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ABSTRACT

This study examined secondary teachers' and recent secondary school graduates' awareness of curriculum change in mathematics and its impact upon teaching and learning. Fifty-three secondary teachers and 54 students enrolled in first year university programs at Northern Territory University (Australia) were surveyed about their awareness and opinion of mathematics curriculum changes as well as impressions of their own mathematics education. Teachers were also asked about their pre-service and in-service training and its effectiveness in relation to implementing curriculum changes. Follow-up semi-structured in-depth interviews were conducted with 14 teachers and 12 students. Results indicated that the teachers were more aware than students of curriculum changes, and the areas they discussed most were: new maths, mathematics investigations, increased use of calculators, the end of Year 10 examinations, and new courses for Years 11 and 12. Teachers indicated both pre-service and in-service education had inadequately prepared them to implement curriculum changes. Both groups indicated the importance of the teacher's personality, the negative impact of prescribed teaching, and the role of rote learning. The questionnaire is appended. (Contains 21 references.) (Author/JLS)

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Curriculum Change: What do Teachers and Students Really Think?

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Curriculum Change: What do Teachers and Students Really Think?

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This paper reports on research into secondary teachers' and recent secondary school graduates' awareness of curriculum change in mathematics and its impact upon teaching and learning. The study was based in the Northern Territory of Australia, where the educational system uses curricula developed outside that region, where many students are educated in small isolated Aboriginal communities in which English is a second language, and where a large portion of the teaching force is recruited from outside the region. 53 secondary teachers (of a total population of 162) and 54 students enrolled in first year university programs were surveyed about their awareness of mathematics curriculum changes and what they think of them, and impressions of their own mathematics education. Teachers were also asked about their pre-service and in-service training and its effectiveness in relation to implementing curriculum changes. Follow-up semi-structured in-depth interviews were then conducted with 14 teachers and 12 students. Results indicated that teachers were more aware than students of curriculum changes, and the areas they discussed most were: 'new maths', mathematics investigations, increased use of calculators, the end of Year 10 examination, and new courses for Years 11 and 12. Teachers and students also expressed a number of concerns with regard to these five areas and their impact on teaching and learning. From both groups also emerged a number of themes in relation to their experiences in their own mathematics education: the role of a teacher's personality, the negative impact of prescribed teaching or assessment methods, the role of rote learning, increased interest or disillusionment as a result of curriculum changes, working with a diverse student population, perceptions of mathematics and mathematics learning, students' confidence, and the use of technology. Teachers indicated that both pre-service and in-service education had been inadequate to prepare them to implement curriculum changes. Discussion is included into the implications of these findings for future research and any future implementation of mathematics curriculum changes.

INTRODUCTION

Mathematics curricula worldwide have seen many changes in the last few decades, beginning in the 1960's with the advent of 'new maths' and continuing most recently with reform efforts aimed at developing curricula that focus on conceptual understandings and 'mathematics for all' (Moon, 1986; International Commission on Mathematical Instruction, 1979). Education has been evolving in an attempt to keep pace with changes in society. For example, to deal with higher retention rates in secondary schools that have arisen from increasing levels of unemployment and advances in technology, an increased range of course options in secondary schools has been developed to cater for a more diverse student population. At elementary school level there have been efforts to decrease rote learning of arithmetic facts and procedures, and increase understanding of mathematical concepts and processes.

The pressures that led to these and other changes were pervasive and included the political, economic and technological changes following World War II, changing views of the nature of mathematics, development of new theories of learning, and broadening of the purposes of education (Moon, 1986). Initiatives to reform mathematics curricula often developed in parallel in the USA and Europe and often flowed on to other

countries, including Australia.

Importing curriculum changes from one country to another does not necessarily result in predictable, effective outcomes. The differing cultural, social, economic and geographic milieus engender different educational needs. For example, d'Ambrosio (1991), in discussing the movement to modernise the mathematics curriculum in Brazil, noted that the "concoction of ideas from around the world" (p.71) was inappropriate for a developing country with a different cultural environment. Even within Brazil the development of a program in Sao Paulo, at that time the "dominant city in the country" (p.73), resulted in innovations "inappropriate for other [rural] areas of the country" (p.73). Further, reliance on textbooks translated from other languages (usually English) led to misconceptions about the meanings of terms and misunderstandings of related teaching processes. Thus, the changes "which actually occurred in the classroom were apparently quite different from the intended curriculum" (p.76).

Despite being a developed rather than a developing country, Australia's experiences in relation to curriculum change initiated elsewhere have not always been different to Brazil's (Mathematics Education Research Group of Australasia, 1984; McDonald, 1975). Admittedly the main sources of influence, the UK and the USA, share the same language, but geographically, politically and culturally Australia is distinctly different to Britain and the USA. In fact, even within Australia, much diversity exists with regard to physical and social environments and their impact on education.

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. 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 (1978) the Northern Territory has continued to rely on other states, currently using the Western 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 reform might vary somewhat from one country to another, or one region to another within a country, successful reform is linked to the way in which curriculum changes are implemented. If any of the participants in the process, which include governments, educators at all levels, textbook publishers and a broad cross-section of individuals and groups in the general community, is ineffective in the process, the entire reform effort is put at risk. It is therefore important that the process be monitored, in the long as well as short term, to ensure that outcomes are those intended and that modifications are made as required. What also must be highlighted is the 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). They should play a role in the decision making processes associated with curriculum changes and subsequent in-service professional development needs.

In the Northern Territory, where curriculum change has generally occurred in response to developments elsewhere nationally and globally, where student and teacher needs differ substantially to elsewhere in the country, and where many teachers received their training outside the Northern Territory, there are numerous questions that could be asked. For example: How does a situation in which mathematics curriculum change is occurring in response to developments elsewhere in Australia affect learning outcomes? In what ways are outcomes monitored in order to evaluate the effects of change? If changes in curriculum content and teaching methods occur with a high degree of frequency, how can pre-service education prepare teachers for regular adjustments? Are teachers' professional development needs being met? Which agencies (government or teacher professional associations) should be responsible for professional development?

To attempt to answer all these questions would require several research projects. Hence, this study only aimed to investigate current teachers' and students' perceptions of their own mathematics education experiences in relation to curriculum changes. Specifically, the study focused on the following three research questions:

1. What past or present curriculum changes are secondary mathematics teachers and recent secondary students 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?

