Planning for an emphasis on numeracy in the curriculum

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Note

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Executive Summary

A capacity for numerate behaviour is important for all school students for ongoing education, employment, private and civic adult lives. Numeracy is having the disposition and critical ability to choose and use appropriate mathematical knowledge strategically in specific contexts.

It is essential that students experience using mathematics in a broad range of situations, which in a school means across the curriculum. The implementation of a relevant mathematics curriculum for all students, for example following guidelines given in the *National Statement* and *National Profiles*, is essential to the development of a numerate student population.

There are packages and mechanisms, including school-based research using student portfolios, which can help teachers to see how a focus on numeracy would help student learning in their subject and improve student numeracy. Current research is beginning to explore ways that numeracy can be developed across the curriculum, but significant research and professional development still needs to be set in place.

Policy makers should ensure they embrace a broad view of numeracy and support research and development initiatives in this area. Parents and community leaders also have an important role to play in developing a numerate population.

Introduction

The purpose of this paper is to provide an overview of current research findings, directions and thinking about numeracy in the school curriculum and guidance about planning for an emphasis on numeracy within it. The paper is to help inform the development of draft material for a monograph on numeracy. The draft material is to be prepared by the Australian Association of Mathematics Teachers (AAMT) for the Department of Education, Training and Youth Affairs (DETYA).

The scope of this paper is wide ranging, so it cannot provide an in-depth analysis of all issues addressed. It begins by exploring the term 'numeracy': looking at what it is, why it is important and attempting to describe what constitutes numerate behaviour. While it argues for a wider focus than just school mathematics, it also acknowledges the central role that school mathematics plays in developing numerate behaviour. Using this broader description, the paper describes what numeracy looks like in the curriculum and how teachers and schools might plan for improving student numeracy. It concludes with some suggestions for future directions in the areas of research and professional development.

Developing a rationale and finding a meaning for numeracy

There seems to be international agreement that numeracy should be an important focus of schooling because numerate students are better able to learn at school and are better equipped for their everyday lives and their lives post schooling. But what exactly is meant by the term 'numeracy'? Can these claims for its importance be sustained? What does numerate behaviour by a numerate person look like?

What is numeracy?

The term was first coined in 1959, by the writers of the *Crowther Report*, as follows:

> numerate is defined as a word to represent the mirror image of literacy… On the one hand… an understanding of the scientific approach to the study of phenomena — observation, hypothesis, experimentation, verification. On the other hand… the need in the modern world to think quantitatively, to realise how far our problems are problems of degree even when they appear to be problems of kind. Statistical ignorance and statistical fallacies are quite as widespread and quite as dangerous as the logical fallacies that come under the heading of illiteracy (Quoted in Cockcroft, 1982, p. 11).

From this description it is clear that the *Crowther Report* regarded numeracy as encompassing metacognitive frameworks in the same way that the concept of literacy does. However, a review of the literature reveals that since then there have been, and still are, many differences in the way people perceive and define numeracy. Furthermore, defining the term numeracy is complicated by the fact that there is a plethora of related terms currently in use around the world. These include mathematical literacy (e.g. National Research Council, 1989; Organisation for Economic Cooperation and Development, 1998), quantitative literacy (e.g. Dossey, 1997; Forman, 1997), mathematical skills (e.g. Marks & Ainley, 1997), critical numeracy (e.g. Yasukawa, Johnston & Yates, 1995), statistical literacy (e.g. Watson, 1995), and critical mathematics (e.g. Frankenstein, 1987). This has had ramifications in the ways policy makers and educators have made decisions for the development of numeracy in students.

According to Willis (1998a, p. 33), many of these are incomplete, as they emphasise either:

- the mathematical concepts, procedures and skills students need to know. For example, being able to do number operations (e.g. Department for Education and Employment (UK), 1998); or
- the kinds of practical tasks/social goals which students should be able to perform or meet. For example, being able to do a budget, go shopping, make a dress; or
- the generic and strategic processes students should be able to use for applying mathematics. For example, when doing a practical task recognise how mathematics might help, choose and adapt the mathematics needed, make decisions about the level of accuracy required and evaluate the methods used in the context (e.g. Mayer, 1992, pp. 33–34).

She goes on to make the case that a numerate person would use a blend of mathematical, contextual and strategic knowledge when required to use mathematics in practical settings. In this paper we will use Willis' (1992, 1996, 1998a, 1998b) definition of numeracy, which has been incorporated into recent reports and statements about numeracy in Australia (e.g. AAMT, 1998, 1997a):

> (B)eing numerate, at the very least, is about having the competence and disposition to use mathematics to meet the general demands of life at home, in paid work, and for participation in community and civic life.

Why is numeracy important?

A fundamental aim of education is to promote and improve student learning across the curriculum in order to equip students for their lives outside school and to prepare them for their adult, personal, social and working lives, and for life-long learning. In this section we will illustrate the necessity for students to develop as numerate people in order to cope efficiently with the demands of their everyday lives and to contribute creatively to their own and others' lives during and after their school years.

There is a range of situations where numerate behaviour by adults would enable them to function more effectively in their everyday lives. For example, by using mathematics in activities such as shopping, paying bills, budgeting, reading the newspaper, preparing food, administering medicine, reading maps and plans, understanding weather bulletins and so on. There are many other tasks which require a greater degree of numeracy such as dressmaking, planning a holiday, designing a garden, home decorating, and understanding economic indicators, loan repayment schedules or insurance policies.

There are also situations related to participation in the wider community. Recent political decisions, for example in the areas of taxation and health, are explained and justified using a large amount of information often presented in tables, and using mathematical relationships, and mathematical arguments. Understanding of public policy making and action in areas such as the environment, education and training, communication and media ownership, increasingly requires people to be highly numerate. People seem only too ready to accept information that is presented quantitatively, believing that it must be factual in the same way that they believe that scientific research must be objective. A genuine understanding and critical view of such decisions can only be arrived at through understanding of mathematical concepts, and a capacity for critical thinking. Indeed, recent developments in technology have increased the quantity of information of this sort being presented to people. As a result, the ability to sift through, understand and question this information is becoming increasingly important if people are not to be misled or manipulated by others.

It is not just the receivers of information who need to be cognisant of the fact that quantitative information can be misleading. Researchers also need to realise that the data they collect are not independent of themselves but reflect the design of their study. Collection and interpretation of data is not neutral; the way that the categories are defined and which particular numbers are collected, and which are omitted, can have an impact on the message that is conveyed in the results. Researchers need to consider these aspects when designing a study so that in fact they themselves are not misled by the results. For example, an article in the *Boston Globe*, 8 September 1987 'Truth in AIDS Tallying' brings home how a definition of a disease can have a big effect on the number of cases recorded. It was estimated that, given the definition of AIDS in 1981, 25 % of cases of AIDS went unrecorded. The article suggests that a restricted definition of AIDS was chosen for a political motive — to keep the apparent number of reported cases down.

