

Mathematics curriculum change in the northern territory: What do teachers really think?

**Rosemary Jacob, Northern Territory University
Sandra Frid, University of New England**

Northern Territory secondary teachers' awareness of curriculum change in mathematics and their thoughts on its impact upon teaching and learning are reported. A survey followed by semi-structured, in-depth interviews were used for data collection and analysis was done inductively. Teachers were aware of a number of changes and expressed many concerns about their impact, especially in relation to appropriate in-service opportunities. Discussion of findings in relation to geographical, educational and cultural features of the NT is included.

Background

The Northern Territory, where this study was conducted, is but one of many distinct educational contexts within Australia. During the last thirty-five years, the Northern Territory has experienced considerable change in relation to mathematics curricula and many of these changes have followed similar changes elsewhere in the country and in the world (Moon, 1986). Changes have generally been made without consideration of the unique educational environment of the Northern Territory. Although the education system in the Northern Territory holds much in common with systems in other parts of Australia, it also differs in some important respects. The Northern Territory's relatively large geographic size within Australia (about one sixth of the total land area) along with a relatively small population (170,000) makes access to educational resources difficult for a number of teachers and students. Further, the population size has made it inevitable that many primary teachers and most secondary teachers have received at least part of their education outside the Northern Territory.

In addition to recruitment of teachers from other states or countries, the Northern Territory has traditionally relied on other states for its syllabus documents. Even since self-Government (1979) the Northern Territory has continued to rely on other states, currently using the West Australian primary mathematics syllabus and the South Australian secondary school program. However, a significant fact that distinguishes the Territory from these other states is that about 30% of the population is Aboriginal. A high proportion of these people live in remote communities in which English is a second language. Provision for primary education in these communities is generally bilingual, although some students enrolled are non-Aboriginal. In schools in the towns and cities there are also ESL (English as a Second Language) students because the Northern Territory has many migrants, largely from Asian countries.

While the nature of curriculum change might vary somewhat from one country to another, or one region to another within a country, successful change is linked to the way in which changes are implemented. There is a complex interplay between curriculum change and the need for teachers to reconceptualise the content of teaching and related teaching and assessment processes. "Teachers are the essence of the innovation process and should play a major role in material development and curriculum planning, as well as being involved in the evaluation of the effectiveness of new materials and methods" (d'Ambrosio, 1991; p.84). In the Northern Territory, where curriculum change has generally occurred in response to developments elsewhere nationally and globally, where student and teacher needs differ to elsewhere in the country, and where many teachers received their training outside the Northern Territory, there are numerous questions that could be asked.

This paper reports on a component of a larger study that investigated Northern Territory teachers' and students' perceptions of their own mathematics education experiences in relation to curriculum changes (Jacob, 1997). Specifically, this paper

reports on the following two research questions from the larger, more comprehensive study:

1. What past or present curriculum changes are NT secondary mathematics teachers aware of and what do they think about these changes?
2. How do secondary mathematics teachers rate the effectiveness of their pre-service and in-service professional education, particularly in relation to preparation for curriculum change?

The importance of addressing these questions lies in the fact that curriculum changes that have occurred in recent decades in the Northern Territory have never been formally evaluated as to the extent or actual nature of their outcomes.

Three areas of research were useful in formulating this study. The first concerns the ideas of change processes as they apply to education. Teacher experiences with change processes were a focus because others (eg. Elmore, 1995; Hargreaves, 1994) have shown curriculum renewal efforts are dependent upon teachers' attitudes towards the changes and capabilities in implementing them. The second area of research is directly related to the first and concerns the nature and role of teacher professional development (eg. Taylor, 1986; Hunter, 1985; Greenes, 1989). The third area that influenced development of this study was the call for reform in mathematics education that has been pervasive worldwide in the last decade (eg. National Council of Teachers of Mathematics, 1989; Australian Education Council, 1991, 1994). Recent changes in some states in secondary school mathematics programs reflect a growing recognition worldwide of a need to re-examine the content, teaching techniques and assessment practices within mathematics curricula. These are amongst the numerous external influences that have impacted upon mathematics curricula in the Northern Territory.

