# Questioning Numeracy Programs for At-Risk Students In The Middle Years Of Schooling

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Snapshots of classroom practice in middle years numeracy classes for students experiencing difficulty with the study of mathematics often show students undertaking individualised programs of study. Such practices are questioned in light of definitions of numeracy and the degree to which they promote critical numeracy skills for adolescents and their diverse life-pathways. In this paper, models of support programs for numeracy are analysed in terms of pedagogical practices. A call is made for a reconceptualisation of what numeracy means for students in the middle years of schooling.

## Background

The development of numeracy in schools and measuring this development is high on the political agenda and is in accordance with the National Numeracy Goal that "students should have attained the skills of numeracy and English literacy; such that every student should be numerate, able to read, write, and spell and communicate at an appropriate level, and that all children achieve a minimum acceptable literacy and numeracy standard (DETYA, 2000, p. 9).

In defining numeracy, the phrase "key enabling skills" (DETYA, 2000) has been used, but this only partially goes towards operationalising the term. Whilst the development of a succinct definition of numeracy has been the focus of debate for the past decade in mathematics education circles in Australia and overseas, it is generally accepted that a single definition is difficult in that it must be sufficiently broad to encapsulate the richness and breadth of the term. Just as the term mulitliteracies takes account of literacy in an ever-evolving and rapidly changing technological and information age, numeracy definitions will continuously evolve and expand (Noss, 1998); it is an elastic term (Doig, 2001).

Like literacy, the development of numeracy is the responsibility of all teachers (AAMT, 1997; DETYA, 2000), yet the foundation for numeracy is located in mathematics as a key learning area (DETYA, 2000). A rich description of a mathematics classroom providing the basis for numeracy is, according to Battista (1999), where:

> Teachers provide students with numerous opportunities to solve complex and interesting problems; to read, write, and discuss mathematics, and to formulate and test the validity of personally constructed mathematical ideas so that they can draw their own conclusions. Students use demonstrations, drawings, and real-world objects – as well as formal mathematical and logical arguments – to convince themselves and their peers of the validity of their solutions. (p. 427-28)

Such a vision of mathematics classrooms describes a learning environment where key enabling skills for numeracy are more than facts and procedures. Although mathematics teachers in schools have a responsibility to ensure that students acquire basic number facts and skills (e.g., Battista, 1999; Goldsmith & Mark, 1999; Noss, 1998; Thomas, 1992), mathematics for numeracy is having rich conceptual schemas of mathematical knowledge developed through problem solving, problem posing, inquiry, reasoning, hypothesizing, higher-order thinking, communicating, justifying.

Stretching the definition of numeracy further and beyond key enabling skills for full and effective participation, is to consider mathematics for empowerment and the development of socially-critically numeracy skills (Zevenbergen, 1995). Mathematics as empowerment is to understand the mathematisation of modern society, of being able to unearth the hidden mathematics upon which aspects of society are based, and thus to make informed decisions. As stated by Ernest (2000):

> …complex mathematics is used to regulate many aspects of our lives, e.g. our finance, banking and bank accounts, with very little human scrutiny and intervention once the systems are in place. Only through a critical mathematics education can future citizens learn to analyse, question, challenge these systems that can distort life chances and reduce freedoms. (p. 85)

Mathematics for numeracy is to question, challenge, argue. All these words are common adjectives frequently associated with adolescent behaviour. The active promotion of critical numeracy skills then, should be the goal of mathematics in the middle years of schooling.

### *Numeracy in the Middle Years of Schooling*

Middle years research has highlighted the fact that students' mathematics and numeracy performance stagnates or declines, and students become progressively disengaged, disenfranchised and unmotivated with school (Barber, 1999; Hill & Russell, 1999). The state of play in the mathematics education of students in the middle school is that the first year of secondary school is a revisitation of mathematics topics covered in primary school with classroom lessons having little analytic depth, posing little intellectual challenge and little dialogue (Lingard, et al., 2001). Frequently, mathematics in the middle years is taught by teachers who have no specific mathematics education training, which results in teachers teaching mathematics the way they learnt mathematics when they went to school (Battista, 1999). What is being presented is an outdated curriculum predominantly focusing on drill and practice of routine facts, procedures and algorithms.

For a technological age, mathematics in the middle school must capture and reflect the essence of the society in which students live and provide them with skills and knowledge necessary to function in such an environment. "The mathematics used in the world today is not the same as that used or needed a century ago" (Thomas, 1992, p. 4). With new technologies, school mathematics classes no longer need to provide students with practise of complicated algorithms and procedures. Access to technology can provide the tools to promote thinking and concept development (Battista, 1999; Lesh & Heger, 2001; Noss, 1998). Capitalising on students' skills with popular technologies is an avenue for by-passing the tedium of computational exercises so that school mathematics provides opportunities for problem solving and thinking.