There are many other examples of participation in the local community for which people are called on to use mathematics to make decisions, develop policies, conduct activities and complete tasks. Examples include: participating in school parent committees where decisions are made in connection with school education priorities; canteens and fund raising; organising a petition to the local shire council concerning the development of a skate board park; running a tennis club, leading youth camps; or running a scout or guide group. Being part of a school parent education committee, for example, could involve the correct reading of financial statements, making decisions about the relative merits of using the money for different purposes to help achieve the school education priorities, and choosing which fundraising activities to use.

These activities are not restricted to older people. Young people also use mathematics in a range of ways and in a variety of activities outside of work and education. The DEETYA funded AAMT project investigating the Key Competency, *Using Mathematical Ideas and Techniques,*(AAMT, 1997b) gave examples of such uses:

> Some senior students were interviewed to ascertain what mathematics they used in their private life and how they used it. *L* constantly juggles her income ($260 per fortnight) in order to make ends meet. Her costs include rent, bills, food, fares and phone calls. She plays the piano and is teaching herself the guitar. *T* is a leader in the cadets and hence is involved in managing marching drills with up to 300 people. This involves decisions about the speed of the march, distances within which to manoeuvre for different dress, the number of ranks (which depend on the number of manoeuvres, the space available and the number of cadets involved), and coordinating the timing of the drills. He is also involved in sailing and this involves, for example, reading charts, determining the best line of approach to a particular destination, and taking into account currents and the wind direction. *M* has designed and made a beanbag. She cooks and often has to modify recipes to suit the number of people needing to be fed (pp. 53–54).

Young people entering the paid workforce need to be good at using mathematics, and not just in those occupations that have obvious mathematical demands like engineering. Part of the above project documented 30 different workers at work. All of them were involved in using mathematics in their work to help complete everyday well rehearsed routines, cope with new situations and new problems in old situations, and make decisions about what action to take:

> The *auto parts recycler* uses mental computation and estimation skills when giving pricing quotes. The *baker* uses her knowledge of fractions to create two equal slabs of bread out of one-and-a-half bowls of dough while ensuring there is enough left to make an extra loaf. The *child care clerical officer* calculated that the impact of a change in a Workcover premium of 0.3% would translate to more

> than $200 per month for the centre. The *electrical mechanic* on a large construction site needed to be able interpret scaled plans in the context of the directional orientation of the worksite. The *farmer* managed the many variables by keeping good records of such things as spraying conditions, rates of product, water used, crop rotation, fertiliser rates, seeding rates, and rainfall. Sampling and interpretation of crop, plant and soil analysis also provide the farmer information for making decisions on crop rotation, management and livestock. The *didgeridoo maker* has a deep understanding of the relationship between shape and size of the 'cylinder' and the different sounds they produce (p. 53).

In paid employment, career prospects have changed. In contrast to expectations of the past, people can no longer expect to stay in the same jobs or careers for their whole lives (Orrill, 1997). It is essential that people be able to adapt to the demands such changes will make on them. Galbraith, Carss, Grice, Endean and Warry (1992, p. 574) have described the extent of numeracy demands made on people in their careers as varying from specific occupational competencies to flexible analytic abilities. These are deemed to be of increasing importance within a society where multi-skilling and vocational change may become the norm. Indeed, as Turkle (1995) puts it, '(w)hat matters now is the ability to adapt and change to new jobs, new career directions, new gender roles and new technologies' (p. 255).

Moves in the workplace such as enterprise bargaining, workplace agreements, and part time employment are requiring workers to have a much stronger understanding of their conditions and of the rules with regard to superannuation, workcover, taxation, occupational health and safety, health insurance, union membership and so on. Much of this activity requires an understanding of mathematical ideas and the applications of them:

> For example the young woman starting work as a gardener needs to know her wage rate, conditions of work (e.g. hours, rostered days off), and taxation responsibilities. She will also want to know about superannuation, medical insurance, sick leave, annual leave, long service leave, leave loading, overtime rates, and the length of tenure of the contract of employment. Further she will need to be aware of her prospects of promotion and the impact of doing further study and training. It is possible that she could be asked to sign a work place agreement where some of these conditions of employment have been traded for more pay. Her ability to agree or not agree let alone negotiate for changes to her package will depend, in part, on her ability to understand and use mathematical ideas and techniques (AAMT, 1997b, p. 75).

People in education and training settings also need to be numerate to successfully complete their studies. After investigating a range of post compulsory school and post school vocational courses the same AAMT project concluded that:

> [t]here is evidence that to be successful in subjects across the curriculum and in vocational courses students sometimes need to use mathematics. In *woodwork* the student making a piece of furniture will choose a design, develop the materials

> list, interpret a plan, and make the furniture. The *art* student creating a design for screen printing a tea towel will work with 2D space, use mathematical ideas such as symmetry in the design, and measure accurately in working within the frame. The *Studies of Society* student interprets rainfall and temperature graphs to draw conclusions about the climate of a particular locality. The *Horticulture* student has to apply treatments to weeds, pests and diseases, make decisions about quantities, make up mixtures, and calibrate sprayers (p. 54).

Tertiary students are expected to learn in a variety of ways and situations, including lectures, tutorials, and the study of written, verbal and on-line material. Students are expected to: 'use the necessary skills, including numeracy skills, at a high level, to think critically about the material presented and to be able to present convincing and logical arguments of their own' (Kemp, 1995, p. 377). The tertiary curriculum creates a wide range of situations in which numeracy demands are placed on students. These include interpreting and writing scientific and psychological reports, interpreting tables in sociology, understanding the nature of population growth in environmental science and using time lines in history.

Given the changing nature of society, and the increasing use of technologies, it is becoming more and more important for people to be numerate in their education, training, employment and social life. On the surface it might seem that changes in the types and availability of technology, including calculators, mean that people can avoid learning or using what used to be called basic mathematical skills. But the execution of mathematical skills is not sufficient for a person to be numerate. There is an increasing need for people to view data and information presented to them in a critical way. With the development of technology there is a massive amount of unedited information on the World Wide Web, for example, and the capacity to judge the quality of it is more important than ever. Access to such technology is increasing and with it the need to be numerate. Indeed the development of a socially just and democratic society depends on all people having an appropriate level of numeracy:

> Innumeracy is widespread amongst people at all educational levels and across many spheres of activity and there are clear economic and social benefits to Australia in changing this situation. Improving numeracy outcomes is particularly important for those who are economically and educationally disadvantaged since numeracy skills are socially distributed, that is, people who are regarded as insufficiently numerate are predominantly working class, are disproportionably female and more likely to be members of certain ethnic and racial minority groups. Perceptions about the numeracy demands of particular tasks and, consequently, what sorts of people succeed with them will have a powerful effect on who gets chosen for, and who chooses, themselves into, certain of life's opportunities at home, at work and in public life (Willis, 1996, p. 5).