Method

The study was essentially an *ex post facto* approach (Cohen & Manion, 1980). It was a survey study, based on the use of questionnaires and subsequent in-depth interviews. The choice of research design was influenced by factors such as the historical breadth of the study and the desire to obtain data from a wide range of teachers, including those from remote regions and from a range of years of experience.

A self-completion questionnaire was developed to focus on teachers' mathematics education background, their knowledge of mathematics curricula changes, and their pre-service and in-service experiences. Some questions required response on a Likert-type five-point scale or a Yes/No choice, while others were an open-ended response format inviting the individual to comment more fully on experiences.

The questionnaire was distributed to all 162 secondary mathematics teachers in the Northern Territory. Fifty-three returned completed questionnaires, one third of which were from outside the Darwin area (where most of the NT population is located), and more than 80% of whom received their own education outside the Northern Territory. Fourteen of these teachers then participated in the follow-up, in-depth, semi-structured interviews. The set of interview questions was not prepared until after examination of the questionnaire responses so that a series of themes developed from this examination could be further investigated in the interviews. Interviews lasted 60-90 minutes. Since the intent was to test the themes developed from a preliminary analysis of the questionnaire responses, it was perceived that the gist of the interviewee's contribution to the discussion, which could be recorded in note form, was of more importance than a word for word transcription. Consequently, a tape recorder was not used for the interviews. Very soon after the interviews had been completed, all the responses were recorded item by item in a consolidated point-form format. This allowed for comparison of responses from each subject for each item included in the interview (for full details of this process, see Jacob, 1997).

Examination of the data was based on an essentially interpretive approach

(Erickson, 1989) rather than quantitative methods. An interpretive approach for data analysis was chosen because it offered avenues to develop insights into the nature and development of descriptive findings. Thus, data collection and analysis proceeded in three stages: (1) obtaining information concerning mathematics education experiences related to curriculum change, (2) analysing the information to identify any relevant themes, and (3) testing these themes through further analyses of data, proceeding through a progressive crystallisation process to reach conclusions that could serve to inform future changes and future research.

Results and Discussion

Awareness of Curriculum Change

The questionnaire results indicated that most teachers were aware of a variety of aspects of a number of mathematics curriculum changes, the most prominent being: various aspects of 'new maths', increased use of investigations in mathematics teaching, increased use of calculators, introduction of the end of Year 10 examinations, and new courses in Years 11 and 12. The last of these two points are particular to the Northern Territory, although other states in Australia have also recently developed new Years 11 and 12 courses.

In reference to teachers' thoughts about curriculum changes, views were expressed that tended to support many of the changes, particularly those that resulted in students developing a greater understanding of mathematical concepts. The general picture created by questionnaire responses was that change in itself was often good. However, there were also a number of criticisms directed at changes. Highlighted in this regard were the short time lines associated with some changes, the disadvantaging of particular sub-groups of students (for example, the less able or more able students, or students with English as a second language), and lack of appropriate resources to support changes.

The five major areas of change that teachers and students expressed awareness of in the questionnaires were examined further in the interviews. A short discussion of each follows, with comments where appropriate from both the questionnaire and interviews used to support and elaborate more general summaries.

New maths: Most of the comments arising in relation to 'new maths' curriculum changes were negative in nature, and were mainly directed at three areas: (1) the fact that changes resulted in the inclusion of topics thought to be largely irrelevant for a majority of students (eg. set theory and calculations in binary and other number bases), (2) communication difficulties that resulted from the language changes introduced, and (3) the inadequacy of teacher preparation for what were perceived to be dramatic changes.

The teachers concerned with teaching higher level mathematics were most supportive of the changes introduced in the new maths. However, in general it seemed that teachers felt there had been unnecessarily sweeping changes that created barriers to implementing changes effectively (such as the language referred to earlier). They expressed beliefs that more gradually developed change processes might have been better received and might have been more effective in the longer term.

Mathematics investigations: Support for using investigations in teaching mathematics was not extensive. Some of the more experienced specialist teachers felt capable of determining when and how to use investigation approaches in their teaching, while less confident or less qualified teachers expressed uncertainties. This latter group perceived there to be a lack of appropriate professional development in using investigations, and they expressed doubts about students' capabilities to do them, making comments such as: ". . . some very weak students do not have the ability to draw the conclusions expected from them. More able students might be frustrated" (Teacher 12).