3. What are teachers' and students' impressions of the mathematics education they have received?

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. 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. Further, the findings are of importance in guiding curriculum change in sound and productive ways, including factors related to teacher professional development and the education of diverse student populations.

THEORETICAL FRAMEWORK

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. In the context of mathematics professional development this includes issues related to knowledge of mathematics content and knowledge of mathematics teaching methods. Some mathematics educators have referred to these two separate yet intertwining facets of mathematics teaching as the "teaching of new maths" and the "new teaching of maths" (eg. International Commission on Mathematical Instruction, 1979; p.25). Studies have shown that increasing the mathematical knowledge of teachers does not necessarily have

any positive effect on the outcomes of their teaching (d'Ambrosio, 1991). Rather, greater teacher involvement in the decisions related to changes have been stated as essential for change to actually occur (d'Ambrosio, 1991; National Research Council, 1989):

> Where teachers were not directly a part of the development procedure, where the ownership of the product was not ensured, where teachers considered district acceptance of the curriculum as a top-down imposition, the revised programs did not last. Where parents could not (or did not) understand the need for change or the reasons new curricular emphases were chosen, resentment and anger resulted and a solid conviction set in that if the "old math" was good enough for parents, it was good enough for their children. (National Research Council, 1989; p.79)

In relation to curriculum change, Taylor (1986) also drew attention to the importance of provision of professional development that integrally involves teachers in the change process: "A one-shot in-service program . . . will have little lasting effect on teaching practices" because teachers must "have opportunities to practice and incorporate identified methods in their classrooms through a support network or coaching" (p.17). That is, whatever strategies teachers might have learned during pre-service training, or even in subsequent in-service activities, changing approaches to teaching and curriculum change bring with them a need for teachers to develop new techniques. They require help in this process. "A professional . . . has never finished learning . . . . systematic and periodic renewal is essential for both teachers and administrators" (Hunter, 1985; p.60). A similar point is made by Greenes (1989) in discussing the *Curriculum and Evaluation Standards for School Mathematics* and *Science for All Americans,* the initiatives for reform in mathematics and science in the USA:

> However, neither report contains curriculum models and blueprints for reformed teaching and testing. Both statements are open to the criticism that they tell mathematics educators what they need to do, but do not show them how to do it. Therefore, even with the good start these reports give us, we continue to need a comprehensive mathematics curriculum with a broad teacher training component if we are to improve the teaching and learning of mathematics for all children. (p.8)

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. Publication of the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989) has provided direction for curriculum development in North America in recent years. More recently, in Australia, publication of *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991) and preparation of *Mathematics - A Curriculum Profile for Australian Schools* (Australian Education Council, 1994) has moved the national agenda for mathematics education in the direction of outcomes based planning and assessment. Both the North American and Australian documents have prompted numerous position and discussion papers, articles on teaching, and research reports. Resultant discussion, debate and action within the mathematics education communities have produced many questions and issues in relation to mathematics learning and the current state of 'knowledge' in mathematics research (for example, see Sierpinska, Kilpatrick, Balacheff, Howson, Sfard & Steinbring, 1993; Silver & Kilpatrick, 1994).

In Australia, recognition of the essential role of mathematics in educational programs can also be seen in recent efforts to relate aims and achievements in mathematics education to societal contexts, employment and national needs (for example, see the Finn Review, 1991; Mayer Committee Report, 1992; Willis, 1991). 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 AND DATA SOURCES

The context of this study is that of an educational environment of relative isolation within a larger, more dominant cultural, geographical and population setting. This region is geographically and culturally distinguished from the surrounding states in that its small population is spread across a relatively large geographic area, with many students living in remote communities, many students of Aboriginal heritage, and a teaching populace educated outside this environment.

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 students and teachers, including those from remote regions and teachers from a range of years of experience. Examination of the data was based on an essentially interpretive approach (Erickson, 1989) rather than quantitative methods. This decision was influenced by the fact that it cannot be claimed that local conditions and needs experienced by Northern Territory teachers and students are typical of the larger national or international population, and that the nature of the information provided by statistical analyses would limit the scope of any conclusions. In comparison, a more interpretive approach for data analysis could provide insights into the nature and development of descriptive findings.

Questionnaire

A self-completion questionnaire was developed. It consisted of a total of 40 questions organised into four sections (see Appendix A). The first section provided a brief history of respondents' mathematics education, while the second section related specifically to changes in mathematics education that had affected respondents either as students or as teachers of mathematics. The focus of the third section was on the ways respondents had been taught mathematics. Each of these three sections was included for all subjects, with response options allowing for the possibility that some items might not be applicable to students. The final section, which was only included in the questionnaire for teachers, was designed to explore experiences in teachers' pre-service programs and subsequent professional development activities. 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 in 1994 to all 162 secondary teachers in the Northern Territory and 150 students enrolled in first year education, science or technical trade programs at the Northern Territory University. Most of these students had completed their secondary education in the Northern Territory. Fifty-three teachers and fifty-four students returned completed questionnaires.

Interviews

Fourteen teachers and twelve students who had completed the questionnaire also participated in 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. Once interview items were prepared, copies were printed in order to permit the interviewee to read the items, having a copy in sight throughout the interview. This enabled clarification of the intent behind the item as well as discussion of the nature and basis of related responses. Of the items developed, eleven were in common to both teachers and students, while a further twelve were essentially the same, having only minor variations. The total number of items for discussion with the teachers was thirty five and for students it was thirty-one. The list of interview items can be found in Appendix B.

Interviews were conducted in July and August 1994. They were conducted at a time and place determined by the interviewee (usually the person's workplace or home), and they were all conducted by the same researcher. Interviews lasted 60-90 minutes. The researcher presented each interviewee with a copy of the items, read each item out prior to discussing the specific details, and clarified any aspects of the item that the interviewee might have found were not immediately clear. The printed form was prepared with space for responses to be recorded by the interviewer. 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).

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

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. There was a greater awareness among teachers than among students, results which were anticipated. From both teachers and students the five main areas of change noted were: 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' and students' 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. 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.

1. 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 mathematics in more specialist contexts 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.