What constitutes numerate behaviour?

This need to be able to recognise what constitutes numerate behaviour has been highlighted in recent writings about numeracy. The Numeracy Education Strategy Development Conference, co-hosted by the AAMT and the Education Department of Western Australia (EDWA), brought together a cross-section of people from around Australia with expertise and interest in numeracy to discuss questions and topics around 'what does it mean to be a numerate person?' and as a consequence, 'what would this mean for schools?'. The conference report *Numeracy=everyone's business* reports on discussions concerning expected numerate behaviour at different ages. In reference to education in schools, it includes the following working definition:

> In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:
>
> - underpinning mathematical concepts and skills from across the discipline;
> - mathematical thinking and strategies;
> - general thinking skills; and
> - grounded appreciation of context. (p. 15)

The AAMT has adopted the same definition as the basis for its *Policy on Numeracy Education in Schools* (1998, p. 2).

A collaborative research project between Murdoch University and the EDWA *Numeracy across the Curriculum Project* (*NATC*) is focussing on numeracy in a range of primary and secondary schools in Western Australia. The staff of the project have been developing a framework for describing numeracy. Willis (1996, 1998a and 1998b) provides descriptions of early versions of these ideas. This framework refers to mathematical, contextual and strategic knowledge. To clarify the ways in which these terms are used here, they are described below with reference to the example of a student making a piece of furniture in a woodwork course.

Mathematical knowledge involves knowing, understanding and using the mathematical ideas which typically comprise the school mathematics curriculum in Algebra, Statistics (Chance and Data), Measurement, Number and Geometry (Space). For example, the woodwork student, in successfully designing a cabinet would be visualising and drawing 2D and 3D shapes; estimating and calculating quantities and costs; and measuring, marking and cutting lengths of timber to the required level of accuracy.

Contextual knowledge involves understanding the contextual features of the mathematics in the situation. That is, what terms mean in the context, and what interpretations make sense. This requires more than a familiarity with the context. It requires an understanding of how the mathematics in the situation is shaped by the context. For example, the student understands that the numbers on an Australian plan represent millimetres, and, when cutting, knows where it is better to leave some 'slack' rather than cut something that may end up too small.

Strategic knowledge involves the orientations and dispositions involved in managing one's way through routine or non-routine problem situations. These include almost habituated ways of getting going when initially stuck, or of breaking a task into component parts and organising the approach in a systematic way. It may involve identifying the key features in a problem, making assumptions explicit in order to judge them and posing questions for oneself to deal with in order to come to grips with the essence of the task. It involves knowing that any solution should make sense in the context and checking that it does so. For the student designing and constructing the cabinet there are decisions to be made, perhaps using conflicting sets of information about suitable joints to use or the use of adhesives. The student needs to know where to find information and who to ask.

It has been proposed earlier in this paper that numerate behaviour involves a blend of mathematical, contextual and strategic knowledge, and that the blend will be determined by both the context and the person. It appears that numerate behaviour is context specific and that people are more or less numerate with respect to particular situations rather than being numerate or innumerate *per se*.

How does this compare with past and current numeracy initiatives?

Historically in Australia, and in the UK, a more restricted perception of numeracy, as being equivalent to routine computational skills, informed the work of national projects on literacy and numeracy. In 1997, Marks and Ainley conducted a study of data from projects undertaken in Australia over the years 1975 to 1995 in order to estimate the proportion of students who had mastered the basic skills which enable citizens to effectively function in modern society (p. 1). Their report makes it clear that during that time it was believed that the mathematics tests administered to students measured their numeracy.

In 1982, Lord Cockcroft chaired a committee which undertook a review of the state of mathematics education in the UK. The resulting report included a list of mathematical ideas and techniques which the committee considered essential for life and work after school. There were also some recommendations for the teaching of mathematics in the classroom. It was implicit in the report that if students learn mathematics well then they will be able to cope with life and work post schooling.

Later, in 1997, the Secretary of State for Education and Employment in the UK established a Numeracy Taskforce to develop a national strategy to raise the standard of numeracy to the target level announced by the Labour government, which was for 75% of 11 year olds, by 2002, to achieve the standard expected for their age in mathematics (Department for Education and Employment (UK), 1998, p. 4). The taskforce defines numeracy as:

> knowing about numbers and number operations. More than this, it requires an ability to solve numerical problems including those involving money or measures. It also demands familiarity with the ways in which numerical information is gathered by counting and measuring, and is presented in graphs, charts and tables (p. 6).

The report also includes recommendations of ways in which the teaching of mathematics in primary schools can be improved and outlines strategies for the community to adopt.

In Australia the Minsterial Council for Education, Employment, Training and Youth Affairs, MCEETYA, National Literacy and Numeracy Plan for schools also has a focus on numeracy. A Benchmarking Taskforce was established with representatives from the States and Territories, the Commonwealth, the National Catholic Education Commission and the National Council of Independent Schools Associations, to create a set of benchmarks of minimum standards that students would be expected to reach at different levels of schooling. The numeracy benchmarks development (managed by Curriculum Corporation) adopted the definition of numeracy proposed by Willis, outlined above. However, the project has chosen to restrict the benchmarks to the contribution that school mathematics makes to the development of students' numeracy. The draft numeracy benchmarks, developed so far for Years 3, 5 and 7, only describe some aspects of school mathematics.

Thus two major initiatives, here and in the UK, aimed at improving numeracy are both focussing on assessing some aspects of school mathematics. This gives rise to two significant questions. Firstly, is the mathematics contained in these documents the right mathematics for the development of numerate behaviour? Secondly, even if it is the right mathematics, and if numeracy is not just school mathematics, then what is the relationship between the mathematics and numeracy?

What is the relationship between school mathematics and numeracy?

The ideas underpinning the following discussion were used by Willis (1996) in arguing that a cross curricular approach to numeracy was needed in schools if numeracy was to be enhanced in students.