Issues raised about difficulties associated with investigations were in the contexts of possible learning disadvantages and the time-effectiveness of this approach. In relation to the first of these points, some teachers expressed concern that students might

'discover' an outcome that is later proven to be incorrect or incomplete, resulting in a sense of confusion or a loss of confidence. Some of the interviewees expressed concern that there were teachers whose competence in using investigation techniques was questionable.

Some of the questionnaire responses indicated a concern that investigation approaches were time consuming to an extent that was disadvantageous for those students wishing to pursue mathematical studies at higher levels. Also, quite a few of the replies indicated that teachers were aware that investigative methods are a valid option but not the only suitable one: "Being used too much. Investigative learning is not a good basis. SOME investigation is GOOD. Talk about it, write about it. But TOO much is a total waste of time. Should be used for a purpose" (Teacher 12). "Is a risk of over doing it. Value of investigation is to engender understanding - it is not an end in itself" (Teacher 39).

Increased use of calculators: Teachers were aware of the increased use of calculators at all levels of mathematics. They had many opinions as to the optimum stage at which calculators should be introduced, but there was a common theme of a need to have some basics, including paper and pencil skills. A prevalent theme of their responses was the concept of the calculator as a tool, along with an awareness of the fact that it is more appropriately used in some situations than in others.

Year 10 examination: The Year 10 examination was introduced into Northern Territory schools in 1989. Some teachers saw it merely as another assessment item (the result contributes a maximum 30% of the final Year 10 mark which is recorded on the Junior Secondary School Certificate or JSSC), while others saw it as quite unnecessary and disruptive. None of the teachers provided a wholeheartedly positive response to questions concerning whether this examination tests effectively the aims and objectives of the current junior secondary mathematics courses. Their main criticisms were directed at the fact that only a relatively small number of students leave formal education without any certification beyond the JSSC, and so the educational reasons for having an examination at this stage of school are unclear. Further, the examination results are not used in determining an appropriate choice for a student's Years 11 and 12 mathematics courses.

New courses in Years 11 and 12: Among the most recent changes in Northern Territory secondary schools has been the introduction of new courses for students in the post-Year 10 (ie. post-compulsory) stages of education. Teachers did not feel they had been sufficiently informed and prepared to implement the new courses. More experienced and qualified teachers appeared to have coped better with the changes, as they felt competent to use their own initiative to make any adjustments they felt would be advantageous for their students. They were still in most cases critical of the way in which the courses were introduced, indicating that "Clear information was not available soon enough nor enough in-servicing" (Teacher 23) and they were ". . . not given enough time to write courses" (Teacher 22). This latter comment was made by a teacher involved with distance education. It is of significance in the context of the Northern Territory because distance education is an essential and significant component of the Northern Territory education system. Since resources and support mechanisms for distance education students must often be developed from scratch, it is not surprising that teachers responsible for these developments felt extreme time pressures when new courses were introduced. Clearly the inclusion of distance education within the Northern Territory education system warrants special consideration when curriculum changes are introduced.

Additional Thoughts about Curriculum Change

When the questionnaire and interview data were analysed, it became clear that as teachers identified areas of curriculum change of which they were aware, they had a

range of concerns supplementary to those related to these areas. These included concerns about: the rationale for changes, the ways changes were introduced, the impact of some of the changes, and the impact upon their own self as a professional.

Rationale for and implementation of changes: The rationale underlying change was an issue raised in many of the questionnaire responses. Some responses indicated a high level of cynicism towards curriculum change. Others indicated acceptance of the need for change, while also being critical of some ways it had been introduced. For example, the following comment from a teacher reflects both positive and negative reactions to changes:

Has been a lot of change and it comes faster. We have to have tools to cope with this increasing speed. Ask 'How is it affecting you?' Have been disappointed by invalid change (eg. Year 10 exam). Who uses a JSSC? Minority of change has resulted in growth. If suitably prepared and professionally oriented, change is no threat. (Teacher 12)

In relation to these concerns, the following main points arose from examination of questionnaire data:

- pilot schemes or trials were not used or were not extensive;
- adequate preparation to teach for the changes was not offered to teachers;
- experiences of other States who had introduced changes were ignored so mistakes were repeated;
- changes occurred after an interval too short to permit valid evaluation of the previous change.