2. *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. Some of the teachers' comments related to these issues included the following and highlighted the ambiguity associated with using investigation approaches in teaching mathematics:

> No [not appropriate] - because of the push to get a senior secondary education. 25% are incapable of doing a quality DI [directed investigation] or project. There is a need to structure the work for the clientele. (Teacher 44)

> . . . some very weak students do not have the ability to draw the conclusions expected from them. More able students might be frustrated. (Teacher 12)

> It is [a good approach] if they are practically oriented. Some do not do it. Cannot be too extensive but they have difficulty following through. Must be directed and short (brief attention span). (Teacher 48)

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. Although the interviewees expressed some concern that there were teachers whose competence in using investigation techniques was questionable, they seemed to feel that the potential for long term damage was nevertheless at an acceptable level. One teacher did however bring out an interesting point when she said "It is all right to be wrong" (Teacher 50). This comment is in stark contrast to the traditional view of mathematics, particularly arithmetic, as leading to one acceptable, right answer. She also rejected the concept of learning facts on a once and forever basis: "Checking and testing is an important part of investigation. Teacher must be in control. Must guide. It is all right to be wrong" (Teacher 50).

Some of the questionnaire responses had 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. Quite a few of the replies indicated that teachers were aware that investigative methods are a valid option but not the only suitable one:

> Investigations should be part but not the only tool used. (Teacher 13)

> 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)

Few of the students had experienced using investigations as an identifiable learning strategy. However, interestingly, the concept of mathematical knowledge being open to modification was evident in the students' comments, as was the notion of multiple solution strategies:

> Teacher must be aware of outcomes. Is responsible for avoiding problems. Should also share alternative answers with whole class. (Student 39)

> There are no universal truths in maths. There is always more to be discovered. Use this approach as a basis for teaching. (Student 45)

Some students saw investigation strategies as possibly inappropriate for at least some students:

> Most effective method varies with the student. (Student 54)

> Need both to find out through investigations but can also take some knowledge on board. Time factors need to be balanced. (Student 51)

> Could be overdone. Need to consider students. Attention span may not be suited to an investigation approach. (Student 39)

The teachers' and students' comments tended to support the notion that prescribing a teaching strategy can be counter-productive. Rather, it is better to provide teachers with a level of skills that enables them to select a teaching/learning strategy appropriate for the student(s) and the specific ideas being learned.

3. Increased use of calculators

The introduction of calculators into many classrooms and the reduction in emphasis in primary school on learning multiplication tables are among the technological changes which have occurred in recent years. Public comment on these issues has been more common than on many other recent changes. *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991) iterates (p.23) the national calculator policy recommendations that state all students should have ready access to these tools.

Some teachers indicated they adopt this policy from the earliest stages of education and aim to replace the learning of tables by suitable calculator activities. Teachers 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. The concept of the calculator as a tool, with presumably an awareness of the fact that it is more appropriately used in some situations than in others, was a theme of some of the teachers' responses.

The students' responses about issues on calculator use were interesting. Most of the replies indicated a similar level of concern to that of the teachers in relation to the importance of the basics and the need for estimation. However, some students indicated a clear preference for paper and pencil methods and a feeling that they were advantaged in being more competent in the mental arithmetic area than were many of their peers. Several students indicated that they would prefer the introduction of calculators to be postponed until some time in secondary school. One student who had recently completed secondary school regarded it as important enough to note that "Fractions and manipulating numbers should be learnt" (Student 28).

4. 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. Examples of students' comments in relation to the Year 10 examination are the following:

> First year of end of Year 10 exam. Exam did not relate to course. Students felt, unjustly, that they had 'failed'. Teachers dismissed the exam as unimportant. . . . May have improved since. Inappropriate to have externally set exam in Year 10 yet not in Year 11 (Student 54).

> Thought it was for Year 11 placings [but it was not]. (Student 53)

5. 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 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.

Thoughts about Curriculum Change

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 in which 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 reforms were ignored so mistakes were repeated
- changes occurred after an interval too short to permit valid evaluation of the previous change

Although comments from students did not indicate as high a level of awareness of changes as the teachers, they still had opinions about change in general:

> It seems like change for the sake of change. Not thought through first. Use kids as guinea pigs. (Student 52)

> The life cycle of changes is so small that it cannot be properly evaluated. (Student 28)

> Not aware of change until recently. Maths is becoming more fun and more relevant. (Student 39)

Looking at change from a different point of view and examining whether it is meeting the presumed purpose of being beneficial to all students was the subject of one interview item. Some of the responses were not entirely reassuring:

> 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)

> Recent changes have been more acceptable. New maths and Year 10 exam are more open to question. There is a need to stop and consolidate. Learning from past experiences is important. (Teacher 33)

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)

> Too much ad hoc. Too few involved. Belated canvassing after but not before. Few people have a big say. (Teacher 38)

> A good teacher will introduce change as needed. Education changes are more frequently imposed from without. (Student 51)

Some teachers felt that changes aimed at 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)

> In year 9, a small group at the top are held back and a quite sizeable group at the bottom are not being helped enough. In a large class (30) there is not enough opportunity to stretch them enough. (Teacher 39)

Pre-Service and In-Service Professional Development

Pre-service preparation was not generally highly regarded by the teachers in relation to developing one's capabilities as an effective teacher throughout ongoing educational changes. Experience was seen as being the most important influence, which begs the question of what happens to the classroom students through whom this experience is gained. The responses indicated that most teachers only really start coming to grips with the job of teaching when they have completed the pre-service activities. For example:

> I learnt most of my teaching techniques in my first year of teaching (1969). I feel that my time spent at university was useful in that it gave me greater depth of Maths than I would need at high school (ie. teaching). My time at Teachers College was a complete waste of time except for the practical teaching sessions. (Teacher 13)

Clearly, provision should be made for some continuing assistance and support, as well as for regular in-service activities to be fairly readily available to teachers. From the questionnaire responses, this need appeared to be greatest for teachers required to teach mathematics without prior training to do so.

Changes in courses, whether affecting content or teaching method, result in a reasonably large number of teachers feeling a need for some assistance. Questionnaire and interview responses indicated that this need is not being met to a satisfactory level for quite a few of them. For example:

> In-servicing for secondary Maths is virtually non existent especially that provided by the Department. New syllabi and teaching strategies are introduced usually with no in-servicing. Teachers support each other rather than being supported from the Department. (Teacher 10)

> Less available in last 5 years. NTU [Northern Territory University] has good facilities for those who wish to do full courses (as pre-service or to further their own education). Private reading and MTANT/AAMT [Mathematics Teachers Association of the Northern Territory / Australian Association of Mathematics Teachers] provide most opportunities - but these are not available systemically. Education Department [ie. state department or ministry of education] really does need to provide more to help teachers at all levels. Networks are very important these days. (Teacher 33)

Thus, it appeared that pre-service training was seen as having little importance in relation to the ability to be effective both in the wider role as a teacher and in relation to subject area specialisation. Experience was seen as being a much more important factor, and there was awareness of a need for continuing professional development. This in turn was seen as being of much greater importance for the teacher required to teach outside the originally chosen specialist area. There was also a perception that failure to provide necessary assistance in situations of curriculum change could have a negative effect on the confidence of the students.