A focus on the essential aspects of mathematics is based on a traditional approach to improving student numeracy which assumes that 'mathematics can be learned in school, embedded within any particular learning structures, and then lifted out of school to be applied to any situation in the real world' (Boaler, 1993, p.12). However, this does not appear to be the case. There is a growing literature on the nature of transfer of learning and the evidence suggests that students do not automatically use their mathematical knowledge in other areas (e.g. Chapman, 1988). Lave (1988) found that even experience in simulated shopping tasks in the classroom did not transfer to the supermarket. On the other hand, it appears that people use highly effective informal mathematics in specific situations (e.g. Carraher, Carraher & Schliemann, 1985).

As Willis suggests, it would be easy to attribute this lack of transfer of mathematical skills to other contexts to a deficient mathematics curriculum and poor teaching, but the quite considerable debate about transfer of skills shows that even if mathematics were taught and learned very well, people would not necessarily apply it to new situations (e.g. Griffin, 1995). Researchers in the area of situated cognition argue that cognitive skills and knowledge are not independent of context and that activities and situations are integral to cognition and learning (e.g. Brown, Collins & Duguid, 1989; Resnick, 1989).

In order to respond to these issues there has been an attempt to contextualise school mathematics using contexts which are relevant to the students. It was hoped that this would help students to see the purpose and usefulness of the mathematics they were learning, and that the mathematics would make sense. However, despite teachers' best efforts many of these 'real world problems' appeared contrived rather than real (Willis, 1992); required students and teachers to participate in 'a wilful suspension of disbelief about reality and mathematics' (Williams, 1993 p. 6); and left out factors relevant to the real situation (Boaler, 1993). Further, these attempts still had a primary purpose of teaching mathematics rather than developing numeracy. It would seem that if students are to learn to use mathematics outside the mathematics classroom then that is where they need to experience using mathematics.

A common response to this in primary and middle schools has been the adoption of integrated or interdisciplinary curriculum approaches which include the creation of authentic tasks through which a range of learning outcomes, including numeracy, are addressed as the need arises. There is some evidence to suggest that in some schools 'the integration of key learning areas supported by a broad range of learning styles appears to be working well' (Cumming, 1994, p. 43), while in other schools the integration does not appear to be so far developed and the outcomes are subject based. There are a number of difficulties with the integrated approach. Personal communication with teachers and observations of students at work, as part of the *NATC* project, has indicated that students may avoid using mathematics to complete a task by using another strategy that they already have, and which they feel gives them a good enough result. In this way the development and use of mathematical knowledge and skills, outside the mathematics classroom, can be circumvented.

Further, it is not clear how a series of authentic tasks would provide students with the chance to develop a well-constructed body of mathematical knowledge, which they can draw on effectively when there are numeracy demands made upon them.

To further complicate the picture, it is often the knowledge of the context that will help a person to decide which mathematics is relevant in a particular situation. However, being numerate should enable a person to learn about a new context or handle new constraints in a familiar context. Hence, some generalisable mathematical understandings are required, along with a range of generic application skills, in order for a person to engage with a new situation.

While a school would find it hard, if not impossible, to recreate a 'real' situation, contexts different from the mathematics classroom are found right across the school curriculum. It is in these situations where students will be required to use mathematics in order to do something — complete a task, make a model, understand a new concept, or solve a problem. If numeracy is about improving students' use of mathematics in life, then numeracy education cannot be restricted to the mathematics classroom. Numeracy across the entire school curriculum should underpin planning for an emphasis on numeracy in the curriculum.

What does numeracy in the curriculum look like?

We have argued that the development of students' numeracy is very important and even essential if they are to function effectively throughout their lives. In order to ensure that this will take place we need to be able to recognise what numeracy looks like and where it is found. Numeracy does not exist solely in the mathematics classroom and any curriculum initiatives which plan to develop numeracy in the mathematics classroom alone will be inadequate for the task. There is an increasing acceptance that the development of numeracy is the responsibility of all teachers across the curriculum. Recent literature in the United States refers to 'quantitative literacy' in the same range of ways that we refer to 'numeracy' and makes clear the need for all teachers to be involved:

> … it may be that the challenges involved in producing a quantitatively literate society are so many and varied that we can only hope to meet them if the responsibility is shared by teachers in all subjects. Indeed if the needs for quantitative competence are now as pervasive in American life as this volume indicates, as well as so diverse in form and substance it seems only common sense that the responsibility of fostering quantitative literacy should be spread broadly across the curriculum A clear message heard from several contributors to this book, in fact, is that opportunities to practice and utilise quantitative skills must be part of all subjects and under the assumed care of teachers in all disciplines (Orrill, 1997, p. xiii).

In our view, these numeracy demands can arise in at least three ways. Firstly, some learning area outcomes naturally/inherently make numeracy demands, which may be explicit or implicit. For example, in *Health*, some mathematical understandings are required to understand the effect of alcohol on a person. This information is often presented in graphical form which means that students need to have an understanding of slopes and rates of change and calibration of scales. Alternatively, there might be a table or the numerical information is embedded in the text. Students' levels of understanding/comprehension of the content of the *Health* curriculum is likely to be related to their ability to use their mathematics in this context.

Secondly, some numeracy demands come about through the classroom strategies used by the teacher. For example, to develop their knowledge of *French* a teacher could ask students to make a travel brochure. The task then will make numeracy demands on the student: they will need to use exchange rates and calculate travel costs as well as designing the layout for the booklet.

Thirdly, numeracy demands can arise because of what a student chooses to pursue. For example, it is not clear what the students will do when, in *Technology and Enterprise*, they are asked to design and make a land yacht model with a sail area of 9000 square millimetres. It is likely that they may begin by attempting to make a crude model. However, they may then decide to conduct some research about more sophisticated aspects of yacht design which may require a more significant understanding and use of mathematical ideas and techniques.

There are numerous examples of potential numeracy demands across the curriculum. Some examples of these can be found in the publications: *Numerate Students: Numerate Adults* produced by the Department of Education and the Arts, Tasmania (1995) and the companion document *Key Intended Numeracy Outcomes* (Department of Education, Community and Cultural Development, 1997), and *Making the Links : Numeracy* (Department for Education and Children's Services (SA), 1997). The *NATC* Project has also collected numerous examples of situations or tasks involving numeracy as a key aspect. A brief selection from these and other publications are contained in the following table.