Examination of whether change is meeting the presumed purpose of being beneficial to all students was a theme of the interview questions and resulted in comments such as: "Year 10 exam was externally imposed and not beneficial. Change for change's sake. Now more analysis. More trialing needed. Imposing change is ineffective. Change people's values etc first" (Teacher 27). "Needs maybe to be more selective so that the disadvantaged benefit without removing advantage from the rest. Change should be gradual. Difficult to teach something which you feel uncomfortable with" (Teacher 48).

Change was generally seen as being imposed from outside, in the absence in many cases of prior discussion, trialing or professional development, as is reflected in the following comments: "Developments have been well researched (not Year 10 exam) but method of introduction has not been very professional or supportive" (Teacher 33). "Well meaning but sometimes lacking in planning, training and resource allocation" (Teacher 2).

Impact of prescribed teaching and assessment strategies: The teachers' comments tended to support the notion (particularly in relation to investigations) that prescribing a teaching strategy can be counter-productive and could disadvantage some students. It seemed clear that those teachers who were adequately prepared mathematically and pedagogically felt they carried out their job in a highly professional manner. This included using whatever strategies they perceived to be the most suitable for the particular situation and the students involved. This seems to imply that provision of professional development for those teachers less confident or less prepared mathematically would be more appropriate than the prescription of teaching strategies which might not even be within an individual's current repertoire. They would then be able to select a teaching/learning strategy appropriate for the student(s), the situation, and the specific ideas to be learned.

Increased interest or disillusionment : Many of the teachers expressed increased interest in and enjoyment of mathematics as a result of more recent curriculum changes,

saying things such as: "I enjoy teaching! The interactive nature of today's maths education means far more relating to students, discussions about content, context, historical bases, philosophy, new ideas and always opportunities to reflect on and evaluate the above. I love it!" (Teacher 38).

It was clear from others' comments that not everyone shared the same joy and satisfaction. Instead, they saw weaknesses in the approaches or had become disillusioned with them. Examples of comments made in this regard are: "I think new Maths teaching methods don't allow for a full understanding of the subject, too fragmental" (Teacher 24). "Senior Maths classes have little background at Maths due to new courses diluting the difficulty level. Even junior classes often see the hands on as 'playing', even though it does help them with concepts" (Teacher 25).

Teaching to a diverse student population: Amongst the wide range of factors associated with a diverse student population, including language, cultural, social, economic, ability and attitudinal factors, what teachers commented on most were the difficulties that arise in catering for the least able and most able students. Many felt that when resources are limited, more effort is put into assisting students of lower ability, putting at risk the full development of the more able students. They felt that making mathematics more accessible to all students had resulted in a loss of mathematical rigour, and an injustice for more capable students. They expressed concerns that more capable students were overlooked, it being assumed that they had the ability to achieve with or without challenge or assistance. For example, their comments included the following: "We have in many cases disadvantaged the more able students. Assumption that bright ones can continue unaided" (Teacher 22).

Amongst the other comments expressing the teachers' thoughts on the issue of high and low achievers were the following: "Should encourage high achievers. This is not elitism. All should have equality of opportunity" (Teacher 33). "Anyone who enjoys and has potential should be facilitated. Resources are wasted because the system is aimed at mediocrity. Very weak students need a more integrated program. System cannot handle the variations" (Teacher 1). These issues were discussed at the interviews and can be summarised as:

- some schools have a policy of attempting to encourage equity by ignoring the specific needs of those talented in a particular academic area;
- some teachers felt that the term elitism is used inappropriately, since assisting high achievers should be an integral part of assisting all students;
- being innately able does not prevent poor teaching from reducing a student's achievement;

With few exceptions, all people interviewed regarded it as important that the more mathematically able students should receive an effective level of teaching but, just as their needs should not be disregarded, neither should they benefit at the expense of their less able peers. These points once more present a picture of the pressure that teachers work under in trying to use limited resources to meet the very diverse needs of their students.