Continuing professional development was 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)

This teacher indicates she sees at least part of the responsibility for professional development as lying with the state Department of Education.

Twelve of the fourteen teachers interviewed clearly saw the Department as having some role to play, even if only as a facilitator. It was suggested that responsibility lay at different levels, depending on circumstances, which included resources within the school as well as from the Department of Education or the Northern Territory University. The responses generally indicated that teachers realised that some in-service needs should be met through the use of a school's own resources of more experienced staff. In the situation of more sweeping changes or more fundamental training needs, it was perceived that there was a definite role for the university in providing appropriate support courses.

Teachers employed in the larger urban schools generally felt they received assistance from colleagues that could go a long way to supporting their professional development needs. Those employed in smaller or more remote schools would be less likely to have such opportunities and would also be more likely to be affected by the difficulty of ready access to resources appropriate for revised courses. The question of the time interval between a decision to introduce a change and the actual date of implementation was an issue that was often raised that required consideration. 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.

Internal school politics obviously have a bearing on the issue of school-based support of professional development. Sometimes in-service activities are available but information about them is not passed on to teachers, not all of whom belong to a professional organisation through which the information would be more readily accessible. It was also suggested by one respondent that there was "No serious cooperation between Northern Territory University and the Department of Education" (Teacher 1), and that this deficiency should be remedied to further develop professional development activities for teachers. Perhaps this is a consequence of a historical situation which has led to a perception of the Northern Territory University as having only a minor part to play in relation to the pre-service preparation of teachers and that being mainly in the primary school area.

While teachers did indicate they see their professional development as something for which they must take responsibility, there was a general feeling that the Department of Education had some obligation to facilitate professional development, particularly for those teachers required to teach mathematics with no prior specialist training. The impact on students of ineffective mathematics teaching at primary level was expressed as a related issue of concern.

It appears that those teachers whose preparation for mathematics teaching has been minimal have experienced greater problems when curriculum change, unaccompanied by appropriate in-service activities, has been introduced. The following comment by a teacher illustrates this point:

> I feel that as a new teacher, JSSC and moderation procedures for Yr 10 & Stage One [grade 11] could have been explained at an in-service held by the moderator. Also on 'EMTs' [Extended Mathematical Tasks], 'DIs' [Directed Investigations], what is expected, what is good, bad etc., so I could have some strong ideas before I started. Not just 'I hope this is alright! ' (Teacher 8)

In the event of curriculum change, these teachers are more likely to require professional development activities to assist them to make the necessary adjustments.

While those teachers who work in the larger urban schools may be able to obtain an adequate level of assistance from peers, others in more remote locations 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.

Perceptions of Mathematics Education

A number of prominent factors emerged in relation to experiences as a mathematics teacher or student, including: (1) the important role in learning of a teacher's style and personality, (2) the negative impact of having prescribed teaching or assessment methods, (3) the positive as well as negative role of rote learning, (4) increased interest or disillusionment as a result of curriculum changes, (5) teaching methods aimed at addressing the needs of a diverse student population, (6) changing perceptions of the nature of mathematics and mathematics learning, (7) students' confidence, and (8) attitudes towards the use of technology.

1. Teacher personality

Of primary importance in the students' thoughts about their mathematics learning was that they felt their experiences and success in mathematics were more affected by teacher personality factors than by any particular teaching or assessment method. This finding is of significance in relation to promoting educational changes in that it implies content or teacher and assessment methods might not be as integral to student learning outcomes as is generally believed. Most students made direct reference to teachers and they implied or stated quite explicitly that as students at school their understanding, enjoyment or level of achievement had been directly related to the way in which the teacher related to them. Sample comments with respect to this issue were:

> The teacher I had for maths was a heavy influence on whether I enjoyed it or not. If the teacher was patient and understanding I usually enjoyed it. However, if the teacher was overpowering, 'scary' and hard to understand then I didn't enjoy it. (Student 42)

> During my secondary education, I along with the rest of the class, because of the teacher failed year 10 maths. I was in the top maths but after this experience I no longer felt confident in maths and therefore I am now able to do only basic business maths. (Student 31)

> Teacher is important. Needs to care as well as have knowledge. Teacher is a facilitator. Also needs to have confidence. (Student 12)

> Not sure about the approach. Certainly the teacher is important. Enthusiasm in the teacher can fire the students up. (Student 51)

It would seem that, from the students' perspectives, the teacher's knowledge was in many ways less important than her or his ability to engender enthusiasm and display a caring, approachable personality. Nevertheless, teaching method was also seen as important, as is shown in the comments belwo:

> System experienced in Alice Springs caused problems. One was right or wrong. Ineffective approach for many, though not for all. Progress with some teachers is better than with others. (Student 45)

> Some students' learning is heavily affected by method used. Style of teaching. (Student 39)

2. Impact of prescribed teaching and assessment strategies

In discussing prescribed teaching and assessment strategies, teachers' and students' responses indicated they felt having one prescribed set of strategies can be disadvantageous for some students. It seemed quite clear that those teachers who were appropriately and adequately prepared 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 implies that provision of professional development for those teachers less prepared or confident would seem more appropriate than the prescription of teaching strategies which might not even be within the individual' s current repertoire.

