Year 9 Mathematics Schemes in New Zealand

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There has been little research into either the writing process for mathematics programme plans or their content. Ideally the scheme provides a template for the teacher to follow throughout an academic year, giving guidance on topics, level and depth of presentation, and examples of suitable tasks for learning and assessment. In New Zealand schemes are also part of a school's accountability process. This paper reports some findings of a study that examined the preparation and composition of such schemes at the year 9 level of schooling from a sample of fifteen North Island New Zealand state secondary schools in provincial cities. This paper does not explore classroom teaching or learning; rather it focuses on the mathematics department policies and the documents that guide classroom practice at year 9.

New Zealand secondary schools are required to have formal written schemes for each subject, for each year of study (The National Education Guidelines (Ministry of Education, 1993a, pp. 3, 4)). Scheme content is a particularly useful and important area to investigate as indicated by the:

- small amount of published research on mathematics scheme content;
- New Zealand report of the Second International Study into Mathematics Achievement (Binns et al, 1987), which indicated that sixty percent (60 %) of teachers would find going without the syllabus "at least fairly easy". One explanation of this is that teachers base their day to day planning on school schemes which suggests that schemes largely determine what is taught;
- low proportion of students (fifty one percent (51 %)) who are taught by teachers who had mathematics and/or mathematics education as a major area of study in their degree course or teacher training programme.[1] This figure is also lower than the 1979, 1981, and 1989 New Zealand figures;[2]
- implementation of a new curriculum in 1993 (Ministry of Education, 1992);
- anecdotal reports from 'mathematics advisors'[3] that schemes vary greatly in terms of the content and depth of treatment.

Year 9 schemes were chosen for the study because it sought to examine the continuity of mathematics education across the year 8, year 9 transition. Furthermore, year 9 is the students' first experience of secondary school mathematics and experiences within this year are likely to affect their attitudes to secondary school, and further study in, mathematics.

[1] Compared with an average of eighty four percent internationally (Ministry of Education, 2000)

[2] As indicated in Forbes et al, 1990, (pp. 31, 32)

[3] 'Mathematics advisors' are contracted by the Ministry of Education to assist schools who request their help.

The Scheme

Ruthven states that the scheme is the "articulation of a clear operational model for practice, explicitly indicating the ends to be sought and the means to be employed (1999, p 210)." Thus the scheme outlines the school's decisions about the learning programme so that teachers have a common plan for the year. The scheme may include aspects such as the order in which topics are to be taught through the year; the length of time to be spent teaching each topic; specific directives on the mathematical content to be taught within each topic; and suggestions of suitable learning experiences, references, and resources that could be used.

The scheme ('school' curriculum) is developed from legislative requirements (the *National Education Guidelines, The New Zealand Curriculum Framework,* and *Mathematics in the New Zealand Curriculum* (the 'intended' curriculum))[4] in conjunction with school policies. Teachers develop short-term unit and daily plans from the scheme, and use these to structure their classroom teaching (the 'translated' curriculum).

This paper is concerned with the 'intended' curriculum and the 'school' curriculum and looks into the writing processes and content of the 'school' curriculum (scheme). It discusses some possible implications for the 'translated' curriculum (what teachers teach) and the 'achieved' curriculum (what students learn).

Curriculum change is relevant because the study investigated schemes that were written soon after a new mathematics curriculum was introduced. Therefore aspects relating to curriculum change and implementation appear in the analysis of the data.

Literature suggests that there are many factors other than the 'intended' curriculum that help to determine the 'school' curriculum, such as teachers' previous practice, assessment practices (Kilpatrick, 1995), belief in and commitment to the curriculum (Ahmed as cited in Ruthven, 1999), and textbook content (Begg, 1995).

There is little published research that is specific to the preparation and content of mathematics schemes and therefore little is available to provide a theoretical base on which to ground discussion of the results of this study. The references in this paper in the main relate to the relevant legislative framework, Ministry of Education expectations, and related information that indicates possible consequences of the study findings. Such literature is included within the relevant sections of this paper, rather than in an introductory section, due to the breadth of this study.

Research Questions

The research questions for this study were:

- What processes are used in writing year 9 mathematics schemes? How do these vary from school to school?
- What use is made of information from contributing schools in scheme development? How does this vary from school to school?