Rather than a curriculum that forces students in the middle years to stands-still, marking time through revision, mathematics in the middle years should be seen as an opportunity for students to consolidate and strengthen basic ideas of primary school mathematics and develop mathematics knowledge that is inter-connected, linked and meaningful. The scope of a mathematics curriculum for middle years is succinctly provided in the following statement by Lesh and Heger (2001):

…to provide powerful foundations for success in the new millennium, the kind of understandings and abilities that appear to be most needed are not about the introduction of new topics as much as they are about broader, deeper, and high-order treatments of traditional topics such as rational numbers, proportions, and elementary functions – topics that have been part of the traditional elementary mathematics curriculum, but that have been treated in ways that are far too narrow and shallow…" (p. 12).

## The Study

The middle years of schooling is undergoing major structural, curricular and pedagogical shifts in light of a building body of research into these formidable years for young adolescents. Mathematics in the middle years is one curriculum area that is being scrutinized in terms of its relevance, accessibility, student-focused nature for young people, and its capacity to engage learners in higher order thinking. Mathematics in the middle years must challenge learners to think, to reasons, to question and to communicate mathematically. It must provide students with rich conceptual knowledge of new and exciting mathematical topics for further successful study of mathematics at higher levels. And this is the case for students who experience difficulty with the study of mathematics.

The study reported here is part of a larger study into support programs for students in the middle years of schooling, particularly from specific target groups (students from lower socio-economic communities, Aboriginal and Torres Strait Islander, Language Background other than English, and students struggling with the transition to middle and secondary years). This report focuses on numeracy programs for students experiencing difficulty with the study of mathematics and also students from the target groups. The aim of this aspect of the study was to develop snapshots of numeracy programs and pedagogical practices for students in the middle years of schooling, and to link such programs and procedures to current literature on curriculum reform in the middle years of schooling.

### *Productive Pedagogies*

The term Productive Pedagogies (Education Queensland, 2000) is used to refer to teaching strategies, which research has shown to contribute positively to student outcomes in the classroom. Developed through the Queensland School Reform Longitudinal Study (QSRLS) literature review (Luke et al., 1998), there are four categories of Productive Pedagogies: intellectual quality, relevance, supportive classroom environment, and recognition of difference. In the QSRLS, an instrument was developed for coding classroom interactions and the incidence of Productive Pedagogies. The Productive Pedagogies instrument incorporates a 1-5 Likert scale for each category. In the study reported here, this instrument was also utilised.

## Methodology

The study utilized case study methodology. For each case, interviews with key personnel at each school were undertaken (principal, teachers, literacy and numeracy support specialists), school policy documents were analysed and classroom observations were conducted, and classroom lessons were observed using a Productive Pedagogies classroom observation sheet. Field notes were compiled and cases developed to describe numeracy programs for target groups. Similarities and differences were identified through analysis of case studies.

## Results and Discussion

The snapshots of cases described here were selected on the basis of their differing approaches to promoting numeracy for students in the target groups in the middle years. The first snapshot described below differs from latter snapshots in that the model used is an inclusive, whole-class model. In this class, all students received mathematics instruction at the same time, yet clearly there were students operating at differing levels. The other snapshots presented are all based on withdrawal of students experiencing difficulty with the study of mathematics.

### *Inclusive Model*

This classroom snapshot is a Year 6 mathematics class in a primary school. Energy and enthusiasm for both teaching and learning mathematics was a dominant feature of this classroom. The lesson began with the teacher demonstrating the equivalence of measures of mass and capacity. Using water and a set of scales, the teacher demonstrated that 1 kilogram is equal to 1 litre. After discussing the link between mass and capacity measures, the teacher informed the students that their task was to demonstrate that measures of mass and capacity were also equivalent to measures of volume. Specifically, each group of students was to demonstrate one of the following four situations: that 1 $cm^3$ equals 1mL; that $5cm^3$ equals 5mL, that 10 $cm^3$ equals 10mL and that 1000 $cm^3$ equals 1L. The teacher invited any group of students to work with her on the task if they felt they required further assistance and guidance. Four students indicated that they did. The other students arranged themselves into their groups. Materials (wooden centicube blocks, measuring devices, plasticine) were distributed to each table. After the teacher started her group, she then went to each table to listen to what each group of students had tried and to provide guidance as required. The activity and conversation generated by this task was considerable. The students expressed enthusiasm for the task, and upon reaching a conclusion, visibly showed excitement. They were extremely keen to share their findings with the rest of the class.

