum agenda. This has in some sense countered the 'New Right' agenda of the national curriculum framework.

Two possible agendas for research come out of this paper. Firstly, the role of mathematics educators needs to be explored further with regard to the influence they exert on the teaching and learning of mathematics, and more particularly, to curriculum development. Howson, (1979, p136) expresses concern that previously

a feature of most projects is that initiation has usually been unilateral in the sense that it was made by mathematicians or by educationalists, and, indeed, that it often concerned mathematics alone, mathematics *qua* mathematics, and not mathematics as a component of a general education.

The development of mathematics education as a discipline, and the role that mathematics educators have played in curriculum development has perhaps allayed some of Howson's concern. It may be particularly interesting to analyse the relationship of mathematics educators with the government, teachers and mathematicians.

Secondly, further comparisons of curriculum change can be undertaken. Comparison could occur historically, between and/or within nations, and between subject areas. Influences on curriculum development need to be made visible. Curriculum development

is a complex process involving a number of different groups working within structural constraints. Understanding and analysis of this process can inform future curriculum development and enable discussion to begin around the questions of 'what will be identified as influential factors in future periods of curriculum change in mathematics?' and 'what influence will mathematics educators have?'

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