[4] The *National Education Guidelines* (Ministry of Education, 1993a) outline the goals, governance and management requirements for New Zealand schools. *The New Zealand Curriculum Framework* (Ministry of Education, 1993b) sets out the foundation policy for learning and assessment in New Zealand schools. *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992) outlines the intended curriculum for students from years 1 to 13. Curriculum content is divided into eight levels.

- What is the content of year 9 mathematics schemes? How does this vary from school to school?

This last question encompassed coverage of curriculum mathematics content, incorporation of Mathematical Processes,[5] references to technology use, and bicultural perspectives. Practices in schools of different socio-economic status were compared.

Study Data and Limitations

The fifteen study schools were taken from North Island New Zealand cities with populations from approximately 20,000 – 83,000.[6] Principals and Heads of Mathematics Departments from a randomly chosen sample of state schools from the provincial cities were approached for agreement to be part of the study. The resulting study sample included schools with a fairly even spread across socio-economic groupings, school size, and school types (single sex, coeducational).

Each Mathematics Head of Department completed a seven-page questionnaire covering a wide range of aspects of scheme preparation and content. The questionnaire responses and the full year 9 scheme from each school provided the data for the study.

Because of the small sample size the analysis does not give a national picture but instead gives a window into some of current practice. Care should be taken in generalising findings outside of North Island New Zealand state secondary schools in provincial cities. However, the breadth of this study allows some insight into the wider picture of the year 9 mathematics programme that a more in depth study of a narrower aspect of school mathematics programmes would not allow.

The schemes and questionnaire responses varied in the amount of detail given. In some aspects of the study, this meant that data from some schools was fuller than that from others.

Many non-standard abbreviations for textbooks, resources and learning experiences were used within most of the schemes. It was not considered appropriate to approach Heads of Department further for clarification of these references.[7] Some references were difficult to trace, particularly as they were so numerous. The effect of this constraint is that within some parts of the study, such as subject inter-connectivities, incorporation of Mathematical Processes, and technology use, the quantitative data should be taken as minimum values.

Study results are numbered below. In order to encompass the breadth of this study within this paper, discussion of each aspect is necessarily brief, and is included with the study results rather than within a separate discussion.

Scheme Preparation

1. Only one third of schools used the curriculum as the starting point for scheme writing. Forty seven percent (47 %) of schools used the previous scheme as the

[5] As listed as a strand of *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992, pp. 23-29)

[6] Figures taken from The New Zealand Official Yearbook, Statistics New Zealand, 1998, p. 90.

[7] Due to further intrusion on Heads of Department time, and the very large quantity of references available for analysis.

starting point. No school reported using any information from literature or research to help inform their scheme writing (consistent with Ruthven, 1999).

Use of scheme writing starting points other than the curriculum may contribute to lower degrees of curriculum implementation. Lack of use of relevant literature and research findings may lead to less effective teaching and learning programmes as schemes produced without the use of such information are likely to be based on a limited range of prior experience and knowledge.

Heads of Department were asked to indicate whether or not they had used information from their contributing schools for scheme writing (in particular; year 8 learning programmes, students' mathematics assessment results, and the textbooks used by contributing schools).

2. Study results indicated that for many schools, very little information of any type from contributing schools was used to inform scheme writing for year 9 programmes. Reasons given for this included the difficulty of establishing working relationships with contributing schools, the reliance on previous experience and assumed student knowledge, the large number of contributing schools of some secondary schools, time constraints, lack of confidence in the information provided, and not having considered collecting such information.

The data strongly suggests that the intention of the *New Zealand Curriculum Framework* and the curriculum with respect to coherent continuity of learning is not fulfilled in the study schools. This is potentially problematic for both students and teachers as the study schemes were based largely on level 4 of the curriculum, a level that encompasses the teaching and learning in year 8. This indicates that students may be exposed to learning which their teachers believe to be new, but that they have previously experienced or even mastered. The ideal is for the scheme to be matched as closely as possible to the learning needs of the cohort, and to do this effectively, the use of baseline information about the students' prior learning is necessary. Possible negative implications of a lack of continuity from year 8 to year 9 include: material in which the students are already competent may be included in schemes; material the students are not adequately prepared for may be included in schemes; and use of textbooks that the students have already used.

Scheme Components and Subject Inter-Connectivities

3. The components used in schemes included Achievement Objectives,[8] learning outcomes, assessment information, ideas for catering for students with different learning needs, resources, textbook references, teaching methods, and learning experiences. The schemes provided little apparent reference to the necessary prior knowledge for each topic area, or for the maintenance of prior learning. Over half of the schemes did not explicitly include components relating to catering for different learning needs, although questionnaire responses indicated that department strategies for teaching such students were in place.