In this lesson, a lot of meta-language was apparent as the teacher reinforced the meanings of the terms *capacity*, *volume*, *mass* throughout the lesson. In this lesson, the teacher clearly enunciated the problematic nature of some mathematical knowledge in terms of the relationship between mass, capacity and volume being a difficult mathematics concept. This lesson had an element of connectedness as the teacher used familiar containers in the demonstration (soft-drink bottles, milk cartons) and encouraged students to discuss when they used such containers in their daily lives. A supportive classroom environment was established through the high level of academic engagement demonstrated as students worked together in their groups on the common task. Students provided each other social support for achievement as they worked together to solve the task and justify their reasoning. There was a high level of inclusivity in this lesson as all students were actively engaged and were provided with an opportunity to access the concept under investigation.

In this lesson, we see evidence of a range of productive pedagogies utilised. In this classroom, students were a community of learners working together to develop rich conceptual understandings. There appeared to be a desire on the teacher's part to implement pedagogy of questioning, to develop a culture of inquiry, exploration, self-discovery, self evaluation in these students. There was also a certain level of authenticity in the activities occurring in the classroom where the teacher was attempting to make connections between class and life and to enable students to access funds of knowledge, particularly within the domain of mathematics.

The above snapshot was taken from a school located in a socioeconomically disadvantaged area. In this school 98% of students enrolled are Vietnamese; 99% of students enrolled in Kinder do not speak English. In the snapshot, we see an inclusive classroom practice where rich conceptual understanding is the focus. What we see here is the teacher catering to all abilities through the use of good questions (Sullivan & Clarke, 1991). In Sullivan & Clarke's terms, good questions are mathematical tasks that enable students of all abilities to engage with the task, and to bring their own level of mathematical knowledge to the situation. Good questions allow students to think in different ways; to express solutions in different ways; and to make use of the mathematical knowledge they possess, whilst expanding their own problem solving and reasoning skills as they interact with others.

### *Withdrawal Model*

Many snapshots from cases in this study showed programs of numeracy for at-risk students that used a model of withdrawal for individual assistance, or individualised programs for students within the classroom. In such cases this appeared to be well-received by students as they seemed to engage eagerly and enthusiastically in such classes. The perceived negative aspect of snapshots taken were that the activities that students were asked to complete were predominantly based on number topics and appeared to be drill and practice of algorithms and basic facts. The following snapshots are summaries of classes observed.

At a state primary school, the structure of the numeracy program was the provision of small group activities one day per week to revise 'basic' numeracy concepts. All students in Year 6 were divided into groups for this day, and worked on topics including addition, subtraction, ordinal numbers, money, time, temperature, 2D shapes. Many of the group activities were supported with computer programs of the same name. In one particular snapshot, a group of 4 students, selected on the basis of their being at-risk in numeracy were working at their own pace on individualised computer programs. The atmosphere of the group was positive and students freely interacted with each other in conversation, but worked individually at their own activity.

In a state secondary school at-risk students in Year 7 were provided with assistance in basic numeracy through a withdrawal mode. The program being followed has a focus on the mathematics curriculum strand of number, specifically on basic facts, mental strategies, place value and the operations of multiplication and division. In the Year 7 class where a snapshot of practice was taken, the students were exploring place value and partitioning tens and ones. The school in which this program takes place is keen to take the strategies of this program up to Year 8. They have made some progress towards this by withdrawing 12 students who are currently in Year 8 and providing them with individualised booklets of exercises. In this mode, the students work at their own pace, completing set exercises, seeking teacher assistance as required.

At a state primary school, a small group of Year 6 students (3 boys and one girl) were working in a withdrawal room under the supervision of a teacher. One boy was working on a reading unit, with the other three working individually on mathematics tasks at separate computers. One boy was working on a fractions activity. The screen contained a number of problems. Each problem involved clicking on an appropriate number of parts of a whole, or items in a collection, to match a fraction written in symbols at the side. The student appeared to be coping sufficiently, but not fluently. Ten minutes later he was tackling problems on fractions and percentages which appeared to be much more difficult. The student had little understanding of what was required to perform these calculations. Another student was adding tens and ones. The screen showed a symbolic representation and concrete base ten blocks. The concrete representation appeared to not help the student and to actually slow down his performance. He then worked on addition problems, which he completed mentally, with no apparent difficulty. The girl worked on word problems involving additions, calculating the solutions mentally and typing in the answers competently. Throughout the lesson they worked with concentration while the teacher went to each student in turn to help or probe students' understanding. At the end of the session, the students logged off and slowly and reluctantly moved to their next class.