Some teachers made it clear that they were always prepared to use their professional judgment, while others saw it as necessary to adhere as closely as possible to any stated requirements:

> . . . because you must meet assessment requirements. Any objections must be properly pursued. Consult with moderator. Should be given scope to choose strategies. (Teacher 44)
>
> Preferred strategies are not necessary. Indications, yes. (Teacher 1)
>
> Recommendations are useful as guidelines but feel free to use alternatives. Part of professional status. (Teacher 48)

The teachers interviewed felt that, unless a specific method were prescribed for educationally sound reasons, it was wrong to penalise a student for using a different but valid method. Nevertheless, some students reported that they had experienced the situation of losing marks because of using a non-standard method and felt this was unfair, particularly as they felt that this was a consequence of mathematics being taught by someone insufficiently knowledgable about mathematics. Comments from both groups included the following:

> It is wrong - if answer and procedures are correct then no penalties should apply. This is assuming that a specific method has not been clearly required. (Teacher 33)
>
> Annoys me. Should be allowed to use any valid method unless a specific method is stipulated. (Teacher 13)
>
> Should get full marks for a valid method but draw attention to better (more appropriate) method. (Teacher 22)
>
> There is a degree of judgment involved and it is bad if the penalty is applied because the teacher does not know another method. Maturity of method is important. Answer is often unimportant. (Teacher 1)

3. The role of rote learning

The issue of rote learning was pursued in the interviews because it had been raised by a number of respondents on the questionnaire. In current educational circles, teaching for understanding is stressed and references to rote learning tend to be derogatory. Several interviewees experienced rote learning as students. Some saw that it could be appropriate, while recognising that ultimately understanding was of paramount importance:

> Rote learning has its place. Teach for understanding BUT rote methods provide an alternative. It is a sort of sausage machine method. (Teacher 44)
>
> If a student is comfortable with rote learning and limiting available approaches, must accept it. Still offer choices of approach and leave student to choose. (Teacher 27)
>
> Rote learning is useful. Learning for understanding is important but may come later. (Teacher 1)

> Rote learning does not necessarily lead to later conceptual understanding. (Student 54)
>
> Most students are content to get the grades. I prefer to have an understanding. (Student 28)
>
> During my pre-tertiary life I found I learned by rote not for understanding. I was very successful at this. However, especially after having taught subjects, my understanding of concepts and their place in mathematics is very good. Students (secondary) that I see, even if taught for understanding, still rote learn and don't seem to care as long as they pass tests or exams. (Teacher 3)

These comments illustrate that from the perspective of students a method which is generally regarded as educationally undesirable (ie. rote learning) is nevertheless acceptable. For many students, the grade obtained or just passing is a sufficient goal. Some of the teachers also agreed with this notion and also held the belief that at a later stage a sufficient level of understanding might be developed, as maturity enables the necessary conceptualisation to develop. Conversely, insistence on the necessity of immediate understanding could be counterproductive.

4. 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:

> Maths is fun now. I enjoy it immensely and I'm sure I am a better teacher for my negative experiences when younger. I know how the students are feeling. (Teacher 16)
>
> 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!
> Some of the new insights I have gained are
> a) understanding the problems, joys, difficulties from a student's point of view.
> b) the challenge to present maths material in a motivational way - by locking into knowledge gained re students.
> c) appreciation of the really bright ideas, the potential maths leaders in the classroom. These days they are encouraged to lead the way and I'm happy (amazed!) that they do it so well!
> d) I have learned as much from various students as I was ever taught about maths. (Teacher 38)

The second teacher emphasises that she sees the interactive nature of her present mathematics teaching as beneficial to both teachers and students.

One of the students enrolled in the Faculty of Education also spoke of current hands-on, conceptually oriented approaches to mathematics learning:

> . . . learning different methods/ideas/looking at different perspectives opened my eyes to Maths from a different angle. Rather than just learning formulas, rules and methods we were kind of looking at maths from "the inside-out". (Student 32)
>
> Generally there is a need for concrete examples and to explore but it does depend on the individual. (Student 12)

Although many teachers expressed a similar increase in enthusiasm as a result of employing more recently emphasised approaches to teaching mathematics, 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)

Certain speculations can be made after consideration of these comments. First, one might suspect that some of the criticisms of the effects of new teaching techniques arise because they have been employed by teachers whose understanding of their nature or intent has not been adequately developed. Second, it seems possible that an underlying purpose of some curriculum changes, to decrease the focus in some areas in order to increase it in others, might not be adequately understood by the teachers involved. In either case the subsequent implication is that some teachers have not had sufficient or appropriate opportunities or assistance in preparing for implementing changes.

5. 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. These issues were discussed at the interviews and some of the views held are summarised below:

- some schools have a policy of attempting to encourage equality 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
- some students felt that the introduction of competency-based training can have the side-effect of lowering standards because there is no explicit recognition of excellence
- being innately able does not prevent poor teaching from reducing a student's achievement
- it is still possible for a student who may be initially less talented to achieve highly as a result of effort or other factors

Among the comments expressing the thoughts of both teachers and students on this 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)

> Education is being geared to lowest common denominator. Competency based training will NOT lead to overall competence. Everyone should be assessed. They must make the grade or get out. The system is over protective - competition is for real. (Student 52)

> School has a distinct principle opposing elitism. Yet meeting needs of student to achieve in area of talent is not elitism. Should recognise talent. (Teacher 39)

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.

6. Perceptions of mathematics and mathematics learning

Some teachers expressed beliefs that mathematics seems to be regarded in many ways as being in a unique category in terms of its importance for life and other studies. Some students indicated a perception that being able at mathematics indicates a generally smarter individual. People in both groups were unhappy about the importance placed on mathematics:

> Is unique. Only activity which students encounter where everything can be totally abstract and has no social interpretations/connotations. To do with ways of thinking. Metaphysical rather than social or physical. Subtle influence. Not recognised by many teachers is its importance if students are going on to a technical discipline. Thought processes not appreciated. Thought training and abstraction often under-valued. Needs the full 12 years to provide an adequate basis from which to go on to higher education. (Teacher 1)

> Is so regarded, rightly or wrongly. More is needed for some groups, less for others. Other disciplines (eg. music, physical education) are under-stressed. (Teacher 33)

The following comment raises some interesting points, social as well as mathematical. It comes from a respondent whose earlier remarks indicated an enthusiasm for teaching and a high level of acceptance of current teaching strategies.

> Memorising facts - I can still recall whole sets of data. Was this a bad thing? I loved it, but in those days we valued knowledge for its own sake. Perhaps we don't anymore. There was security in knowing that in maths at least there were absolutes, correct or incorrect answers. Today things are so relative - an investigation is assessed on effort, originality, etc. but not on accurate outcome. (Teacher 38)

The apparent indication is that what we now have is different from and might in many ways be better than what we had in the past. Nevertheless, it carries an implication that the system still could benefit from further refinement.