Table 1. Examples from across the curriculum that may make possible numeracy demands on a student

	Early Years of Schooling	Middle Years of Schooling	Later Years of Schooling
The Arts	Students drew a 'bird's eye' view of a familiar setting.	Students designed and illustrated a page for a children's picture book.	Students designed the sets and the lighting for a school drama production.
English	Students heard a story, which included the line 'they went about sinking twice as many ships'. They discussed with the teacher what this might mean and if it made sense.	Students read a magazine article and had to summarise the main points. The article was about Australian eating habits and some of the information was presented in a statistical form.	Students examined media coverage of a minority group over a period of time, commenting on the patterns of representation, and the ways in which the group was represented.
Health and Physical Education	Students kept score in a game of basketball by counting the number of points scored rather than the number of 'hoops' thrown.	Students studied the relationship between pulse rates and exercise. They designed an experiment that required them to measure and record their pulse rate at rest, after vigorous exercise and while cooling down. Then they summarised, represented and interpreted the data.	Students chose a health issue and had to gather and analyse information on it. They then designed and implemented a health promotion project to encourage a healthy lifestyle in relation to the issue.
LOTE	After tasting a variety of food from the culture being studied, students talked about what they liked and did not like and why. Students collected the class opinions using a variety of methods, and working in groups found ways to represent the information they had gathered.	Students collected information on travel within Tasmania for some French-speaking students. They published the information in a booklet in both English and French.	Students researched a social issue, present a written report on it in the target language and then discussed the issue in that language.
Science	Students grew some seedlings. They made decisions about the size of the container, the amount of soil and fertiliser and conducted experiments which required them to measure and record growth.	Students needed to make sense of the solar system and the universe. They were presented with a range of statistics such as light years, gravity, mass, and so on.	Students compared the relative efficiencies of appliances in heating 500mL of water. They used a wattage/cost table to work out the relative cost of heating the water with each appliance.
Society and Environment	Students drew maps showing the routes they usually followed to and from school.	Students investigated the impact of white settlement on Aboriginal Australians. They designed their own plans of research, collected data and drew conclusions.	Students prepared a folio on different economic systems, including media coverage of them, developed criteria to select six items and to prepared a brief report on each.
Technology and Enterprise	Students designed and made a library bag.	A class designed and make a land yacht model with a sail area of 9 000 square millimetres.	Students designed and made a piece of furniture.

These examples give some illustration of where numeracy demands are placed on students in all learning areas, other than mathematics, and in all phases of schooling. The work of the *NATC* project with primary and high school teachers has found that students are confronted, on a daily basis, with similar situations. Each of these situations include opportunities for teachers to enhance student numeracy by encouraging students to use their mathematical ideas and techniques in their learning across the curriculum.

What is the role of the Mathematics Learning Area?

In this section we consider the role of the mathematics learning area with regard to the development of numeracy. Mathematics is part of all schools' curricula and it is evident that some mathematical knowledge is a necessary part of being able to operate as a numerate person, but not sufficient to ensure it. Indeed, we have argued earlier that numeracy is more than mathematical skills; that there are mathematical, contextual and strategic aspects of numeracy which people blend when exhibiting numerate behaviour.

However, in this section we will focus on what can be done in the mathematics classroom to enhance students' numeracy. It seems reasonable to claim that a person with a good understanding of a broad range of mathematical ideas and techniques will be better placed to act numerately than one who hasn't the same level of understanding. The school mathematics curriculum should play a significant role for all students in helping develop their mathematical and strategic repertoires.

A review of the literature in mathematics education indicates that there has been a significant amount of research and development aimed at improving students' learning of mathematics. A major achievement in Australia in this area was the development of the *A National Statement on Mathematics for Australian Schools* (Curriculum Corporation, 1991) which includes guidelines for the school curriculum. In addition, *Mathematics — a curriculum profile for Australian Schools* (Curriculum Corporation, 1994) describes in detail the sorts of mathematical outcomes that are desired for all students, what they are expected to know and to be able to do as a result of their education. Similar national and state statements about mathematics exist in the USA, Canada and the UK (e.g. National Council of Teachers of Mathematics, 1989).

It is not the brief of this paper to describe the rationales and content of these documents, as they are available for those wishing to pursue the matter further. However, there are aspects of the teaching of school mathematics that would assist students to improve their capacity to use their mathematical knowledge in other contexts. In particular, the following examples outlined under *Appreciating*

Mathematics and *Working Mathematically* (Curriculum Council (WA), 1998, p. 180) are fundamental to this aim. These include:

- developing a disposition to use mathematics to help understand a new situation or give a new perspective on a known context
- developing a positive attitude to their own continued involvement in learning and doing mathematics
- helping students appreciate the significance of mathematics in explaining and influencing aspects of their lives
- developing a range of problem solving and strategic strategies when working mathematically;
- choosing mathematical ideas and techniques in practical situations — to fit the constraints, interpret and make sense of the results and evaluate the appropriateness of the methods used.

These outcomes for school mathematics should pervade the mathematics curriculum for all strands, in all phases of schooling and for all students.

A recent study (Brinkworth & Truran, 1998) reported that:

> students believe that mathematics is a relatively uncreative subject, which is not essential for succeeding in life, but it is a necessary stepping stone for most students to future study or careers; that is, it is useful but more in an instrumental than practical way (p. iii).

It would seem that students leaving school with this attitude are less likely to behave numerately and less likely to have a disposition to use mathematics in their everyday or civic lives, their work, education or training. Therefore we would argue that the mathematics learning area is one place to develop the sorts of desirable attributes outlined by the Curriculum Council in Western Australia (see above) and through the kinds of practices described in the above mentioned policy documents.

Planning for numeracy

The examples of situations with numeracy demands given in Table 1 are just some of many such cases which are widespread in schools. They provide many opportunities for students to both use and improve their numeracy. It is vital that teachers recognise that there are many existing situations where there are numeracy demands, as well as ones that they can initiate to provide opportunities for students to develop their numeracy. This section will look at ways that teachers might plan for numeracy in a variety of situations and in different ways.

How might teachers deal with numeracy demands as they occur in a classroom setting?

The following scenario describes a lesson that occurred in a Western Australian primary school (Hogan, Jeffrey & Willis, 1998). It is included to illustrate the ways that a teacher might identify the numeracy demands of a story and encourage students to think about them. It also highlights her reflection about numeracy and the lesson. The teacher was reading the story *'Fifteen pigs on a pirate ship'* to Year 1 Primary School students. The first part of the story describes 15 male pigs on a pirate ship. Later in the story the pigs meet up with another ship of female pirate pigs. After some fighting they join forces and buy a bigger boat and become 30 pigs on a pirate ship.