Being individualised programs, examples of good pedagogy are difficult to find in these snapshots. The exercises have no, or only tenuous links to real situations; tenuous in terms of real tasks being number exercises encased in contrived 'story' contexts. In terms of the productive pedagogies categories, there appeared little higher order thinking required by the tasks. The students were only minimally engaged in inquiry, with little expectation of problem solving, reasoning, thinking or justifying solutions and solution procedures. Marginally, the lessons showed supportive classroom environments in that students appeared happy enough to work in the withdrawal mode and were engaged with the tasks.

These snapshots are both positive and alarming at the same time. In small group withdrawal mode, we see students in the middle years appearing to enjoy the activities they are provided with. We see a clear image of skill development and practice. We see success in small doses where students are beginning to achieve at mathematical tasks they may not have previously. However, the alarming thing appears to be a perpetuation of what mathematics, and being numerate, is all about. Through becoming skilled in basic facts and applying routine procedures, these students are having little experience to apply their skill and knowledge in real situations. Such a condition is enunciated by Goldman, Hasselbring, et al, (1997) as they describe the short-comings of programs for students with learning disabilities that are decontextualised and dominated by practice of procedural computational skills. They describe mathematical literacy as being able to solve problems at home or at work; "to solve problems, reason, take charge of their learning" (p. 199). The basis of such an approach for at-risk students in numeracy, according to Goldman et al. is that "the idea of learning in complex problem-solving environments runs counter to the recommendation of the behaviourist learning theories that have dominated instructional approaches to students with learning disabilities" (p. 203).

The snapshots described here show a predominance of withdrawal, and skill and drill approaches for students deemed as having learning difficulties in mathematics. Such approaches appear to actually embody the following foreboding description of catering for students at-risk:

> Teaching to the lowest common denominator and stripping out intellectually imaginative and challenging work in a belief that children struggling with basic skills problems are unintelligent can effectively preclude minority, lower socioeconomic and marginalized students for better outcomes. (Education Queensland, 2000 p. 20)

Numeracy programs do not have to be like this. Goldman et al. (1997) provide the following design principles for mathematics achievement for students with learning disabilities (and general education students as well) for basic mathematical literacy:

- Situated, meaningful and authentic problem contexts that motivate the need for fundamental basic skills.
- Opportunities for development of self-assessment skills, including opportunities for feedback and revision.
- Support for the acquisition of conceptual understanding of foundational mathematics concepts.
- Mechanisms for practicing procedural skills such as addition, subtraction, formulaic manipulation, and so forth.
- Support for developing multiple ways to represent and communicate information.

In the information age the use of technology for more than skill and drill should also be a dominant aspect of any numeracy program.

Such principles are not radical, but are a means for questioning the dominant model of withdrawal programs for at-risk students. Students in withdrawal classes as seen through the snapshots presented here, appear to enjoy developing skills and completing individualised skill-building programs. Yet in the inclusive model we see a much richer mathematical environment where students are engaged in thinking and communicating at a higher mathematical level. The range of productive pedagogies utilised is far-reaching, compared to those in the withdrawal mode. The inclusive model is highly demanding of the teacher in terms of effort and energy, but the cognitive, social and interest in learning of the students was palpable in this class compared to that exerted by students in the withdrawal classes. Productive pedagogies appears to link to students output through comparison of these snapshots.

There is a clear need to consider mathematics classes in the middle years of schooling and their impact on developing students' key enabling skills beyond basic numeracy to critical numeracy. In this study, the classes selected for observation were on the basis of exemplary programs and teaching practice in numeracy for at-risk students. Many questions are raised through these snapshots, particularly in relation to the perpetuation of a particular view of mathematics by the nature of these programs. What relevance do these programs have to the students at this stage of their schooling? Are they preparing them to be active citizens, possessing enabling skills to make informed choices, especially in light of the fact that the time these students have left at school is running out? Will these students leave school empowered to use mathematics to make effective decisions; that is, will they be critically numerate? From the small number of snapshots presented here, generalisable conclusions are tentative. But what has been presented here is evidence that, in the tide of middle years research and calls for reform, a reconceptualisation of what numeracy is must also take place.

## Concluding Comments

The numeracy literature provides us with a definition of numeracy as the key enabling skills of mathematics, together with the confidence to apply them as required in any personal situation (at home, at work, within the community). The foundation for numeracy is mathematics, where knowing mathematics is more than the ability to execute skills and procedures. Mathematics for numeracy is having rich conceptual schemas of mathematical knowledge developed through problem solving, problem posing, inquiry, reasoning, hypothesising, higher-order thinking, communicating, justifying. Teaching mathematics for numeracy is augmented through middle years literature that emphasises a student-centred curriculum that engages students in learning and decision-making; providing socially supportive environments; where group work and collaborative problem solving is encouraged; where, in the words of Barber (1999) the "energy, creativity, idealism and passion that characterises adolescent young people" (p. 9) is capitalised upon.

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