Pre-Service and In-Service Experiences

Teachers in general seemed to find their pre-service training of limited value and they stated that later experiences had been more helpful and influential in their teaching. They appreciated that professional development activities can and should be undertaken within schools and professional groups, but also felt strongly that the Department of Education has a major role to play. This was seen as being particularly true when major changes occur and it was suggested by some that a more effective use of the resources of the Northern Territory University could be beneficial. Those whose preparation for teaching did not equip them to teach mathematics felt more so than others that in-service professional development had been inadequate in meeting their needs. Continuing professional development was therefore seen as the key component of any change efforts. That is, to ensure curriculum change is effective, professional development must

be provided: "If department wants this done properly then in-service activities must be done" (Teacher 27). There was also a perception that failure to provide necessary assistance in situations of curriculum change could have a negative effect on students' confidence and capabilities.

Teachers employed in the larger urban schools generally felt the assistance they received from colleagues could go a long way to supporting their professional development. Those employed in smaller or more remote schools lack this opportunity, in addition to the other disadvantages of their remoteness. Since a possible consequence could be that their students might be offered a less adequate mathematics education than those in the urban schools, the long term disadvantages to these students could have a social cost greater than the monetary cost required to offer the appropriate professional development activities and resource materials.

The question of the time interval between a decision to introduce a change and the actual date of full implementation was an issue that was often raised by the teachers. If this interval is of a suitable duration, there is time for adequate Departmental support, and time for teachers to develop networks, between as well as within schools, to provide the necessary opportunities to update knowledge and resources.

Conclusions

In summary, it can be said that although in general teachers welcomed change and saw it as both necessary and appropriate, they were critical of the manner in which change was often introduced: lack of consultation with teachers, inadequate preparation of teachers, and absence of appropriate evaluation or modification of changes. Criticism was also aimed at changes made without the decision makers providing evidence of likely improvement in educational outcomes, but rather, in relation to political issues.

This study raises a number of noteworthy issues related to effective curriculum change. What is of most significance from these findings are those issues which the key participants in change, the teachers, saw as essential factors in any changes: the opportunity for them to participate in change related decisions at system as well as classroom levels, the gradual introduction of change supported by appropriate and ongoing professional development activities, and the need to adapt changes to meet the needs of students in diverse language, cultural, social, economic and geographical situations. Finally, a major issue that emerged in this study's findings that is in need of much further study because it questions the actual impact of any changes on student learning, is the fact that teachers expressed strong opinions that the most important factor related to student learning was the personality and personal teaching style of the teacher.

In so far as there will always be a time delay, it seems important to ensure that when new programs are implemented they have been subject to rigorous prior scrutiny through trialing or some similar process. It is also important to ensure they are implemented by teachers who are appropriately prepared. Secondary teachers in the Northern Territory do not perceive either of these points as having occurred. It is therefore important that a continuing evaluation process be conducted to ensure that gradual change to adapt to changing needs replaces the previously experienced radical change in a climate of under preparedness.

Above all, given the importance of mathematics and the fact that it is unlikely that in the near future the Department of Education of the Northern Territory, in common with other education authorities, will be able to recruit sufficient appropriately trained mathematics teachers, acceptance of a need for continuing and thorough professional development at all levels is an issue which must be given adequate consideration.

In a more general sense, the findings of this study have importance internationally for the insight they can offer into effects of curriculum change as they pertain to a variety of educational and cultural situations, be that between one country and another, or within a single country composed of diverse educational and cultural needs. More specifically, it is clear that curriculum changes cannot be transferred in a 'ready-made' format from one educational context to another. Although this is not a 'new' claim within the research

literature on educational change, it is highlighted here in a context previously under examined - that of the Northern Territory. This study highlights specific needs within the Northern Territory for provision of professional development of secondary mathematics teachers with little background preparation to teach mathematics, or who work in remote regions where there is little opportunity for professional development interactions with colleagues. Any curriculum changes in the Northern Territory should therefore also involve more extensive consultation with 'local' educators, and a more feasible time frame in which to educate for changes in philosophy, teaching or assessment methods. Resources made available to support networking of teachers, or opportunity for further in-service programs with the Department of Education or the Northern Territory University, would also be beneficial in assisting isolated teachers in their professional development, particularly in relation to curriculum changes.

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