> **Fifteen pigs on a pirate ship**
>
> Nicola, their teacher, took the opportunity to use the numbers and discussed with the children where the 30 had come from. They used a counting on strategy to go from 15 boys to 30 altogether and, using the fingers of several children, came to the conclusion that there were 15 female pirates.
>
> Nicola felt that interrupting the story session in this way was worthwhile because it gave the children the opportunity to use the counting on strategy they were developing in mathematics in a context of interest to them. But, more importantly, it provided the children with the experience of using their mathematics to help them better understand a situation; it provided evidence that they could use mathematics to learn something about the pirate pigs that the author of the story hadn't told them. This is the very essence of numeracy and it couldn't be developed in a curriculum where mathematics only happened in the mathematics lesson.
>
> Describing this lesson several days later, however, Nicola was taken aback to realise that she had completely overlooked another line of the story which said '… they bought a bigger boat and another parrot and went around sinking twice as many ships'. What sense did the children make of this? Any sense? Non-sense? Did the children have any idea what twice meant? Did they think of it as two, or two lots of a particular amount, or did they understand it as a ratio twice as many as…? And did they realise that the twice was linked to the 15 and 30? (Why not thrice as many?). Understanding this sentence is quite demanding for a five or six-year-old. Does that mean we should ignore it or deal with it? And if the latter, then how? What should Nicola have done? What could she have done to help them understand?
>
> Many conventional views of numeracy would suggest that trying to explain this passage would only confuse children unless they had already been taught the relevant mathematics. An alternative perspective, however, is that mathematics is, after all, like language in that you can make sense of the whole without understanding fully the specifics of any particular bit. Perhaps partly understanding the story or having a sense of what the story is saying could help

> children to make sense of the mathematics in the situation. Nicola might, for example, have had children each guess how many boats the boy pigs had sunk (each day or week or month) and to use their own guess to work out how many the bigger boat would sink. By listing and comparing their results, the variable notion in twice as many is introduced within a context to which the children can relate; the seeds are sown for later mathematics lessons.
>
> Having developed some idea of what twice as many means, of course, the highly numerate six-year-old might even question whether it makes sense that a bigger boat with twice as many pigs aboard would sink twice as many ships as the smaller boat with only the boys aboard! This too is the essence of numeracy (Ibid, pp. 48–49).

This example illustrates an important point related to the students' phase of development. Students draw on their life experiences to help with their early learning of mathematics. In this instance the story can help them intuitively understand 'twice as many'. Eventually we hope that students learn to understand and use some mathematics to help them understand unfamiliar aspects of the world: that is, the students will understand the whole before they understand the parts.

Underlying this scenario is the need for the teacher to recognise the situation as involving numeracy. While reading the story Nicole recognised and dealt with the number combination, but only later did she notice the phrase 'twice as many'. This echoes the experiences of researchers in the *NATC* Project and the *Rich Interpretation of Using Mathematical Ideas and Techniques* (RIUMIT) (AAMT, 1997b) project. Primary teachers and secondary teachers across the curriculum do not always recognise the mathematics embedded in the texts, let alone see it as a numeracy issue. Providing teachers with a range of examples of the sorts of situations where they might deal with numeracy would help them to understand the extent to which mathematics is involved in their learning area. It might also help them to appreciate that the development of students' numeracy can enhance their performance in that learning area.

The teacher will also need to unpack numeracy demands of this kind. This involves more than noticing that mathematics is somehow involved, but also being aware that a numerate person uses a blend of mathematical, contextual and strategic knowledge. This awareness should help teachers to diagnose students' problems and assist in their endeavours to improve student learning. Nicola uses the context of the story to help students see that mathematics could be used to learn more about the story, that they could apply their knowledge of a mathematical idea, from mathematics, to literature. If Nicola had asked the students what the phrase 'twice as many' meant, we would expect that many of the children wouldn't have understood as the mathematics concept might be beyond their experience. Treating this misunderstanding as a lack of mathematical understanding and trying to deal with it separately from the context would be a fruitless and confusing exercise. However, dealing with it as a blend of the mathematical, contextual and strategic knowledge would help (Willis, 1998a, 1998b).

Inevitably the teacher will be confronted with decisions concerning the appropriateness of dealing with numeracy issues there and then, whether to follow up in the next lesson, whether to deal with those sorts of numeracy demands at a later date or leave them altogether. Whatever the decision, it involves the teacher in acting and developing strategies for action. However, to date, detailed strategies for dealing with particular numeracy issues within the various learning areas have not been developed. Once teachers are aware that these kinds of situations exist, and that there are ways of dealing with the numeracy demands, they are arguably the best ones to decide on appropriate strategies to adopt in their own classrooms.

Teachers will select different strategies according to the needs of the students. In the *NATC* Project a teacher of a Year 8 class in *Design and Technology* discovered that a student could not measure and mark a piece of timber, because he was unable to use a ruler. At first the teacher did not quite know how to respond. After the lesson the teacher reflected on the incident and decided to teach the student how to use a ruler and oversee the student's practice. In addition she chose to consult with her colleagues to alert them to the problem. This meant that collectively they could help each other develop strategies to help the student to confidently use a ruler and develop some new understandings about number and measurement.

These examples illustrate the fact that teachers need to make decisions about their actions in their classrooms when numeracy demands arise. In some cases the students will cope efficiently with the demands, in others the actions of the teachers will no doubt depend on a number of factors, including the age and mathematical knowledge of the students, the time available, and the teacher's own confidence. It will also depend on whether knowledge of the associated mathematics is crucial to the student's understanding of the content matter or the completion of the task. Alternatively, the situation might be viewed as a vehicle for developing student numeracy.

How does a teacher plan for numeracy?

It would be ideal to have all teachers in a school working cooperatively on looking at numeracy across the curriculum. When this is not feasible, an individual teacher or a group of teachers can still find ways of developing numeracy for students in particular areas. As a starting point teachers could consider the activities in their program and analyse them for the potential numeracy demands, thus putting them in a better position to deal with such demands as they arise in their classrooms. They could then look to see if what is planned will provide students with sufficient opportunities to improve their fluency in familiar situations, to use their numeracy to learn about new situations and to practise being critical of the mathematics used in a situation.

What is the role of the teacher of mathematics?

Although there is considerable debate and concern about the extent to which students can transfer their mathematical knowledge from the mathematics classroom to other areas, it is arguable that students who learn the appropriate mathematics will have a stronger chance of being numerate. Thus, for an emphasis on numeracy in the curriculum, teachers of mathematics, both primary teachers and secondary mathematics teachers, have a responsibility to provide a classroom learning environment where students learn mathematics to their maximum potential. This involves taking into account not only the mathematics that they want the students to learn, but also the different ways in which students learn. Documents such as *The National Statement for Mathematics in Australian Schools* (1991) clearly outline the need to cater for the diverse nature of students.