7. Students' mathematics confidence

Students' responses indicated that influences on a student's achievement included success, enjoyment, having explanations provided, having a one-to-one teaching situation and experiencing good rapport with the teacher. It also seemed that a higher priority should be placed on developing and maintaining a student's self confidence. That confidence is often seen as an essential component of success in mathematics can be seen in the following comment:

> Yes. Maths is seen as a major hurdle - clearing it builds confidence. Culture results in maths ability being responsible for raising self esteem. (Student 32)

An awareness of teaching practices which had adverse consequences was accompanied by indications of a loss of confidence for many students, although there were some who perceived their mathematical abilities to be above average and relatively unaffected by such experiences. There were appreciably many more students than teachers who felt that they would now have higher levels of both confidence and achievement had they had the opportunity to learn mathematics differently from the ways they had experienced. The lack of consistency of teaching or assessment approach from one teacher to another was not one which was specifically explored in the questionnaire or interviews, but it was raised by one student in the following comment:

> One teacher used to give 1 mark for the answer and 4 for showing the workings. Another didn't even want to see the workings! (Student 49)

This same perception of variability in teaching standards and attitudes was noted by another student:

> I simply found that from swapping from primary to secondary or even to tertiary levels. I was not prepared for the change. ie. each of the teaching methods differed from one another, thus creating conflict. (Student 29)

Students who had suffered negative experiences generally related them to failing to achieve at a satisfactory level and having a teacher who criticised publicly or in some other way lowered the student's self esteem. Those teachers who had been enthusiastic and whose classroom techniques earned them respect were those most likely to be responsible for encouraging achievement. Even if the mathematical knowledge of the teacher was inadequate, an honest attempt to ensure that the students were provided with adequate resources ensured that no perceived disadvantage ensued.

These findings highlight that students need to be considered individually. Perhaps more importantly, the need for students to feel that they are empowered, or in control of their own learning, should be taken into account.

8. Students' perceptions of calculators

Most of the students had completed their education before there was as strong an emphasis on the use of calculators as is now the case. Only two of the twelve students interviewed claimed to always carry a calculator and all the students indicated that they perceived advantages in not being dependent on a calculator:

> No. Not used much. Some advantages (eg. shopping). (Student 32)

> No. Only use one rarely. Advantage in not being dependent as you might then be lost without one. (Student 49)

It seemed clear that the students interviewed did not feel that they experienced any undue problems in their current situation as a consequence of having less familiarity with using a calculator than might be true of those more recently in school. Students who were interviewed, and whose school education was completed before the use of calculators became accepted, seemed content to have the capability of handling a variety of calculations without feeling dependent on an electronic aid. Few of these students appeared to have suffered memorably in transferring to secondary school, although not all of them had happy memories of primary school mathematics.

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 reforms made without the decision makers providing evidence of likely improvement in educational outcomes, but rather, in relation to political issues.

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 also 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.

Both teachers and students voiced both support and criticisms of their own mathematics education. They both recognised the important role played by a teacher's rapport with students to the extent that it potentially had more impact on student learning than did things such as teaching methods. Unquestioned adherence to specific teaching or assessment methods were generally seen as a hindrance to learning, while rote learning was felt to have positive and negative outcomes. Teachers expressed concerns with teaching to a diverse student population and with perceived negative outcomes as a result of curriculum changes. Other factors that appeared as influential in shaping impressions of one's mathematics education included self confidence, attitudes towards mathematics and towards the use of technology, and perceptions of the nature of mathematics and mathematics learning.

The students who chose to be interviewed were self-selected. Therefore, the possibility of bias in relation to their attitudes towards mathematics makes it unwise to attempt to draw any broad-ranging or definitive conclusions at this point. The extent to which the students could be regarded as a typical sample would be limited by this selection process. Similarly, not all of the teachers interviewed were mathematics specialists. They too might not be a representative sample of the teachers currently responsible for mathematics teaching in the Northern Territory. Among them, however, there was clearly an awareness that there are problems in some mathematics classrooms because of the inadequacy of the professional development available to teachers who are not properly prepared to teach mathematics. There was also clear indication that often the interaction between the teacher's individual style and a particular student influenced a student's achievement level to a greater extent than did the teaching methodology employed.

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 and students, see as essential factors in any changes: the opportunity for teachers and students 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 both teachers and students expressed strong opinions that the most important factor related to student learning was the personality and personal teaching style of the teacher.

Change is a fact of life. As society changes, so must the education offered to future generations. Of concern is the fact that educational change is not always designed to produce optimal outcomes. The importance of mathematics in a world of increasing technological complexity makes it crucially important that any attempt to enable education to keep pace with change is as successful as can be reasonably expected.

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. Further, it is equally 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 budgetary consideration.

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APPENDIX A - Student and Teacher Questionnaire

Section 1 - A brief history of your own mathematics education

1. Please indicate the time period and location in which you received your education.

Stage of education	Period (eg 1972-76)	State (or Country)	Rural or urban area
Infant/primary level			
Junior secondary			
Senior secondary			
Tertiary			

In considering the following questions, please circle the appropriate response.

2. Was there any stage during your infant/primary/secondary education or during your teaching career when a significant change took place which affected either content or teaching method in relation to mathematics ?

Yes / No / Don't know

3. In relation to your infant/primary education, do(es) any particular teacher(s) stay in your memory as being significantly more/less effective in helping you understand mathematics than were your other teachers ?

Yes / No

4. During your secondary schooling, do(es) any particular teacher(s) stay in your memory as being significantly more/less effective in helping you understand mathematics than were your other teachers ?

Yes / No

5. Did you have the experience, at any time during your mathematics education, when you were required to use a specific method to solve a problem or when you may have been penalised for using an alternative method which you felt was valid ?

Yes / No

6. Have you become aware of any approaches to introducing mathematical concepts which you wished had been used at the appropriate stage in your own education ?

Yes / No

Jacob, R. & Frid, S. Curriculum Change: What do Teachers and Students Really Think?
Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, March 1997.

7. If you are currently teaching mathematics, do you feel that your preservice preparation for teaching was adequate and appropriate? Yes / No / NA

8. If you have been involved in teaching mathematics for some time, have you had what you would regard as reasonable opportunities for professional development? Yes / No / NA

9. If you are now teaching mathematics but were not originally trained to teach this subject, have you been encouraged to attend appropriate courses to assist you to develop suitable strategies and procedures ? Yes / No / NA

10. If you are now teaching mathematics but were not originally trained to teach this subject, has access to appropriate inservice courses been readily available?Yes / No / NA

In considering the following statements, please circle the appropriate response.