[8] As listed in *Mathematics in the New Zealand Curriculum* (New Zealand Ministry of Education, 1992). These define what students should be able to achieve after appropriate learning experiences.

The components included in study schemes correspond well to most of those recommended in the literature (Cohen & Manion, 1989, Sutton, 1991, Begg, 1992, Edwards & Healy, 1994, and Ministry of Education, 1997). The study schemes differed from these recommendations in their lack of use of prior learning and maintenance components, and a light emphasis on catering for different needs.

It is of concern that nearly half of the study schools did not include learning outcomes in their schemes. Achievement Objectives were included in seventy five percent (75 %) of study schemes, but in general the Achievement Objectives are broad and need to be broken down into smaller learning outcomes.

4. Differences were found in the components used in schemes from schools of different socio-economic groups. In particular, components less often found in schemes from low socio-economic schools included learning experiences, resources, textbook references, and extension work.

This result suggests that teachers in schools with low socio-economic status may have difficulty in providing their students with mathematics education opportunities given to students in other schools.

5. Sixty percent (60 %) of the study schemes included considerable detail in the lists of learning experiences, resources, teaching tips, and assessment.

The wide range of creative and interesting learning experiences that were indicated within eleven of the fifteen schemes suggests that a considerable proportion of study school year 9 students are experiencing interesting and varied mathematics programmes and that most schemes would be helpful to beginning teachers in this regard.

The study explored whether or not Heads of Department were aware of the use of year 9 mathematics within other programmes in their school, and whether such use was apparent in the schemes.

6. The majority of Heads of Department indicated that they were aware of some year 9 mathematics within other subject areas, but none of the written schemes indicated noticeable links to these areas.

This result suggests that in study schools the onus of following the intent of the Ministry of Education[9] in relation to subject inter-connectivities falls on individual teachers. Lack of links with other curriculum areas could encourage students to perceive mathematics as a stand-alone subject unrelated to the other essential learning areas, and effective learning opportunities offered through mathematics arising in other learning areas may be missed. The advantages of integrating mathematics across the curriculum, as discussed by Fraser (1996), Thornley and Graham (as cited by Bishop and Glynn, 1999) seem unlikely to be being experienced in the study classrooms, particularly as it is likely to be difficult for teachers to gather sufficient information from all subject areas to enable these links to be made on an individual basis.

[9] As indicated in the *New Zealand Curriculum Framework* (Ministry of Education, 1993b) and the curriculum itself

Mathematical Content and Mathematical Processes

The New Zealand mathematics curriculum is divided into six strands: Number, Measurement, Geometry, Algebra, Statistics and Mathematical Processes. The study sought to examine similarities and differences in the coverage of the Achievement Objectives from these strands within schemes.

7. Seventy three percent (73 %) of schemes included the teaching of Number in the first half of the year, the same percentage as for Measurement. Fourteen schemes included the teaching of Algebra within the first three (of four) terms. Most study schemes included the majority of Geometry and Statistics teaching in the second half of the year (eight and ten respectively). All schemes were based largely on level 4 of the curriculum.
8. The level 4 Achievement Objectives that were absent in some schemes were those relating to understanding and skills that are in the current curriculum, but were not in the previous syllabus (Department of Education, 1987).

This may indicate that the curriculum has not yet been fully implemented in some schools.

9. Nearly one third of schemes incorporated some level 3 Achievement Objectives in three or more of the five curriculum content strands. Number was the strand most likely to include *level 3* Achievement Objectives, followed by Measurement. Eleven of the fifteen schemes included Achievement Objectives from *level 5* in at least two strands. Level 5 Achievement Objectives from the Geometry and Algebra strands were those most often included (ten schemes), followed by Number, Statistics and Measurement (eight, six and five schemes respectively).

The New Zealand mathematics curriculum includes Achievement Objectives for each of the processes: Problem Solving, Developing Logic and Reasoning, and Communication. The curriculum requires that these objectives be incorporated throughout every topic. Schemes were examined to establish how these Achievement Objectives had been incorporated.

10. Lack of specific coverage of the Mathematical Processes Achievement Objectives was widespread in the study with only two schemes quoting any of the Achievement Objectives directly. Although three schemes included 'problem solving' topics, it appears that study schools are not addressing, through their schemes, the curriculum directive regarding learning and assessment of Mathematical Processes (Ministry of Education, 1992, p 23). Some schemes indirectly and partially address the incorporation of Mathematical Processes through the learning experiences they list.