Recent mathematics curriculum frameworks (e.g. Curriculum Council (WA), 1998; National Council of Teachers of Mathematics, 1989) describe the common outcomes expected for all students. This does not mean that there should be a common curriculum for all students, but rather, the outcomes are based on the assumption that all students, regardless of class, gender, race, ethnicity and so on, can achieve them. Willis and Johnston (1998) have argued that:

> common curriculums typically do not result in common outcomes and it is time to try something different. If we want all students to be in a position to succeed at a high level on common mathematical outcomes we will need to respond appropriately to their non-standard needs and this means different curricula.

It is the responsibility of the schools and systems to vary curriculum content and pedagogy to ensure that students do succeed.

An essential part of the role of a teacher of mathematics is to develop their own understanding of the nature of numeracy and how it relates to school mathematics. Mathematics teachers should also use this understanding in dealing with student numeracy issues within the mathematics classroom: that is, they need to recognise when a numeracy issue arises, diagnose the issue, and develop strategies for improving each student's response. They could also teach the students about numeracy and have an expectation that students will be 'knowledgeable, flexible, reflective and critical users of mathematics' (Willis, 1998b, p. 76).

Teachers of mathematics in primary and some middle school settings have opportunities to use other subjects and themes to develop student outcomes in mathematics. This should assist students, in addition to engaging them in learning some mathematics, to see connections between mathematics and other areas. However, there is need for caution. Firstly, approaching a situation from the point of view of teaching some mathematics is not necessarily the same as a student using some mathematics to help them understand or do something else. For example, a teacher might develop a series of mathematics lessons using the theme of a sport. This is not the same as a lesson in Health and Physical Education where some mathematics might be needed by the student to help them understand about pulse rate and fitness. In the first case the goal of the teacher is to teach mathematics, while in the second it is to teach students about fitness. Secondly, the cross curriculum ideas used for the teaching of mathematics need to make sense. Inappropriate links between mathematics and the subject may only encourage students to think that mathematics has no real life applications. Thirdly, teachers express concern, particularly at the primary level, that it is difficult to keep the balance between teaching the mathematics of a situation and learning about the situation. This balance will be easier to keep if the teacher is clear about the purpose of the tasks. That is, if the task is to teach the student about a subject then they need only teach the mathematics that is needed to enhance the student learning of the subject. If the purpose is related to learning the mathematics then this should be factored into the time allocated for mathematics and not the subject.

Another important role of the mathematics teacher in the secondary school is to act as a resource person for other members of staff. The mathematics teachers should familiarise themselves with the ways that mathematics can be used to improve learning across the curriculum and be ready to offer advice and support for other teachers in these matters.

How do you plan for numeracy at the whole school level?

We were unable to find research evidence on how a school might plan for the development of student numeracy in the broader sense described in this paper. There is anecdotal evidence of planning in some schools for numeracy across the curriculum. In some settings, particularly high schools, there have been agreements between faculties about who will teach what and where. For example, it may be decided that the staff of the mathematics department will teach the construction and interpretation of graphs to the Year 8s early in the year, thereby saving the staff of other subjects time and energy. There may be some benefits of this approach but only if students are able to see why and how graphs are used in the other subject areas and explicit links are made back to their various subject areas. In some primary and middle schools, there is a cross curricula approach, possibly with curricula themes (see previous page).

Research into how a school might look at planning for an emphasis on numeracy across the curriculum is currently being undertaken by members of the *NATC* project. Work with teachers in schools in 1998 has led to the design of a draft model of a set of procedures aimed at ultimately involving all staff in a planning process. This model will be further trialled in 1999 in Western Australian. Since this is research in progress there are many unanswered questions about a range of issues.

The researchers are describing the model as a numeracy audit. This numeracy audit has three main goals:

- To collect information about the numeracy demands across the curriculum which will enable the school to make judgements about the extent to which numeracy requires action and where that action should be directed
- To develop the skills of teachers to recognise numeracy demands in their classroom and their curriculum
- To extend teachers' knowledge of a range of strategies to develop students' numeracy.

The researchers consider these three aims to be fundamental to a numeracy audit, but the ways in which an audit is carried out depends to a large extent on the size of the school, the enthusiasm of the staff and the resources available. It might involve all staff of a small primary school or initially a department in a secondary school or a research team in a large school. Underpinning the development of the model is the assumption that there is a need for professional development for teachers and administrators to raise their awareness of the nature of numeracy, and to inform them of strategies that can be used in the research and planning process.

Although there will variations among schools it is expected that the stages of such an audit would include the following:

Identify staff perceptions of numeracy

At this stage staff perceptions of numeracy are identified through interviews or group discussion. The purpose is to get teachers to voice their views of numeracy and to be explicit about how they currently develop student numeracy. A summary is prepared so that staff can see the range of views held within the school.

Examine curriculum documents for descriptions of numeracy

Here an individual or team examines the school, system and commercial curriculum documents used by the school for reference to numeracy and strategies they suggest for teachers to use for developing students numeracy. Records of these are kept for the planning stage.

Teachers review their own curriculum documents for references to numeracy

The teachers involved in the audit look at their own programs and support materials to see whether they contain any references to numeracy. These materials are also examined to identify activities with potential numeracy demands, strategies for developing students' numeracy and relevant assessment and reporting procedures. A record of these is also compiled.

Collect examples of what actually happens in the classroom

At this stage teachers collect data from their classroom and reflect upon it. During a set period of time teachers look for situations in their own and other teachers' classrooms where students perform tasks which involve them using some mathematics. They record as many incidents as possible, some in detail. They also observe situations where students needed to use some mathematics but were unable to do so. The mathematics records of such students are also noted.

Discuss and identify issues that arise from reviewing the information collected

The results of the audit to this point are collected and summarised to form a basis for a discussion with members of staff about numeracy and what teachers can do to develop student numeracy. One or two of the classroom examples are looked at in depth, so that staff develop a better understanding of what constitutes numerate behaviour.

The planning stage

The collection of information and teacher discussion in the previous stages enables a school to make some judgements on how well they are attending to numeracy and these form the basis of an action plan. This plan might include ideas for further professional development, school-based research, and the development of some effective classroom strategies.

How is it possible to monitor, assess and report on student numeracy?

Assessment plays an important role in the learning process by providing feedback which may influence the actions of both the students and their teachers. It can occur in many ways and for different purposes. There are diagnostic, formative and summative assessments which have different functions; there are paper and pencil tests, informal assessments, practical tasks, observation, interviews and so on. In addition the assessment might be designed to give feedback to parents, prospective employers or educational institutions.