11. During your secondary education, there were times when you felt that what you were learning in mathematics conflicted with what you had learned at primary school. I agree / I disagree / NA

12. There were times during your primary and/or secondary education when you felt that your confidence in relation to your performance in mathematics was reduced because of the way in which you were being taught.
I agree / I disagree

13. Since leaving school, you have discovered that you were given incorrect information in relation to mathematical facts or methods during your primary and/or secondary education. I agree / I disagree

If you wish to make further comment relative to this section, which concerns your mathematics education, please use the space below or, if that is insufficient, attach a sheet with your further remarks.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

****

Section 2 - Changes in mathematics education, particularly in the Northern Territory, which have affected you during your education or since you began teaching

1. Please list below any significant change(s) of which you are aware in relation to mathematics, which may have taken place at any stage during your infant/primary/secondary education.

_____

_____

_____

_____

_____

_____

_____

2. Please list below any significant change(s) relating to mathematics which have occurred during your teaching career, which affected either content or teaching method.

_____

_____

_____

_____

_____

_____

_____

3. Did any of these changes affect you in one of the following ways:

(a) by requiring you, as a student, to use a different method from that previously recommended ? Yes / No / NA

(b) by making you feel that your teacher lacked confidence or understanding in relation to the work being taught ? Yes / No / NA

(c) by making it difficult for you to obtain help from your parents because they used different methods or mathematical language from you ? Yes / No / NA

(d) because the change was a consequence of moving inter-State and the method/content of the course was different ? Yes / No / NA

(e) by requiring you, as a teacher, to change your teaching practices to a significant extent ? Yes / No / NA

Jacob, R. & Frid, S. Curriculum Change: What do Teachers and Students Really Think?
Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, March 1997.

4. There have been times when you felt that changes in content or method in mathematics courses were being introduced unnecessarily.

I agree / I disagree / NA

If you agree, please elaborate below

5. There have been times when you felt that changes were being introduced without sufficient consultation.

I agree / I disagree / NA

If you agree, please elaborate below

6. Have you felt that your level of achievement or enjoyment in learning or teaching mathematics has been affected by changes which you have experienced?

Yes - it has increased / Yes - it has decreased / No - it has not been affected at all

Please use the space below to make any comments you wish on this section about changes in mathematics education which you have experienced. If the space provided is insufficient, attach a sheet with your further remarks.

****

Section 3 - Your views of the way in which you were taught mathematics

1. Your interest in mathematics is a direct outcome of your experiences as a student with one or more particular teachers. I agree / I disagree

2. If you have had experiences resulting in positive or negative changes in your attitude towards mathematics, please indicate this by circling appropriately.

Positive experiences at	home	infant/primary	secondary	tertiary
Negative experiences at	home	infant/primary	secondary	tertiary
				NA

3. If you have been told that you were using the wrong mathematical procedure, although it was a method another teacher had shown you,

OR

if you have been given information which later you have found was incorrect, did this make you

(a) lose confidence in yourself ? Yes / No / NA

(b) lose confidence in your teacher ? Yes / No / NA

(c) lose interest in mathematics, at least temporarily ? Yes / No / NA

(d) more likely to ask why a particular method was required ? Yes / No / NA

4. Were there times at primary school that you wanted a different teacher for mathematics because you did not feel that your teacher was competent ?
Yes / No

5. Were there times at secondary school that you wanted a different teacher for mathematics because you did not feel that your teacher was competent ?
Yes / No

6. Have you ever had additional tutoring in mathematics because you or your parents felt that your achievement level would not be high enough if your only source of help were your regular teacher ? Yes / No

7. Do you feel that your level of confidence and/or competence in mathematics could have been higher if you had been taught differently ?
Yes / No / Don't know

8. Have you ever asked why a topic is being taught or a particular method used and not been given a satisfactory response ? Yes / No

9. Have you, to your knowledge, ever had a teacher for mathematics who was not suitably experienced and/or qualified to teach it ?
Yes / No

Jacob, R. & Frid, S. Curriculum Change: What do Teachers and Students Really Think?
Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, March 1997.

10. If, when you were at secondary school, you found out you had been given incorrect information on some mathematical issue while at primary school, did this affect your confidence in

(a) yourself ? Yes / No / NA

and, if your confidence in yourself was affected, was the result a reduction ?Yes / No / NA

(b) your present teacher ? Yes / No / NA

(c) your primary school teacher ? Yes / No / NA

(d) the system ? Yes / No / NA

11. If you have been asked to accept some fact or formula used in mathematics (for example, the value of π or the formula for solving a quadratic equation), without explanation as to its source or derivation, has this left you feeling

(a) the teacher did not think that you needed to know where it came from ? Yes / No / NA

(b) the teacher did not think you capable of understanding the explanation ? Yes / No / NA

(c) the teacher could not provide an explanation ? Yes / No / NA

(d) you were happy to take it on trust because you would not have understood any explanation ? Yes / No / NA

(e) you wanted to have an explanation and were upset by not receiving one ? Yes / No / NA

(f) you did not care, anyway ? Yes / No / NA

12. If you had been able to approach learning mathematics differently from the way you have experienced, would you

(a) feel more confident about mathematics ? Yes / No / Don't know

(b) have a higher level of achievement behind you ? Yes / No / Don't know

(c) have made different decisions about your career ? Yes / No / Don't know

Please use the space below for further comment on the ways in which you were taught mathematics. If the space is insufficient, attach a sheet with your further remarks.

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Section 4 - For teachers: Your views on your own professional development experiences

1. Please indicate the location(s) in which you have been teaching and the levels at which you have taught:

Type of school/institution (primary, senior college, etc)	Period (eg 1972-76)	State (or Country)	Level (eg years 6 - 7, junior secondary, etc)

2. When you entered the teaching profession, did your preservice training prepare you

(a) to teach only mathematics, as a specialist subject at secondary level ? Yes / No / NA

(b) to teach mathematics and science at secondary level ? Yes / No / NA

(c) to teach any subject, including mathematics, at primary level ? Yes / No / NA

(d) to teach a limited number of subjects, which did not include mathematics ? Yes / No / NA

3. When you first were employed as a mathematics teacher, did you find that the preservice training had prepared you adequately for all the situations which you encountered ? Yes / No

4. Please list below details of mathematics curriculum/mathematics methods units which were included in your preservice education.