The lack of emphasis on Mathematical Processes will not help to address the gaps found in student achievement by recent studies (Flockton & Crooks, 1998, and Garden, 1996), neither will it equip students well for further mathematics study, nor will it assist the beginning teacher to implement the curriculum.

Bicultural Perspectives, Calculators and Computers

Bicultural perspectives were defined as those having an identifiable Mäori aspect or bicultural emphasis. Ministry and curriculum expectations indicate that such references

should occur in classroom programmes. Three types were found: those with the activity title written in Te Reo Mäori; activities that were referenced to a Mäori craft; and activities that were referenced to a Mäori legend.

11. No bicultural references at all were found in the schemes of eight of the fifteen schools. Of the seven schemes that did include bicultural perspectives, three had only one reference. The school with the most inclusions (ten) was a school with over ninety percent (90 %) of its students Mäori.

The lack of reference to bicultural perspectives in a scheme does not necessarily mean that bicultural perspectives have not been incorporated into the classroom programme. However, each individual teacher would need to incorporate bicultural aspects into their programme independently, which can place a heavy burden on the classroom teacher despite the amount of accessible bicultural material.

It seems likely that year 9 children in the study schools are not experiencing mathematics programmes that are rich in bicultural perspectives, and that schools are not meeting the legislative requirements in this area. Possible consequences of mathematics programmes which lack bicultural focus include: Mäori students perceiving that mathematics is not a subject for them; and the continuation of a performance gap between Mäori and non-Mäori students in mathematics (Flockton & Crooks, 1998, Garden, 1996).

Schemes were analysed for explicit references to the use of calculators and computers. Such useage was difficult to gauge accurately, as many of the learning experiences and resources listed within schemes were not described in detail.

12. The study schemes included a range of ways of referring to the use of calculators and computers including general statements; learning outcomes (for mathematics content and for skills in the use of calculators and computers); resources; learning experiences (requiring use of calculators and computers); and units of work. A combined total of sixty-nine references to calculator or computer use and two two-week teaching units were found in the fifteen schemes.

These results indicate rather light incorporation of technology use and are consistent with other findings that school mathematics does not appear to reflect the emphasis placed on the use of calculators and computers by the Ministry of Education[10] (Garden, 1996, and the Mathematics Education Unit, University of Auckland, 1994). Furthermore, the mathematics programmes of the study schools may not be equipping students with the technology skills that will be needed when they leave school.

13. The heaviest emphasis on the use of calculators and computers that was exhibited in the study schemes was within the Number strand, consistent with the emphasis given in the curriculum.
14. Correlation coefficients showed no significant relationship between the number of bicultural inclusions and either the proportion of Mäori students, or the socio-economic status of the school (0.551 and –0.141 respectively). Similarly,

[10] See the National Education Guidelines, (Ministry of Education, 1993a, (pp. 3, 4)); the Numeracy essential skills, (*New Zealand Curriculum Framework*, Ministry of Education, 1993b, p. 18); and the current curriculum (Ministry of Education, 1992)

correlation coefficients for the number of references to technology use and such factors indicated no significant relationships (-0.353 and 0.330).

Conclusions

In this study, the schemes varied markedly from school to school with respect to content, detail, depth and layout. Most study schemes did not provide sufficient depth or detail to allow teachers to easily address *all* curriculum requirements in their teaching through use of the scheme alone. Insufficient guidance within a scheme is likely to be particularly problematic for beginning teachers and those returning to teaching after a break in career. Possible implications of the results of this study are that curriculum aspects such as content and process coverage, emphasis on the use of technology, and bicultural perspectives that are missing from schemes, may also be missed in classroom programmes. Students taught by teachers using such schemes may not be made aware of how mathematics links with their other subjects; may not experience technology-rich mathematical experiences; and may not meet bicultural perspectives in their programme. Furthermore those taught by teachers using schemes that were prepared without accurate information regarding year 8 programmes may be exposed to content they have already been taught. All such aspects may lead to reducing student enjoyment, interest, and achievement in mathematics.

Until there is wide discussion about the necessary content and detail of school schemes, who should write them and how, or until a comprehensive and effective resource on scheme writing is published and used by schools, it is likely that the current situation of wide variation in practice will continue, and that students may not receive the mathematics education intended by the curriculum.

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