One possibility is to provide a framework of numeracy outcomes for teachers to use in monitoring, assessing and reporting on student numeracy. The Tasmanian

Department of Education, Community and Cultural Development (DECCD, 1997) outlined a set of Key Intended Numeracy Outcomes (KINOs) for Years 2, 5 and 8. They are a subset of the outcomes outlined in the profiles of mathematics (Curriculum Corporation, 1994). One of the multiple purposes of the KINOs is to guide teachers in their planning of learning activities. The examples could provide teachers with insight into how mathematics is often embedded in areas across the curriculum. The other purposes of KINOs relate to monitoring, assessing and reporting on student numeracy.

The across-the-curriculum nature of numeracy makes monitoring, assessing and reporting students' numeracy a complex issue, so a broad approach is necessary. Members of the Numeracy in South Australia Catholic Schools Project (Catholic Education Office, 1997) believe that:

> in order to assess student numeracy, teachers need to draw upon a wide range of strategies over a period of time, in a variety of different contexts. Informed teacher judgement should provide the basis of any assessment procedure and strategies for assessment should included a combination of observation, conferencing and analysis of work samples. These enable teachers to assess aspects of numeracy… (p. 5).

This seems to be a suitable approach to the issue, although it must be recognised that there are no quick answers.

The incorporation of work samples into the assessment ties in with the recent focus on the development of student portfolios (e.g. Forster & Masters, 1996) which may be used to demonstrate numerate behaviour across a number of contexts. If portfolios are being used by teachers, schools and students to demonstrate learning outcomes in a range of areas, then the same work samples could be used to demonstrate numeracy without impacting too much on teacher workload. The *RIUMIT* Project (AAMT,1997b) recommended the use of personal portfolios as a way of involving post compulsory students in collecting and organising their own work to illustrate evidence of their *using mathematical ideas and techniques* key competency in a range of different contexts. Portfolios could be used in primary and secondary schools with teacher support. They could also provide a mechanism for students to reflect on the choice of mathematics that they have used — or could have used — in different contexts and in this way further enhance their capacity to act numerately.

More research and development is required to provide exemplification of numeracy in action. The *RIUMIT* Project (AAMT, 1997b) recommended that research and development projects be established to develop examples of student work, in collaboration with teachers, which can be used to exemplify student performance and develop the criteria for determining the differences between good and poor performance.

Such a research and development project by the National Center on Education and the Economy, University of Pittsburgh has produced a model for assessment based on students' work. Standards were developed for each of three phases of schooling and used the work of some 60 000 students in the field. This project suggests a possible model for looking at numeracy across the curriculum.

It would be unreasonable to expect teachers to monitor, assess and report on numeracy without these kinds of standards as support. There needs to be a combination of providing support for all teachers to begin to deal with numeracy as it occurs in their classrooms and research projects aimed at documenting and exemplifying numeracy across the curriculum. These would include trialling of the use of portfolios and the development of appropriate benchmarks.

Implications

What is the role of research?

Research can play an important part in shaping future directions in education. If we assume that developing students' numeracy is important then there are a number of research questions that need to be answered:

- How can we recognise evidence of numerate behaviour?
- How can strategies be developed to help teachers recognise numerate behaviour?
- What kinds of pedagogy would make a difference in developing numerate people?
- Are there levels of numerate behaviour?
- Do cross curricula programs work towards developing numerate behaviour?
- How can teachers improve students' transfer of knowledge across subjects or contexts? What conditions are needed?
- What are the most appropriate methods of professional development?

How do teachers become informed about numeracy?

Since the development of numerate students and responsible numerate citizens is important, every teacher needs to see themselves as a teacher of numeracy. However, this responsibility is not universally acknowledged. Further, many teachers have a narrow perception of what numeracy is, and little awareness of how mathematics contributes to learning in other areas. Research done at the secondary school level (Kemp & Kissane, 1990) indicates that even teachers who are aware of the mathematical demands of their subject areas may choose not to address them directly.

Teachers need professional development activities which will enable them to recognise the kinds of numeracy demands made upon students across the curriculum, identify numeracy demands in their teaching areas and develop the strategies and actions they might take to help student numeracy. When working with teachers about numeracy in the *NATC* Project and the *RIUMIT* Project it became apparent that many teachers lack confidence in dealing with mathematics across the curriculum. In order to address this problem there should be professional development opportunities so that teachers can have opportunities for their own learning, in a sufficiently supportive and yet challenging environment. *Making the Links-Numeracy package* (DECS (SA), 1997) is an example of a project that has incorporated this kind of professional development.

It is not clear which approach to professional development would be most appropriate, indeed there is considerable debate about the merits of the various approaches. In some cases school-based research would be useful (e.g. Coggan & Foster 1989). As part of developing their awareness of numeracy demands outside of school, the teachers might also be involved in research into the numeracy demands in workplaces and in the community (e.g. NATC, 1998 and AAMT, 1997b). The dissemination of documents (e.g. Department of Education and the Arts (Tas.), 1995) which include examples of mathematics across the curriculum and ensuring that these examples also focus on contextual and strategic knowledge (e.g. AAMT, 1997c; AAMT, 1996) would also aid the professional development of teachers.

Is there a role for parents and the community?

Anecdotal evidence suggests that people in the community view numeracy as a set of routine computational skills. This is unfortunate but hardly surprising given the media coverage of this issue. It would seem then that a greater community awareness of how mathematics is connected to our everyday lives, and of what it means to be numerate in a particular setting would help provide a more supportive environment for students and schools. This might be achieved through the media, through workshops and discussion at a local level with principals and teachers. In addition, people could be made aware of the principles underlying current mathematics education as described in the *National Statement on Mathematics for Australian Schools* (1991) and come to appreciate that there is more than computation in being numerate. Parents can play a major role in developing and enhancing their children's numeracy and confidence, giving positive reinforcement for tasks successfully completed outside of the classroom.

What is the role of the policy makers?

There are policy makers at different levels in our society. It is important that they are all aware of the importance of the development of student numeracy. Bearing this in mind, it is the responsibility of those who control resources to allocate funds to appropriate research projects to look for answers to the kinds of research questions outlined above. The outcomes of some of these projects might include professional development packages and resource materials. Subsequent allocation of funds for the training of consultants to assist teachers is essential.

Policy makers then need to reflect on the findings, consult with informed people, think carefully how they affect current policies and adjust them accordingly.

Conclusion

In this paper we have illustrated that to be numerate requires much more than being able to perform some basic mathematical skills, that the enhancement of student numeracy is an essential goal of schooling, and that the curriculum is full of numeracy demands as well as opportunities to develop student numeracy. We have argued that there is a need to continue the current focus on numeracy, but that significant further research and development work is essential to better inform teachers, across the curriculum, for their task of improving student numeracy.

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