_____

_____

_____

_____

5. Have you been able to attend any inservice activities relevant to teaching mathematics since you started employment in the NT? Yes / No

If your answer was yes, please give details below:

_____

_____

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6. While you have been teaching mathematics in the NT, you have been able to meet any needs you have had for appropriate inservice.
Always true / Sometimes true / Never true / NA

7. While you have been teaching in the NT, you have felt adequately prepared for any change to curriculum or assessment procedures which have occurred.
Always true / Sometimes true / Never true / NA

8. Are you aware of any major innovations in relation to the mathematics curriculum which have subsequently been significantly changed ? Yes / No

9. You have children of your own who have been or are being educated in the NT and you are satisfied that they have had good assistance from their teachers in relation to their mathematics education.
Always true / Sometimes true / Never true / NA

Please use the space below for further comment on your professional development experiences relating to mathematics. If the space is insufficient, attach a sheet with your further remarks.

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APPENDIX B - Student and Teacher Interview Questions

Interview questions - Teachers

(Cross referencing to the *Interview questions - Students* is indicated after each relevant question.)

How many maths staff at your present school?

1. Was your own education/teaching affected by the introduction of the "New Maths" and, if so, what do you remember about its effects on (as relevant) you, your parents, your teachers, your students? Anecdotal evidence is OK. (See S1)

2. What aspects of "New Maths" are you aware of, ie content/methodology which may still be affecting current teaching? Comment (if possible) on the relevance of "New Maths". (S2)

3. Was your own education/teaching affected by the introduction of the end of Year 10 examinations and if so what do you remember about its effects on (as relevant) you, your teachers, your students, progress to Year 11? (S3)

4. Do you think that the examination set for Year 10 students tests in an effective way the aims and objectives of current junior secondary maths courses? Explain. (S4)

5. Comment on what you perceive to be the intention of this examination. (S5)

6. Have you personally felt sufficiently informed and prepared for the most recent changes in SSABSA/Board of Studies Approved Courses? (S6)

7. Do you feel comfortable with the relationship between the recommended teaching strategies and the assessment methods for Stage 1?

8. Do you feel comfortable with the relationship between the teaching strategies used at Stage 1 as preparation for Stage 2 PES courses?

9. Do you see it as appropriate to use investigation/directed investigation methods with all your students? Comment.

10. Responses imply that the effectiveness of students' learning varies with the approach used or depends on having one teacher rather than another. Comment. (S7)

11. It is probable that not all teachers responsible for maths classes have had any or enough preservice and/or inservice preparation. Whom do you see as being responsible for assisting them in general and particularly when new courses/teaching strategies are introduced, which may restrict access to appropriate materials? (S8)

12. If certain strategies are required, do you feel comfortable ignoring the recommendation if you feel an alternative approach would be more effective? On what basis do you decide?

13. Have you always enjoyed/ achieved highly in/wanted to teach maths? What factors have influenced your enjoyment/interest etc? (S10)

14. Does the way in which you related to your maths teachers when you were a student give you any insights as a teacher concerning your students learning outcomes? Explain. (S11)

15. How has your own approach to teaching maths been affected by your experiences as a student, by your teacher training and/or by your teaching experience?

16. Mathematics seems to be regarded in many ways in a unique category in terms of its importance for life and other studies. How do you regard this statement? Explain. (S12)

17. Many teachers have commented that their own experience has been of rote learning at school, achieving quite satisfactory results and then arriving at an understanding of the underlying concepts, usually as a result of teaching. Possibly many students are content to learn by rote, also. Comment. (S13)

18. Calculators are now used more widely. There still seem to be some teachers who resist allowing their use. At what stage should they be introduced, in your view, and how important do you think it to be to explain how the calculator works, and the need for estimation? (S14)

19. Investigation approaches can result in the student 'owning' knowledge which is not in fact correct. Who is responsible for correcting this situation and can you, in fact, avoid destroying the student's confidence in so doing? (S15)

20. In Physics, there were moves to teach the most recent developments first rather than follow a chronological or historical approach. In the light of this perceived need to acquaint students with the 'now', do not investigations in maths run the risk of re-inventing the wheel over again? (S16)

21. Most recent changes in maths seem geared, understandably, to providing more effective courses for students struggling with maths concepts when taught more traditionally. The perceptions of some teachers and students is that this has affected more able students in a negative way. Given that ideal conditions of suitably small classes, adequate individual attention etc are not necessarily available how do you view this? (S17)

22. Many teachers comment that a great deal of change seems to be 'fashionable', a 'fad', an over-large swing of the pendulum, the result of the Assistant Moderator trying to make a mark. These views are based, in part, on the speed with which the change occurs and the ephemeral nature of this change. Comment. (S18)

23. One of the names thrown at educators who are interested in high achieving students is 'elitist'. Define what you mean by elitism and explain what you feel about it and why. (S19)

24. Do you believe that the purpose of Extended Mathematical Tasks has been clearly defined and is understood by all maths teachers involved in setting and assessing them? Comment.

25. It is assumed that changes are introduced to benefit students, although you may feel that the Yea 10 examinations do not fall in this category. Is the assumption well founded or is it a case of one man's meat . . . ? (S20)

26. Particularly if you have taught in more than one school, have you been aware of significant differences in the grasp of maths concepts demonstrated by students transferring from primary school which you think are more likely to be due to their primary school experiences than to their personal level of ability?

27. Do you believe that students who are high achievers in maths have innate ability that is little affected by how they are taught? (S21)

28. Do you, personally, feel adequately equipped to teach maths at all levels in secondary school? Comment on any misgivings you might have and means of rectifying them.

29. Responses clearly indicate that there are many occasions when students are penalised for not using a specified method. What are your feelings about this situation? (S22)

30. How would you assess the professionalism of yourself and other maths teachers with whom you work/have worked?

31. Are you aware of any other subject which has experienced such frequent change? (S23)

32. Do you feel that the developments introduced in the last few years have been well devised and the outcome of professional response to a perceived need?

33. Do you think that experienced maths teachers have had enough opportunity to provide input at the planning stage when curriculum development has been undertaken?

34. Despite all the changes, are there still students who are not achieving? If so, what reasons would you put forward to explain this? (S24)

35. Teaching style is an outcome of personality, knowledge, experience and confidence. Are ALL teachers of maths equipped to <u>start</u> at an adequate level?

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